BRILL'S ANNUAL OF AFROASIATIC LANGUAGES AND LINGUISTICS

Brill's Annual of Afroasiatic Languages and Linguistics

Aims & Scope / Readership

Brill's Annual of Afroasiatic Languages and Linguistics is a new peer-reviewed international forum devoted to the descriptive and theoretical study of Afroasiatic languages. The territory of the Afroasiatic family spans a vast area to the South of the Mediterranean, extending from the Atlantic Ocean to the Middle East and reaching deep into the heart of Africa. Some of the Afroasiatic languages have been studied for centuries, while others still remain partially or entirely undocumented. In the course of the second half of the 20th century, the constantly increasing qualitative and quantitative contribution of Afroasiatic languages to the elaboration of linguistic theory has met with considerable attention from the linguistic community.

The Annual will seek top-level contributions in phonology, morphology, syntax, semantics, comparative and historical linguistics. Its target audience comprises specialists in Afroasiatic languages and general linguists.

Editorial Address, Instructions for Authors, and Open Access

Submissions to the annual should be sent electronically as an email attachment (in PDF, Word or RTF format) to the *Series Contact Editor*:
Sabrina Bendjaballah, sabrina.bendjaballah@linguist.jussieu.fr

Books for review and book reviews should be sent to the *Book Review Editor*:
Chris Reintges, CReintges@linguist.jussieu.fr

For author instructions, please be referred to the fourth page of the prelims. More detailed guidelines can be obtained from the Editors, or please visit the journal's website at brill.com/baall to download the same. The Instructions for Authors include details on how to publish on an Open Access basis with Brill Open.

Brill's Annual of Afroasiatic Languages and Linguistics (ISSN 1876-6633, e-ISSN 1877-6930) is published anually by BRILL, Plantijnstraat 2, 2321 JC Leiden, The Netherlands, tel +31 (0)71 535 3500, fax +31 (0)71 531 7532.

BRILL'S ANNUAL OF AFROASIATIC LANGUAGES AND LINGUISTICS

Volume 4 2012

BRILL
Leiden • Boston

General instructions for submission

Brill's Annual of Afroasiatic Languages and Linguistics is a new peer-reviewed international forum devoted to the descriptive and theoretical study of Afroasiatic languages. It welcomes top-level contributions in phonology, morphology, syntax, semantics, comparative and historical linguistics.

All submitted papers will be subject to double, blind peer review. For the purpose of reviewing the draft paper should be anonymous. No author details should be identifiable from the article itself or in the acknowledgements. Details of the author(s) should be submitted in a separate file and include the author's name, affiliation, full postal and email addresses.

Papers that are submitted for initial consideration should be complete, including all notes, bibliographical references, tables, etc. The final draft of a manuscript accepted for publication must be submitted both as hard copy and electronically. Electronic files should be saved in .pdf format. Final versions and printouts must be proofread carefully before submission; please use your spelling and grammar check.

Manuscript pages should be numbered consecutively, double-spaced with wide margins on all sides (use ragged rather than justified right margins).

Consent to publish

Transfer of copyright
By submitting a manuscript, the author agrees that the copyright for the article is transferred to the publisher if and when the article is accepted for publication. For that purpose the author needs to sign the **Consent to Publish** which will be sent with the first proofs of the manuscript.

Open Access
In case the author wishes to publish the article in **Open Access** he/she can choose the **Brill Open** option, which allows for a non-exclusive Open Access publication in exchange for an Article Publishing Fee, and sign a special **Brill Open Consent to Publish**.
More information on Brill's policy on Open Access can be found on brill.com/openaccess.
The Brill Open Consent to Publish can be downloaded from brill.com/downloads/BrillOpen-Consent-to-Publish.pdf

For a detailed stylesheet and further instructions, please check brill.com/baall.

Koninklijke Brill NV incorporates the imprints Brill, Global Oriental,
Hotei Publishing, IDC Publishers and Martinus Nijhoff Publishers.

Printed in the Netherlands (on acid-free paper).

BRILL Brill's Annual of Afroasiatic Languages and Linguistics 4 (2012) BAALL brill.com/baall

Editors' Note

Sabrina Bendjaballah, Edit Doron, Jean Lowenstamm & Jamal Ouhalla

This 4th issue of BAALL is entirely devoted to the acquisition of the phonology and morphology of Hebrew. We wish to extend our thanks to Outi Bat-El, the guest editor for this volume, for her collaboration. We are prepared to consider other projects with similar coherence and unity for thematic issues in the future. Nevertheless, BAALL remains primarily a medium devoted to the rapid publication of original articles in all areas of theoretical and descriptive Afroasiatic Linguistics.

DOI: 10.1163/18776930-00400012

BRILL

BAALL

Brill's Annual of Afroasiatic Languages and Linguistics 4 (2012) 3–5 brill.com/baall

A Note from the Guest Editor

Outi Bat-El
Department of Linguistics, Tel-Aviv University
obatel@post.tau.ac.il

This special issue of *Brill's Annual Afroasiatic Languages and Linguistics* contains eleven papers on the acquisition of Hebrew phonology and morphology. The authors of these papers are or were associated with the department of linguistics at Tel-Aviv University, where most research on the acquisition of Hebrew phonology and morphology is conducted. The research started decades ago, with Ruth Berman's studies on the acquisition of Hebrew morphology. The study of the acquisition of Hebrew phonology only began during the last decade by researchers associated with the author of this note.

Out of the eleven papers in this special issue, seven (Cohen, Gafni, Karni, Becker, Albert and Zaidenberg, Bat-El, Lustigman) use mostly the naturalistic longitudinal data obtained in the Child Language Project led by the author of this note and Galit Adam (partially supported by ISF grant #554/04). Two papers are experimental in nature (Tubul-Lavy, Armon-Lotem and Amiram) and another two use independently collected data (Ben-David, Adi-Bensaid).

Many Wug tests have been conducted since 1958, when Jean Berko published her article *The child's learning of English morphology* and many universal hierarchies have been studied since 1941, when Roman Jakobson published (in German) his book *Child language, aphasia and phonological universals*. The field of theoretical linguistics has made some progress since then and so has the study of the acquisition of phonology and morphology. The growing body of research in this domain allows us to improve our understanding of the mechanisms involved in language acquisition, raise new questions and reconsider old ones.

This special issue of *Brill's Annual Afroasiatic Languages and Linguistics* is a humble contribution to the joint enterprise between theoretical linguistics and research in the development of phonology and morphology. When it comes to the acquisition of phonology, Hebrew is a new member in the limited pool of studied languages (English, Dutch, German, French, Spanish, Portuguese, Japanese, Greek, and just a few more). The fresh data provided in the present volume allow one to evaluate old issues and address new ones.

 DOI: 10.1163/18776930-00400013

The two papers on harmony highlight these two facets of research. **Vowel harmony** in the acquisition of languages with no vowel harmony has hardly been discussed in the literature, and some even argue that it does not exist. Cohen's paper suggests otherwise. **Consonant harmony**, on the other hand, is one of the oldest and most popular issues in the literature of language acquisition, but nevertheless there is disagreement with regard to the factors determining directionality. Gafni's paper adds fresh data and intriguing generalizations to this issue.

Going up to the prosodic structure, Ben-David follows the **development of the prosodic word and the syllables** step-by-step, with reference to the number of syllables in the word and the subsyllabic units (onset, nucleus, coda). The development of the subsyllabic units is further studied in the three ensuing papers. Karni concentrates on **word initial simple and complex onsets**, accounting for the intriguing observation that children produce onsetless syllables for targets with simple onset but not for targets with complex onsets. Adi-Bensaid studies the development of **final and medial codas** in the speech of hearing impaired children, with reference to stress and position in the word. As it turns out, coda development in hearing impaired children is very similar to that of typical development. From a somewhat different perspective, Becker addresses the issue of **selectivity in the acquisition of onsets and codas**, suggesting a method for diagnosing and quantifying children's avoidance of attempting words that do not conform to their grammar.

The interface of phonological knowledge with writing proficiency is discussed in Tubul-Lavy's paper on **phonological spelling errors**. Children with past and more so present phonological impairment make spelling errors identical to speech errors in early acquisition and impaired speech (e.g. consonant harmony, coda deletion).

The next two papers bridge between phonology and morphology. Albert and Zaidenberg provide a prosodic account of **filler syllables**, which start as pure prosodic extensions within the phonological word and gradually develop into prosodic extensions corresponding to morpho-syntactic particles. Phonology does not only lead to morpho-syntax but also stays on guard during the acquisition of morpho-syntactic units. This is shown in Bat-El's paper, which shows that the **development of word final codas affects the acquisition of verb inflectional suffixes**.

The last two papers are purely morphological. Lustigman shows how children's morphological specification in **early non-finite verb forms** gradually develops from bare stems to full infinitives and present tense (participial) forms. Armon-Lotem and Amiram, the only paper in this volume on L2, **study the interference of L1 systems in the acquisition of L2 gender**, where L1 is English and Russian and L2 is Hebrew.

In the name of all the authors in this volume, I would like to acknowledge with much appreciation the support of Jean Lowenstamm, the Chief Editor of *Brill's Annual Afroasiatic Languages and Linguistics*, and the editorial work of Gila Zadok from Tel-Aviv University and Dick Kraaij, the Desk Editor of *Brill's Annual Afroasiatic Languages and Linguistic*.

BRILL *Brill's Annual of Afroasiatic Languages and Linguistics 4 (2012) 7–29* brill.com/baall

BAALL

Vowel Harmony and Universality in Hebrew Acquisition

Evan-Gary Cohen
Department of Linguistics, Tel-Aviv University, Israel
evan@post.tau.ac.il

Abstract
The role of universals versus language specific grammars during acquisition is at the focal point of this study. A corpus-based investigation of two children's harmony patterns during acquisition is carried out. It is shown that although Hebrew does not have a productive harmony grammar, there is nevertheless a considerable amount of vowel harmony in the children's productions, suggesting speakers have a universal predisposition for such patterns. The children start out at roughly the same point, the ultimate goal being determined by the ambient language. The developmental paths, however, are individual. One child shows a preference for segmental considerations in determining harmony patterns, while the other shows a preference for prosodic considerations. Both children, however, gradually modify their grammars, presented herein within an Optimality Theoretic framework, ultimately reaching the same goal, an adult grammar without active vowel harmony.

Keywords
vowel harmony; variation; language acquisition; universal constraints; Hebrew

1. Introduction

There is much discussion in the literature on the acquisition of vowel harmony in languages with productive harmony systems (Leiwo et al. 2006 for Finnish, Altan 2007 for Turkish, among others). There is, however, little discussion on vowel harmony in languages without an active harmony grammar. In Ben-David's (2001:148) study of the acquisition of Hebrew, final syllable doubling, resulting in identical syllabic nuclei in the final and penultimate syllables, is mentioned as the first stage of disyllabic productions (see also Ben-David this volume). That is, when additional syllables are added, the vowel is first copied (e.g. *'bosem* → [*'etem*] 'Bosem (name)'). This doubling is unaffected by vowel quality (Ben-David 2001:149) or stress (Ben-David 2001:151), and is not directly attributed to vowel harmony, but rather to a general preference for reduplicated forms and faithfulness to word-final syllables (Ben-David 2001:150). Mintz and Walker (2006) mention a role that vowel harmony possibly plays in the segmentation

 DOI: 10.1163/18776930-00400001

of strings in the acquisition of English, hypothesizing that infants may show a universal predisposition to use harmony as one of their segmentation cues. In this paper, I not only show that such a predisposition exists in Hebrew, but that the acquiring infant's initial state has an active harmony grammar.

Following Ben-David's (2001) findings with respect to reduplication and doubling and Mintz and Walker's (2006) claims regarding English acquisition, I argue that vowel harmony is, in fact, utilized by the acquirer in order to facilitate production before the acquisition of all the segments has been completed. The acquisition of vowels in Hebrew is much faster than that of consonants (Ben-David 2001:271), so by the time infants start producing disyllabic forms, the vowels have more or less been acquired, making evidence for segmentally-motivated vowel harmony relatively scarce, and subsequently resulting in very little research in this area. In order to find productive vowel harmony, one needs to collect data from the earliest stages of acquisition, to ensure that one does not overlook the extremely small amount of relevant data.

The question this paper addresses concerns the universal status of vowel harmony implied by Mintz and Walker (2006). Does vowel harmony play a role in the acquisition of non-harmony languages such as Hebrew? If so, this would suggest the universality of vowel harmony, as children acquiring such languages could not have got their harmony grammar based on input from the ambient language. Note, the universal nature of vowel harmony was also proposed in Cohen (2010, 2011), but this refers to adult grammars in which harmony may surface in parts of the lexicon's periphery, such as in loanwords.

The goal of this paper is to demonstrate that vowel harmony, a non-native process in Hebrew, nevertheless applies systematically during early stages of acquisition. The infants may follow different paths in their phonological development on the way to the ultimate goal, a final status in which there is no productive vowel harmony. Since vowel harmony is not supported by the ambient language, this suggests that it is universally motivated.

The paper is structured as follows. In § 2, I review harmonic forms in the native Hebrew lexicon and establish that Hebrew has no productive harmony grammar. In § 3, I present vowel harmony data from two Hebrew acquiring infants, and discuss the interaction among various factors known to affect vowel harmony. This is followed by a formal analysis within Optimality Theory, in § 4 and § 5. I then address the issue of variation briefly, before concluding in § 6.

2. Harmonic Forms in the Native Hebrew Lexicon

Various phenomena in the native Hebrew lexicon have been attributed to vowel harmony. These might suggest a productive vowel harmony system, something which would then be unsurprising to find in acquisition. However, these phenomena, briefly outlined below, can be shown to be neither vowel harmony nor productive.

A quantitative analysis of Bolozky and Becker's (2006) Hebrew nouns dictionary shows that there are 6429 disyllabic nominal forms, 1441 (roughly 22 %) of which have identical vowels (henceforth, harmonic forms) as in table 1.

Table 1: Harmonic forms in the Hebrew lexicon

Vowels[1]	**Total**
a-a	890
e-e	428
i-i	60
o-o	44
u-u	19
Total	1441

In the 5-vowel system of Hebrew, if the vowels in disyllabic forms were selected by chance, we would expect ~20 % to be harmonic, and this is more or less what we get, i.e. the distribution of harmonic forms in the lexicon is no better than chance. This result does not take into consideration various suffixed monosyllabic bases in which the suffix and base have identical vowels (e.g. the masculine plural morpheme *-im* added to a monosyllabic base with the vowel *i*, as in *ʃiˈʁ-im* 'songs'), nor does it separate loanwords from native lexical items, or consider token frequencies.

There are several cases cited in the literature as being products of vowel harmony in Hebrew: (i) segholate nouns (Bat-El 1989:180, Bolozky 1995) like *ˈmelex* 'king' and *ˈʃaʕaʁ* 'gate', (ii) cross-guttural harmony and cross glottal harmony (McCarthy 1994, Kawahara 2007) as in */jədaʕnuka/* → *jədaʕənuka* → [*jədaʕaˈnuka*] 'we knew you', and (iii) irregular plural suffixation (Becker 2009: 109) as in *moˈt-ot* 'poles', where the masculine noun *mot* 'pole' taking the feminine plural suffix *-ot* due to its stem vowel. These cases were shown in Cohen (2011) to largely be residual effects from Biblical Hebrew or products of certain noun templates which are inherently harmonic, rather than being products of an active vowel harmony system.

Observing the above, it appears that there is indeed no productive vowel harmony in Hebrew. Therefore, children acquiring the language are exposed to a distribution of harmonic forms which is no better than chance and unsystematic, i.e. they are not exposed to an active harmony system.

1) 25 of the *i-i* forms are monosyllabic bases with the *-im* masculine plural suffix, 20 are loanwords, and only 8 are commonly occurring words. 32 of the *o-o* forms are loanwords, 2 are monosyllabic bases with the *-ot* feminine plural suffix. At least 9 of the *u-u* forms are loanwords, 2 are monosyllabic bases with the *-ut* derivational suffix.

3. Data and Generalizations

In order to pinpoint the effects of various factors on vowel harmony, disyllabic productions of two typical Hebrew-acquiring children, RM (female) and SR (male), were extracted and analyzed.[2] Furthermore, only forms which were completely harmonic (i.e. identical vowels, not just vowels agreeing in some feature) were considered.[3] This enables us to tease apart the roles of various competing factors discussed.

The data (available in http://www.outibatel.com/wp-content/uploads/2010/12/Cohen-Appendix.pdf) are all organized according to the developmental periods laid out in Adam and Bat-El (2008, 2009), which reflect the size of the child's acquired lexicon as an indicator of the developmental stage, rather than the child's age. Adam and Bat-El show this to be a better indicator of developmental progress than chronological age. The data were examined up until the eighth developmental period. After this period, the presence of harmony in the child's productions was no different from the ambient language. The developmental periods are shown in table 2.

Table 2: Developmental periods in acquisition

Period	**Cumulative Attempted Targets**	**Ages**	
		SR	**RM**
1	~10	1;02.00–1;03.05	1;03.27–1;04.09
2	~50	1;03.14–1;04.17	1;04.18–1;05.29
3	~100	1;04.24–1;05.08	1;06.05–1;08.01
4	~150	1;05.15–1;05.21	1.08.07–1.09.18
5	~200	1;05.29–1;06.02	1.09.27–1.10.13
6	~250	1;06.12–1;06.20	1.10.28–1.11.18
7	~300	1;06.26–1;07.02	1.11.25
8	~350	1;07.09	2;00.02–2;00.09

Complete tables of SR and RM's productions are provided in Appendices I and II respectively. A general description of the children's productions appears in the following §3.1. The two infants are compared with respect to various factors

---

2) The data used in this study are drawn from the Language Acquisition Project directed by Outi Bat-El and Galit Adam at Tel-Aviv University (ISF grant #544/04).

3) An anonymous reviewer mentioned that the harmonic forms may not, in fact, be the result of vowel harmony, but rather could be the result of reduplication or some other phonological process. It makes no difference, however, whether the vowel copying is a result of reduplication or vowel harmony as what is crucial here is the factors selecting the sponsor vowel and the target vowel.

influencing vowel harmony: stress (§ 3.2), directionality (§ 3.3) and vowel quality (§ 3.4), followed by a discussion and comparison in § 3.5.

3.1. *Description of the Children's Vowel Harmony*

In SR's disyllabic productions during Period 1 (henceforth: P1), only three vowels were attempted and produced consistently, *a, u, i*. Note, all vowels are produced in monosyllabic forms during P1. The vowel *e* was only attempted and produced for the word *'ine* 'here'. The vowel *o* was not produced at all. SR only started to attempt and produce all five vowels in P2, and even here, *o* was severely restricted, (in both attempts and productions), surfacing only for *'ʁoni* 'Ronny (name)' and *'alo* 'hello'. The vowel *a* was the only anchor (i.e. underlying sponsor) in harmonic forms in P1 (e.g. *ta'puax* → [*'baax*] 'apple'). The vowel *u* first appears as an anchor in P2 (e.g. *'tuki* → [*'kuku*] 'parrot'), *i* in P3 (e.g. *leo'ʁid* → [*'ʔijit*] 'take down'), *o* in P7 (e.g. *'ejfo* → [*'ʔofo*] 'where') and finally *e* in P8 (e.g. *ja'ʃen* → [*ʔe'θen*] 'asleep'). Table 3 summarizes all disyllabic productions by SR.

Table 3: SR's disyllabic productions and harmony

	Tokens						Types	
Period	(a) 2σ Forms	(b) Harmonic Forms		(c) Vowel Harmony			(d) Harmonic Forms	(e) Vowel Harmony
	N	% of (a)	N	% of (b)	% of (a)	N	N	N
1	131	61.8	(81)	2.5	1.5	(2)	5	1
2	251	39.0	(98)	14.3	5.6	(14)	19	8
3	227	26.0	(59)	32.2	8.3	(19)	17	5
4	160	28.8	(46)	41.3	11.9	(19)	24	7
5	205	41.0	(84)	8.3	3.4	(7)	34	3
6	190	30.5	(58)	10.3	3.2	(6)	26	4
7	382	35.6	(136)	8.8	3.1	(12)	55	8
8	332	32.8	(109)	11.9	3.9	(13)	41	11

Table 3 presents the number of disyllabic forms produced, the number of harmonic forms out of these disyllabic forms, and the number of these harmonic forms which, in fact, are a reflection of vowel harmony. The overall occurrence of harmonic forms during P1 is 61.8 % (81/131), only 2.5 % (2/81) of which are the result of vowel harmony. This shows a clear preference for selecting targets which are harmonic to begin with. Selectivity plays a role here, as harmonic targets are more likely to be selected than disharmonic targets. Such a role of selectivity has been found for Hebrew phonology (Ben-David 2001:342, Bat-El this volume, Becker this volume) and morphology (Lustigman 2007, this volume), as well as other languages (Schwartz and Leonard 1982, Schwartz et al. 1987, Drachman 1973, Ferguson et al. 1973, Stoel-Gammon and Cooper 1984, Mintz and Walker 2006, to name a few). This selectivity indicates a preference for harmonic forms (recall, this preference is not supported by the language itself), which decreases after P1, as selectivity loses its influence on target selection. However, the percentage of tokens in which active harmony takes place rises progressively from the first period, peaking at P4, when 41.3% (19/46) of all harmonic forms are the product of vowel harmony. It then drops to 8.3% (7/84), more or less where it remains until P8. Throughout the 8 periods, the frequency of harmonic forms produced by SR was well above Hebrew's ~20%.

Since Hebrew provides no evidence for a preference for harmonic forms, SR's preference for such forms must be universally motivated (Cohen 2011). The effect of this universal principle, which is not supported by the ambient system, can only surface during acquisition before the ambient system has "taken over", i.e. during the earliest stages of acquisition (Rose 2000, Adam and Bat-El 2009), before the children have acquired sufficient contradictory evidence not supporting the principle. Note, in adult languages, universal preferences not supported by the native grammars might surface, but largely only in the lexical periphery, such as loanwords, blends and acronyms (Shinohara 2004, McCarthy and Prince 1994, Bat-El 2000, Berent et al. 2009, Kenstowicz 2004, Cohen 2010, 2011).

RM attempted and produced all vowels from P1. There were no disyllabic harmonic forms in P1. The vowel *a* was the only anchor in harmonic forms in P2 (e.g. *'peʁax* → [*'hawa*] 'flower'); *e*, *u*, and *i* in P3 (e.g. *ma'kel* → [*je'ken*] 'stick', *bak'buk* → [*pu'pu*] 'bottle', *'ine* → [*hi'niʃ*] 'here'); and finally *o* in P4 (e.g. *ipa'ʁon* → [*o'boj*] 'pencil'). Table 4 summarizes all disyllabic productions by RM.

Table 4: RM's disyllabic productions and harmony

	Tokens						Types	
Period	(a) 2σ Forms	(b) Harmonic Forms		(c) Vowel Harmony			(d) Harmonic Forms	(e) Vowel Harmony
	N	% of (a)	N	% of (b)	% of (a)	N	N	N
1	7	0	(0)	0	0	(0)	0	0
2	126	31.7	(40)	7.5	2.4	(3)	15	2
3	247	30.0	(74)	10.8	3.2	(8)	23	7
4	140	27.9	(39)	25.6	7.1	(10)	24	8
5	124	19.4	(24)	25	4.8	(6)	17	4
6	299	22.7	(68)	7.4	1.7	(5)	40	5
7	155	20.0	(31)	19.4	3.9	(6)	21	5
8	320	20.3	(65)	12.3	2.5	(8)	48	8

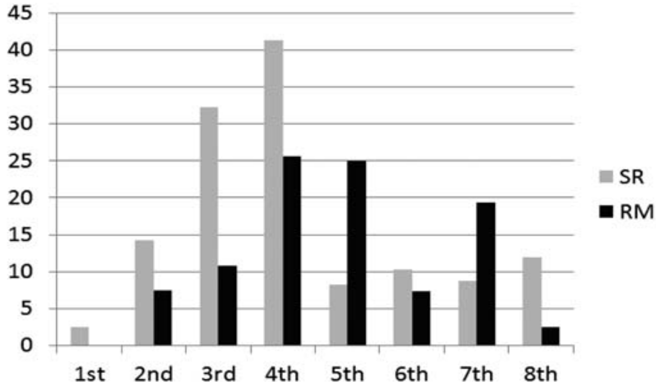


Figure 1: Harmony: % of vowel harmony out of all harmonic forms

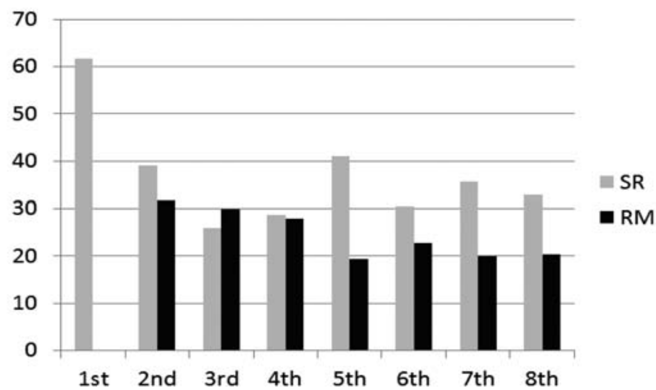


Figure 2: Selectivity: % of harmonic forms out of all disyllabic forms

During P1, RM barely produces disyllabic forms (and of course produces no harmonic forms whatsoever). Harmonic forms are attempted and produced more during P2–P4 (around 30% of all forms produced) dropping to around 20% during P5–P8, which is more or less the expected rate for Hebrew. Selectivity plays a lesser role for RM than for SR. Non-harmonic forms undergoing harmony gradually rise, peaking at P4, where 25.6% of all harmonic forms produced are the product of vowel harmony. This dips to 7.4% (5/68) in P6. RM's pattern is similar to that of SR, with both children's harmony increasing towards P4, where it peaks, and gradually dropping from P5 onwards, as figure 1 shows.

Selectivity also plays a role for both infants during the initial stages, more so for SR than for RM. More harmonic forms are attempted and produced, as both show a preference for harmonic forms (selectivity), as shown in figure 2.

3.2. *Harmony-Stress Interaction*

Vowel harmony may interact with stress (e.g. Revithiadou et al. 2006). There are two logically possible ways for harmony to interact with stress. The first, the stressed syllable may serve as the anchor of the harmony, with the unstressed vowel serving as the target of the harmony and changing accordingly. The second (unattested crosslinguistically, though logically possible), the unstressed syllable may serve as the anchor of the harmony, with the stressed vowel being targeted. When observing the data, the question is whether vowel harmony interacts at all with the word's stress pattern or not. Table 5 presents data relevant to harmony-stress interaction.

Table 5: Harmony-stress interaction (types)

	SR			**RM**		
Period	**Total VH**	**Stressed Anchors**		**Total VH**	**Stressed Anchors**	
	N	%	N	N	%	N
1	1	0	(0)	0	0	(0)
2	8	37.5	(3)	2	50	(1)
3	5	80	(4)	7	71.4	(5)
4	7	71.4	(5)	8	87.5	(7)
5	3	33.3	(1)	4	100	(4)
6	4	75	(3)	5	100	(5)
7	8	75	(6)	5	60	(3)
8	11	54.5	(6)	8	62.5	(5)

If stressed anchors are selected 50% of the time, then stressed anchors are not preferable to unstressed anchors. For SR, there seems to be no obvious correlation between stress and harmony. If there is some interaction between the two, it certainly does not develop with any consistency over the eight periods. Harmony and stress appear to interact in P3, P4, P6 and P7, where the stressed syllable serves as the anchor in most cases. However, the interaction between the two is no better than chance in P8. In P1, P2 and P5, the unstressed syllable serves as the anchor in most cases. There appears to be no systematic interaction between stress and anchor selection.

For RM, the picture is completely different. Here, the interaction between stress and harmony is clear. Initially, during P2, no preference was given to stressed anchors over unstressed anchors. However, this changed dramatically during P3, when stressed anchors were preferred, rising in P4, and peaking in P5–P6, where all anchors were stressed, gradually dropping thereafter. A certain pattern emerges here, showing a clear development in the interaction between stress and harmony in RM's acquisition.

3.3. *Harmony-Directionality Interaction*

Vowel harmony may interact with directionality (i.e. positional prominence, Kiparsky 1997, Zoll 1998, Gordon 2004, Smith 2004, Revithiadou et al. 2006 among others), with either the righthand vowel or the lefthand vowel being the anchor.

Table 6: Directionality

Right-to-left (right anchor)				**Left-to-right (left anchor)**			
Child	**Target**			**Child**	**Target**		
'hapa	'opa	'upsy daisy'	SR (P2)	'kuku	'tuki	'parrot'	SR (P2)
'hawa	'peʁax	'flower'	RM (P2)	pa'xa	pʁa'xim	'flowers'	RM (P3)
bu'buk	bak'buk	'bottle'	SR (P4)	da'jan	ba'lon	'balloon'	RM (P7)

Table 7 presents the effect directionality has on harmony.

Table 7: Harmony-directionality interaction (types)

	SR			**RM**		
Period	**Total VH**	**Righthand Anchors**		**Total VH**	**Righthand Anchors**	
	N	%	N	N	%	N
1	1	100	(1)	0	0	(0)
2	8	50	(4)	2	100	(2)
3	5	100	(5)	7	71.4	(5)
4	7	85.7	(6)	8	87.5	(7)
5	3	66.7	(2)	4	100	(4)
6	4	100	(4)	5	100	(5)
7	8	100	(8)	5	40	(2)
8	11	72.7	(8)	8	62.5	(5)

For both infants, directionality has an overwhelming effect on harmony. For SR, the anchor is on the right side in all cases in P1, P3, P6, P7, and in most cases in P4, P5 and P8. The only exception is P2, where the effect of directionality seems no better than chance. RM patterns similarly to SR. Directionality has an overwhelming effect on harmony in P2, P5, P6, with the anchor being on the right side in all cases. In P3 and P4, a righthand anchor was preferred in most cases, but after P6, the effect of directionality seems to drop to not much better than chance.

Both infants' clear preference for a righthand anchor is supported by the literature. The prominence of the right edge in acquisition is well documented (Ota 2006, Smith 1973, Ben-David 2001, Adam 2002, Dinnsen and Farris-Trimble 2008, to name a few) and could very well be playing a role here.

3.4. *Harmony-Quality Interaction*

Vowel quality may play a role in determining directionality.

Table 8: Vowel quality

	Anchor vowel				**Target vowel**			
Vowel	**Child**	**Target**			**Child**	**Target**		
i	ti'im	ta'**im**	'tasty'	RM (P4)	'ʔaθaa	kiv'sa	'sheep'	SR (P4)
u	nu'nux	lix'**lux**	'dirt'	RM (P8)	θi'θim	su'sim	'horses'	SR (P7)
e	ʔe'θen	ja'ʃen	'asleep'	SR (P8)	o'po	le'po	'to here'	RM (P5)
o	o'boj	ipa'**ʁon**	'pencil'	RM (P4)	taj'da	to'da	'thank you'	RM (P2)
a	va'ʁa	dvo'**ʁa**	'bee'	SR (P8)	tu'nun	tam'nun	'octopus'	SR (P7)

The selection of anchor could be determined on the basis of sonority (e.g. *a* > *o* > *i*; Revithiadou et al. 2006), or height and dispersion (e.g. high > mid > low; Cohen 2011). Note, as mentioned in § 3.1, SR did not produce mid-vowels during P1, and barely did so during P2. Since I argue, following Ben-David (2001), that vowel harmony is utilized by the acquirer in order to facilitate production before segmental acquisition has been completed, it is not surprising to find some effect of vowel quality on anchor selection for SR. The following table shows the correlation between various vowel qualities and harmony for anchors (0 values were deleted, maximal values in each row are shaded and in bold):

Table 9: Harmony-quality interaction: Anchors (number of types)

	SR						**RM**					
Period	**Total VH**	**a**	**u**	**i**	**e**	**o**	**Total VH**	**a**	**u**	**i**	**e**	**o**
1	1	**1**										
2	8	7	1				2	**2**				
3	5	**3**	1	1			7	1	**2**	**2**	**2**	
4	7	**3**	1	**3**			8	**3**		1	**3**	1
5	3	**2**		1			4	1			1	**2**
6	4	**2**		**2**			5		2		**3**	
7	8	2	2	**3**		1	5	**2**		1	**2**	
8	11	7	2	1	1		8	2	1	1	**4**	

For SR, during P1–3, the preferred anchor is clearly *a*. This apparent preference seems to continue throughout the eight stages, though high vowels play a considerable role from P3, with mid-vowel anchors only being selected from P7. For

RM, on the other hand, there is no clear interaction between vowel quality and anchor selection.

Recall that SR did not produce mid-vowels at all until P3, so the effect of vowel quality on anchor selection is not surprising. RM, on the other hand, produced all vowels from P1, which might explain why anchor selection is unaffected at all by vowel quality for RM. Table 10 shows the correlation between various vowel quality and harmony for targets.

Table 10: Harmony-quality interaction: Targets (number of types)

	SR						RM					
Period	**Total VH**	**a**	**u**	**i**	**e**	**o**	**Total VH**	**a**	**u**	**i**	**e**	**o**
1	1		1									
2	8		1	2	2	3	2				1	1
3	5	1		1		3	7	3		3	1	
4	7	2		1		4	8	4	1			3
5	3					3	4	1			2	1
6	4	1				3	5	5				
7	8	3	1		2	2	5	2			1	2
8	11	1	1	3	3	3	8	3		2	3	

For SR, as far as targets go, *o* is clearly a preferred target (bold) for harmony, with other vowels being targeted less frequently than *o*. For RM, mid-vowels were the only targets in P2 (in both cases, *a* is the anchor), which might indicate the preference of *a* over mid-vowels during the very early stages. This preference, however, disappears from P3 onwards, showing no clear quality-based preference similar to SR's. Since RM produces all vowels early on, this may very well restrict the role of vowel quality in anchor/target selection.

In Ben-David's (2001:272) study, the order of the vowel acquisition found for acquirers of Hebrew is roughly *a > i, u > o, e* (where a comma indicates the absence of precedence relations), a scale which coincides with SR's data. Assuming acquisition order is, inter alia, motivated by some notion of markedness, and harmony reflects this same acquisition order, it would suggest that the relevant factor affecting harmony is this notion of markedness. Dromi et al. (1993) present even a rougher markedness scale than Ben-David's, with *a, i* and *u* being produced before *o* and *e*. Based on this previous research and the current harmony data, it is possible to construct a developmental scale of sorts: *a > u > i > e > o*, which reflects the ability of the various vowels to serve as anchors. This may be a complex scale resulting from the interaction among various features such as sonority, height and dispersion. However, for simplicity's sake, I will refer to the harmony-quality interaction scale henceforth as markedness. Note that such a markedness scale is not surprising, given that it plays a role in target selection and production for SR from P1, regardless of its specific effect with respect to harmony.

3.5. *Summary and Discussion*

Generally speaking, both infants attempt and produce more harmonic forms during earlier periods, with both children peaking in P4. After P4, there is a turning point. Here, selected forms are of all types, and only newly introduced lexical items tend to harmonize, and even then, only for a brief period, before being produced faithfully. Note, all harmonic forms produced were also produced faithfully. Furthermore, all harmonizing forms are produced the same way. For example, *hipopo'tam* 'hippopotamus' would potentially allow for *to'tom* or *ta'tam*, but we only get the latter. All of this indicates that some harmony system does indeed play a role in the infants' acquisition, one which gradually diminishes as the infant becomes more faithful to the target language, which does not have vowel harmony.

The apparent inconsistencies with some of the data become considerably less problematic when the interaction among the three criteria is examined.

Recall the following observations. Stress seems to play no role for SR (we'll get back to this shortly). Directionality (right-to-left) had a considerable effect in almost all stages (P2 being the exception). Markedness also played a role, with more inconsistencies later in the development.

However, the following observations are immediately evident from SR's data. Competing factors may clash, and when they do so, markedness is only violated if both stress and directionality are satisfied. The cumulative effect of stress and directionality is the only justification for the violation of markedness. If stress and directionality do not agree with one another, then markedness is satisfied.

For SR, during P1, the only instance of harmony is determined via markedness and directionality, with the unmarked *a* serving as the anchor in the righthand, unstressed syllable. In P2, every single instance of harmony prefers the unmarked vowel, often contradicting both of the other factors, showing a clear preference for markedness over directionality and stress. In P3, the only instance in which markedness is violated is one in which stress and directionality are satisfied. In P4, there are two instances in which markedness is violated. Once again, stress and directionality are both satisfied here. This systematic behavior continues throughout all eight periods. Harmony is governed by markedness. Markedness can only be violated if both stress and directionality are satisfied. First of all, this shows that all three factors do indeed play some role, but that of markedness is more dominant. Note, there are only two instances in which markedness and stress are violated, giving preference to the directionality. The first, *'efo* → [*'ofo*] 'where' (both mid vowels) and the second *'tuki* → [*'tiki*] (both high vowels). In cases in which markedness is a clear issue (low vs. mid/high or high vs. mid), there are no exceptions to the markedness preference.

With respect to the various factors affecting harmony, markedness (*a* > *u* > *i* > *e* > *o*) and directionality (R > L) seem to play a considerable role for SR. Stress, on the other hand, seems to play a lesser role in the selection of the anchor. SR's initial productions and harmonies are strongly affected by markedness. However, once all segments have been acquired, directionality starts to play a substantial role too.

For RM, the picture is somewhat different. Similarly to SR, target harmonic forms are attempted and produced earlier on. Later, other forms are attempted, but are forced to harmonize in many cases, up until the end of P4, where there is a turning point, and the role of harmony starts to decline. Also similarly to SR, the harmonic forms produced were produced faithfully. While production is variable, with forms being produced both faithfully and with vowel harmony, harmony is not variable, and all the harmonic forms of each word are identical. There was only a single exception: the target form *'ine* 'here' was produced as *'ene* and *'ini* interchangeably. Harmony plays a systematic role, which gradually diminishes as RM becomes more faithful to adult forms.

However, RM differs from SR in the role of the various factors influencing harmony. For RM, the relevant factors are primarily prosodic (stress, directionality) rather than segmental (markedness). Stressed syllables and righthand syllables (which usually coincide in Hebrew) are preferred anchors, with no obvious influence of markedness.

This is, however, misleading. A closer examination of RM's data shows that in all cases in which the stress factor contradicted the directionality factor (i.e. where the stressed syllable does not coincide with the righthand syllable), the anchor selected was the least marked vowel *a*. Furthermore, in the cases in which the selected anchor was neither stressed nor on the right, the anchor selected was *a* and the target was a mid-vowel (most marked). This may suggest that although prosody is the most important factor for RM, in the event of a contradiction between the two prosodic factors, or in the event that the factors do not play a role, markedness kicks in, selecting *a* anchors over all others.

4. Towards a Formal Analysis

In this section, I incorporate the above generalizations into a formal grammar of vowel harmony within Optimality Theory (Prince and Smolensky 1993/2004). My analysis is within an Optimal Domains Theoretical approach (ODT, Cole and Kisseberth 1994, Cassimjee and Kisseberth 1999). Since the infants exhibit different behaviors with respect to the effect of the relevant factors on vowel harmony, they should have different developmental grammars. As I will show in the remainder of this section, the two infants do have different developmental grammars, but the differences are the result of different rankings of the same constraints.

4.1. *Setting Up the Harmonic Domain*

Harmony is a requirement for a feature *F* to be realized on all sponsors within a domain *D*. How harmony is realized is a result of the interaction among constraints on the structure of domains and constraints on the realization of *F*.

For features to be realized, they have to be within a domain. Domain construction is achieved via alignment constraints, which designate the domain's edges.

(1) Align (Anchor, L/R; F-Domain, L/R) (Cole and Kisseberth 1994)
The anchor of a feature is aligned with the domain's L/R edge

This constraint, consisting of two members (one for each edge), sets up the left and right edges of the domain. In a situation in which there is no harmony, for example in the adult grammar of Hebrew, the left and right edges of the domain are aligned with the left and right edges of the segment, and every feature is realized on its underlying anchor. The alignment constraints militate against vowel harmony.

However, if, due to constraint interaction, one of the domain's edges shifts, then a feature may be realized over a larger span than a single segment, and the domain expands. One type of constraint which could trigger the domain's expansion sets a lower limit on the domain's size. Alternatively, the requirement could be for a bimoraic domain, such as a foot (Halle and Vergnaud 1987, Harris and Lindsey 1995, van der Hulst and van der Weijer 1995, McCarthy 2004 and more). For simplicity's sake and due to a lack of evidence preferring one analysis over the other, I adopt the following constraint requiring domains to be larger than monosyllables. Effectively, this is equivalent to constructing a bimoraic domain while assuming constraint violation is minimal (economy, do only what is necessary; Prince and Smolensky 1993/2004):

(2) *MonoD (Cassimjee and Kisseberth 1999)
Domains cannot be monosyllabic

On the one hand, features would like to align themselves with their anchors. On the other hand, there are both articulatory and perceptual motivations for features to spread beyond the boundaries of their anchors. If the constraint forcing domains to be larger than a single syllable outranks those setting up the domain edges, then harmony can occur. The (in)ability of domains to spread onto neighboring vowels is controlled by the interaction between the alignment constraints and the constraint militating against monosyllabic domains. In a non-harmony grammar (e.g. adult Hebrew), the ranking is ALIGNL/ALIGNR >> *MONOD, and no harmony occurs. In a harmony grammar (e.g. the grammar of SR and RM during P4), *MONOD is ranked above one (or both) alignment constraints, forcing the violation of the lowest ranked alignment constraint and the expansion of the domain.

However, it is insufficient to construct domains in order for harmony to occur. We have to ensure that the harmonic features are realized on all sponsors (i.e. vowels) within a domain.

(3) REALISEF (similar to Cole and Kisseberth's (1994) EXPRESS)
Underlying features must be realized within their domain

This constraint ensures that features are realized on all sponsors within the anchor's domain. Since consonants are not potential sponsors of the vowel features, they vacuously satisfy REALISEF.

Of course, realizing the underlying features of one vowel within a bimoraic domain would cause the other vowel within the domain *not* to have its features realized. Assuming domains must be bimoraic (otherwise harmony would not occur), how do we determine which vowel is the one to expand its domain, and which vowel, in effect, "sacrifices" its underlying features? Otherwise phrased, what are the factors determining the relative faithfulness of vowels to their underlying features in instances of harmony? Three such factors are those discussed earlier, namely stress, directionality and markedness. The interaction among the domain construction and feature realization with these three factors is discussed in § 4.2 (stress), § 4.3 (directionality) and § 4.4 (markedness).

4.2. *Harmony and Stress*

The interaction of harmony and stress is a result of constraints requiring the stressed vowel to be more faithful to its underlying features than other vowels (Steriade 2001/2008, Kenstowicz 2007 and more):

(4) a. IDENTF(STRV)
Stressed vowels are faithful to their underlying features
b. IDENTF(V)
Vowels (in general) are faithful to their underlying features

These constraints interact with one another. All other things being equal, stressed vowels are more faithful than unstressed vowels, implying the fixed ranking: IDENTF(STRV) >> IDENTF(V). Since all cases of harmony require the violation of IDENTF(V), my analyses only refer to IDENTF(STRV).

4.3. *Harmony and Directionality*

An additional characteristic of vowel harmony is that it typically operates in a certain direction (leftward or rightward). The direction of the spreading is controlled by the relative ranking of two alignment constraints, AlignL and AlignR, which determine the "default" directional preference. For example, if AlignR >> AlignL, then domains will tend to spread leftwards in order to satisfy *MonoD.[4]

4.4. *Harmony and Markedness*

Generally speaking, grammars prefer to realize unmarked underlying segments more so than marked underlying segments, when given the choice. Assuming the expansion of the domain to satisfy *MonoD, when deciding whether to select a marked or unmarked anchor, all other things being equal, grammars would go with the unmarked anchor. A markedness scale (such as the one suggested in § 3.4) is reflected in the following constraint ranking:

(5) Markedness
*o >> *e >> *i >> *u >> *a

Henceforth, I do not refer to the whole scale. Rather, I use the constraint Markedness, a violation of which would indicate the selection of a more marked anchor in a given situation. This constraint would naturally compete with IdentF(V). However, if due to harmony, one of the vowels has to sacrifice its features, it would be the more marked vowel.

5. The Developmental Path of a Harmony Grammar

5.1. *SR's Grammatical Development*

Recall the relevant generalizations from the development of SR's harmony (§ 3). The three factors interact in the following ways. Stress appears to be irrelevant with respect to determining the anchor of the harmony (hold this thought). Directionality, on the other hand, has an overwhelming effect, with the preferred anchor being on the right side. In all but two cases, when directionality and stress clash, directionality wins. The only two exceptions are cases in which markedness and directionality also clash, and then markedness wins (giving the "appearance" of stress winning). This would imply, at the very least, that AlignR, which

[4] Of course, if AlignL>>*MonoD and AlignR>>*MonoD, then there is no harmony at all.

requires anchors to be on the right is ranked higher than IDENTF(STRV), which requires the anchors to be stressed, as demonstrated in the following tableau (note, henceforth, deletion and consonant quality are ignored).

(6) SR's P1: *ta'puax* 'apple'

ta'puax	ALIGNR	IDENTF(STRV)
☞ 'baax		*
'buux	*!	

How do these factors interact with markedness? In SR's data, the preferred anchors (in descending order) are *a* > *u* > *i* > *e* > *o*, which is evident in all eight stages, and is reflected in the MARKEDNESS hierarchy **o* >> **e* >> **i* >> **u* >> **a*.

(7) SR's P4: *sevi'von* 'spinning top'

sevi'von	MARK(*o>>*i)	ALIGNR
☞ vi'vim		*
vo'vom	*!	

However, the interaction between MARKEDNESS and ALIGNR is, in fact, more complex. There are occasions in which directionality wins (assuming that the ranking of the markedness constraints is fixed). In the following tableau, ☛ indicates the candidate which is selected by the (incorrect) grammar, while ☹ indicates the candidate which was actually produced:

(8) SR's P3: *bak'buk* 'bottle' (first attempt)

bak'buk	MARK(*u>>*a)	ALIGNR
☛ ba'bak		*
☹ bu'buk	*!	

In all such cases, i.e. cases in which MARKEDNESS and ALIGNR clash and in which ALIGNR wins, MARKEDNESS also clashes with IDENTF(STRV). This suggests that the combined effect of ALIGNR and IDENTF(STRV) may be greater than that of MARKEDNESS. MARKEDNESS is violated only if *both* stress *and* directionality are satisfied. The cumulative effect of stress and directionality is the only justification for the violation of markedness. This could be achieved formally via two different mechanisms, constraint weighting (Pater 2009, Smolensky and Legendre 2006, Prince and Smolensky 1993/2004: 236) or constraint conjunction (Kirchner 1996, Moreton and Smolensky 2002). Without advocating either approach, I demonstrate this interaction via constraint conjunction (see also Karni this volume):

(9) SR's P3: *bak'buk* 'bottle' (second attempt)

bak'buk	ALIGNR&IDENTF	MARK(*u>>*a)	ALIGNR	IDENTF(STRV)
ba'bak	*!		*	*
☞ bu'buk		*		

The conjoined constraint ALIGNR&IDENTF is the highest ranked constraint, and is only violated if both ALIGNR and IDENTF(STRV) are violated, giving the cumulative effect necessary. This shows that all three factors, including stress, do indeed play some role, but that of markedness is more dominant.

The ranking of the constraints militating against vowel harmony gradually overtakes that of the highest ranked constraints militating for vowel harmony as the language pattern—i.e. no harmony—takes force.

5.2. *RM's Grammatical Development*

SR and RM display different vowel harmony patterns during the various stages of their phonological development and the three relevant factors discussed (markedness, directionality, and stress). These different behaviors, therefore, should be reflected in different constraint rankings, i.e. different harmony grammars.

Recall the generalizations regarding RM's data (§ 3). The factors influencing harmony for RM are primarily prosodic (stress and directionality) rather than segmental (markedness). Stressed syllables and righthand syllables, which usually coincide in Hebrew, are preferred anchors. A closer examination of the role of markedness shows that in *all* cases in which stress contradicts directionality (i.e. the stressed syllable does not coincide with the righthand syllable), the anchor selected was the least marked vowel *a*. Furthermore, in the cases in which the selected anchor was neither stressed nor on the right, the anchor selected was *a* (least marked) and the target was a mid-vowel (most marked).

Such an interaction would suggest that the constraint ranking for RM differs from that of SR. ALIGNR and IDENTF(STRV) outrank MARKEDNESS, however, the combined effect of MARKEDNESS with either of the other two constraints outweighs the effect of any single constraint:

(10) RM's P2: *'peʁax* 'flower'

'peʁax	ALIGNR&MARK(*e>>*a)	IDENTF(STRV)	ALIGNR	MARKEDNESS
☞ 'hawa		*		
'hewe	*!		*	*

5.3. *Variation*

In adult Hebrew, there is no productive harmony system. Therefore, ALIGNR/L, the constraints militating against harmony, outrank *MONOD, the constraint forcing harmony. For SR and RM, it is clear that *MONOD is ranked higher than at least one of the alignment constraints. Although this would explain why harmony takes place with SR and RM, it would fail to explain why harmony does not take place in all cases, but rather only in some cases, albeit considerably more than the language's general patterning of harmonic forms. Furthermore, as mentioned in § 3.5, all cases of harmonizing forms are also produced faithfully, i.e. without harmony.

In a system in which constraints are strictly ranked, such variation is impossible. Variation would require the fluctuation in the ranking of *MONOD, which would vary in any given evaluation. This could be achieved via stochastic OT (Boersma 1997), a noisy harmonic grammar (Boersma and Pater 2008) or suchlike. This discussion is beyond the scope of this paper. Suffice it to say that the strict ranking presented in § 4 reflects the general tendencies of the infants' grammars, and some mechanism of variation is necessary to cover the exceptional behaviors.

6. Discussion and Conclusions

The developmental paths of SR and RM shed light on the mechanism of the acquisition of the ambient language's grammar. The children start out at roughly the same point (the initial stage). While this point is universally conditioned, the ultimate goal is determined by the ambient language's grammar. The developmental path, however, is individual, with each infant pursuing a different route until reaching the final goal, the adult system.

Hebrew does not have productive harmony, yet the infants acquiring the language show a distinct preference for harmonic forms from the beginning of acquisition (selectivity). This suggests that harmonic forms are universally preferred. The infants then form some harmonic grammar in order to deal with disharmonic forms. However, the grammars they form differ from infant to infant as a result of the differing rates of prosodic and segmental development. SR, whose segmental development was slower than RM's, ranked constraints requiring unmarked vowels higher in his system than RM did, amplifying the role of markedness in SR's grammar. On the other hand, SR's prosodic development was rapider than RM's. Therefore, prosodically motivated preferences (the preference for the righthand syllable and the preference for the stressed syllable) play a lesser role for SR than they do for RM.

The infants' harmony grammars are universally motivated, however, they stand in contradiction to the adult grammar in which there is no harmony. Therefore, they constantly adjust the grammars, eventually reaching the goal (AlignR/L >> *MonoD), but doing so along different developmental paths.

References

Adam, Galit. 2002. *From Variable to Optimal Grammar: Evidence from Language Acquisition and Language Change*. Ph.D. dissertation, Tel-Aviv University, Tel-Aviv.

Adam, Galit and Outi Bat-El. 2008. The trochaic bias is universal: Evidence from Hebrew. In A. Gavarró and M. Freitas (eds), *Language Acquisition and Development: Proceedings of GALA 2007*, 12–24. Newcastle: Cambridge Scholars Publishing.

Adam, Galit and Outi Bat-El. 2009. When do universal preferences emerge in language development? The acquisition of Hebrew stress. *Brill's Annual of Afroasiatic Languages and Linguistics* 1:1–28.

Altan, Asli. 2007. The acquisition of vowel harmony in Turkish. Paper presented at the OCP4, University of the Aegean.

Bat-El, Outi. 1989. *Phonology and Word Structure in Modern Hebrew*. Ph.D. dissertation, University of California, Los Angeles.

Bat-El, Outi. 2000. The grammaticality of "extragrammatical" morphology. In U. Doleschal and A. Thornton (eds) *Extragrammatical and Marginal Morphology*, 61–84. Munich: Lincom Europa.

Bat-El, Outi. this volume. Phonological constraints on morphological development: The acquisition of Hebrew verb inflectional suffixes.

Becker, Michael. 2009. *Phonological Trends in the Lexicon: The Role of Constraints*. Ph.D. dissertation, University of Massachusetts, Amherst.

Becker, Michael. this volume. Target selection in error selective learning

Ben-David, Avivit. 2001. *Language acquisition and phonological theory: Universal and variable processes across children and across languages*. Ph.D. dissertation, Tel-Aviv University, Tel-Aviv [in Hebrew].

Ben-David, Avivit. This volume. The development of prosodic structure: Evidence from typical longitudinal data

Berent, Iris, Tracy Lennertz, Paul Smolensky, Vered Vaknin-Nusbaum. 2009. Listeners' knowledge of phonological universals: Evidence from nasal clusters. *Phonology* 26:75–108.

Boersma, Paul. 1997. How we learn variation, optionality, and probability. *Proceedings of the Institute of Phonetic Sciences of the University of Amsterdam* 21:45–86.

Boersma, Paul and Joe Pater. 2008. Convergence properties of a gradual learning algorithm for Harmonic Grammar. Ms., University of Amsterdam and UMass Amherst. Available at http://roa.rutgers.edu/.

Bolozky, Shmuel. 1995. The segolates—linear or discontinuous derivation? In O. Schwarzwald and Y. Schlesinger (eds) *Hadassah Kantor Jubilee Book*, 17–26. Ramat Gan: Bar-Ilan University (in Hebrew).

Bolozky, Shmuel and Michael Becker. 2006. Living lexicon of Hebrew nouns. Ms., University of Massachusetts Amherst. Available at http://becker.phonologist.org/LLHN.

Cassimjee, Farida and Charles Kisseberth. 1999. A conspiracy argument for Optimality Theory: Emakhuwa Dialectology. In J. Alexander, N-R. Han and M. Fox (eds) *Proceedings of the 23rd Penn Linguistics Colloquium* 6:81–96.

Cohen, Evan-Gary. 2010. *The role of similarity in phonology: Evidence from loanword adaptation in Hebrew*. Ph.D. dissertation, Tel-Aviv University, Tel-Aviv.

Cohen, Evan-Gary. 2011. The Emergence of UG in the periphery: Vowel harmony in Hebrew loanwords. *Proceedings of the 26th meeting of the Israeli Association for Theoretical Linguistics*. http://linguistics.huji.ac.il/IATL/26/Cohen.pdf/

Cole, Jennifer and Charles Kisseberth. 1994. An Optimal Domains theory of harmony. *Studies in the Linguistic Sciences* 24:1–13.

Dinnsen, Daniel and Ashley Farris-Trimble. 2008. The prominence paradox. In D. Dinnsen and J. Gierut (eds) *Optimality Theory, Phonological Acquisition and Disorders*, 277–308. London: Equinox.

Drachman, Baberell. 1973. Generative phonology and child language acquisition. *Ohio State University Working Papers in Linguistics* 15:146–159.

Dromi, Esther, Tova Most and Na'ama Yehuda. 1993. The case of homonymy in early lexical development: Interactional and acoustical analyses. Paper presented at the 6th International Congress for the Study of Child Language, Trieste, Italy.

Ferguson, Charles, David Peizer and Thelma Weeks. 1973. Model-and-replica phonological grammar of a child's first words. *Lingua* 31:35–65.

Gordon, Matthew. 2004. Positional weight constraints in Optimality Theory. *Linguistic Inquiry* 35:692–703.

Halle, Morris and Jean-Roger Vergnaud. 1987. *An Essay on Stress*. Cambridge, MA: MIT Press.

Harris, John and Geoff Lindsey. 1995. The elements of phonological representation. In J. Durand and F. Katamba (eds), *Frontiers of phonology: Atoms, structures, derivations*, 34–79. London and New York: Longman.

Hulst, Harry, van der, and Jeroen van de Weijer. 1995. Vowel harmony. In J. Goldsmith (ed.) *The Handbook of Phonological Theory*, 495–534. Oxford: Basil Blackwell.

Karni, Noa. this volume. Minimizing faithfulness violation in the acquisition of Hebrew onsets.

Kawahara, Shigeto. 2007. Copying and spreading in phonological theory: Evidence from echo epenthesis. *University of Massachusetts Occasional Papers in Linguistics 32: Papers in Optimality III*. 111–143. Amherst: GLSA.

Kenstowicz, Michael. 2004. The role of perception in loanword phonology. *Linguistique Africaine* 20; *Studies in African Linguistics* 32:95–112.

Kenstowicz, Michael. 2007. Salience and similarity in loanword adaptation: a case study from Fijian. *Language Sciences* 29:316–340.

Kiparsky, Paul. 1997. The rise of positional licensing. In A. van Kemenade and N. Vincent (eds), *Parameters of Morphosyntactic Change*, 460–494. Cambridge: Cambridge University Press.

Kirchner, Robert. 1996. Synchronic chain shifts in Optimality Theory. *Linguistic Inquiry* 27:341–350.

Kitto, Catherine and Paul de Lacy. 1999. Correspondence and epenthetic quality. In Carolyn Smallwood and Catherine Kitto (eds.) *Proceedings of ALFA VI: The Sixth Meeting of the Austronesian Formal Linguistics Association*, 181–200. Toronto: University of Toronto Press.

Leiwo, Matti, Pirjo Kulju, and Katsura Aoyama. 2006. The acquisition of Finnish vowel harmony. In Anu Airola, Antti Arppe, Orvokki Heinämäki, Matti Miestamo, Kaius Sinnemäki, Urho Määttä, Jussi Niemi, Kari Pitkänen and Mickael Suominen (eds.) *A man of measure: Festschrift in the honour of Fred Karlsson on his 60th birthday*, 149–161. Special supplement to the SKY Journal of Linguistics 19.

Lustigman, Lyle. 2007. Selectivity in early child grammar: The case of Hebrew verb morphology. MA thesis, Tel-Aviv University, Tel-Aviv.

McCarthy, John. 1994. The phonetics and phonology of Semitic pharyngeals. *Linguistics Department Faculty Publication Series*. Paper 86. http://scholarworks.umass.edu/linguist_faculty_pubs/86.

McCarthy, John. 2004. Headed spans and autosegmental spreading. Unpublished manuscript, University of Massachusetts, Amherst.

McCarthy, John and Alan Prince. 1994. The emergence of the unmarked: Optimality in prosodic morphology. *Proceedings of the Northeast Linguistics Society* 24:333–379.

Mintz, Tobi and Rachel Walker. 2006. Infants' sensitivity to vowel harmony and its role in word segmentation. Paper presented at the annual meeting of the Linguistic Society of America, Albuquerque, New Mexico, 5–8 January.

Moreton, Elliott and Paul Smolensky. 2002. Typological Consequences of Local Constraint Conjunction. *WCCFL 21*. Cambridge, MA: Cascadilla Press. [ROA-525]

Ota, Mitsuhiko. 2006. Input frequency and word truncation in child Japanese: Structural and lexical effects. *Language and Speech* 49:261–295.

Pater, Joe 2009. Weighted constraints in generative linguistics. *Cognitive Science* 33:999–1035.

Prince, Alan and Paul Smolensky. 1993/2004. *Optimality Theory: Constraint interaction in generative grammar*. Oxford, Basil Blackwell. [Also TR 2, Rutgers University Cognitive Science Center].

Revithiadou, Anthi, Marc Van Oostendorp, Kalomoira Nikolou and Maria-Anna Tiliopoulou. 2006. Vowel harmony in contact-induced systems: The case of Cappadocian and Silly. In Mark Janse, Brian Joseph and Angela Ralli (eds.), *Proceedings of the 2nd International Conference on Modern Greek Dialects and Linguistic Theory*, 350–365. University of Patras, Patras.

Rose, Yvan. 2000. *Headedness and prosodic licensing in the L1 acquisition of phonology*. Doctoral dissertation, McGill University, Montréal.

Schwartz, Richard and Laurence Leonard. 1982. Do children pick and choose? An examination of phonological selection and avoidance in early lexical acquisition. *Journal of Child Language* 9:319–336.

Schwartz, Richard, Laurence Leonard, Diane Frome Loeb and Lori Swanson. 1987. Attempted sounds are sometimes not: An expanded view of phonological selection and avoidance. *Journal of Child Language* 14:411–418.

Shinohara, Shigeko. 2004. Emergence of Universal Grammar in foreign word adaptations. In Rene Kager, Joe Pater and Wim Zonneveld (eds.) *Constraints in phonological acquisition*, 292–320. Cambridge: Cambridge University Press.

Smith, Neilson. 1973. *The acquisition of phonology: A Case Study*. Cambridge: Cambridge University Press.

Smith, Jennifer. 2004. Making constraints positional: Toward a compositional model of CON. *Lingua* 14(12):1433–1464.

Smolensky, P. and Legendre, G. (2006). *The harmonic mind: From neural computation to Optimality-Theoretic grammar*. MIT Press, Cambridge, MA.

Steriade, Donca. 2001/2008. The phonology of perceptibility effects: The P-map and its consequences for constraint organisation. In Kristin Hanson and Sharon Inkelas (eds.) *The nature of the word*, 151–179. Cambridge: MIT Press.

Stoel-Gammon, Carol and Judith Cooper. 1984. Patterns of early lexical and phonological development. *Journal of Child Language* 11:247–271.

Zoll, Cheryl. 1998. Positional asymmetries and licensing. Ms., MIT, Cambridge, MA. Available on Rutgers Optimality Archive, ROA 282, http://roa.rutgers.edu.

BAALL
BRILL Brill's Annual of Afroasiatic Languages and Linguistics 4 (2012) 30–54 brill.com/baall

Child Consonant Harmony: Identification and Properties

Chen Gafni
Department of Linguistics, Tel-Aviv University
chen.gafni@gmail.com

Abstract
The study investigates the status of Consonant Harmony in the process of language acquisition, based on longitudinal data of two typically developing children acquiring Hebrew. The analysis indicates that Consonant Harmony is motivated mainly by prosodic factors; the directionality of assimilation between identical positions (e.g. onset-onset) is usually correlated with the direction of prosodic development—from old to new (i.e. from right to left). In addition, segmental (or phonotactic) factors may also play a role—for one child Consonant Harmony is used mainly to reduce the sonority of the target. On the other hand, the analysis does not support previous claims that Consonant Harmony involving place of articulation is governed by a markedness trigger-target hierarchy. I propose that a trigger-target hierarchy (if such exists) depends much on input frequency and individual factors.
In addition to examining the motivation behind Consonant Harmony, I propose in this study a statistically based method to separate unambiguous Consonant Harmony from potential context-free substitutions (e.g. velar fronting). With this method, I show that a large part of the harmonized words produced by the children can be attributed to context-free substitutions, and thus suggest that Consonant Harmony may not be as common as previously assumed.
The findings of the present study are affected to some extent by inter-subject variation. The two children exhibited differences both in the use of Consonant Harmony (abundance, duration, etc.) and in general language development (segmental, prosodic and lexical). These findings, other than being indicative of individuality in language acquisition, limit the extent to which general conclusions can be made.

Keywords
consonant harmony/assimilation; language acquisition; inter-child variation; Hebrew

1. Introduction

Consonant Harmony (hereinafter, CH) is defined as assimilation between non-adjacent consonants (e.g. Cruttenden 1978), as in English *dɔg* → [*gɔg*] 'dog' or Hebrew *panas* → [*nanas*] 'flashlight'. It is relatively rare in adult languages (Hansson 2001), and there are no known languages with harmony involving primary

 DOI: 10.1163/18776930-00400002

place of articulation (Pater and Werle 2003).[1] In contrast, CH has been widely reported in the speech of children acquiring various languages; a partial list includes (see a review in Gafni 2012): English (Lewis 1936/1951), Dutch (Levelt 1994), German (Berg 1992), French (Rose 2000), Italian (Keren-Portnoy et al. 2009), Spanish (Macken 1978), Greek (Tzakosta 2007), Estonian (Vihman 1978) and Hebrew (Ben-David 2001). In addition to the abundance in child CH cross-linguistically, it has been found that harmony involving primary place of articulation is the most common type of child CH (Berg 1992, Goad 1997, Pater 1997).

The seeming universality of CH in child language and the apparent differences between child and adult CH have made child CH the topic of many studies. Some of the research questions addressed in the literature relate to the source of CH, its phonological characteristics, and its status in the course of acquisition. These questions and related studies will be discussed in the next section.

In the present study, I examine CH in the acquisition of Hebrew, focusing on its interaction with segmental and prosodic development. The results indicate that CH is motivated mostly by prosodic factors, though segmental (or phonotactic) factors may also have some influence. Place harmony does not seem to be governed by markedness hierarchies, but rather by input frequencies. On the other hand, manner harmony can be used by some children to deal with difficult segments (sonorants) or sequences. Directionality of assimilation between identical prosodic positions (e.g. onset-onset) seems to be correlated with the order of acquisition, namely that the prosodic word is acquired from right to left and newly acquired positions are assimilated to well-established ones. On the other hand, directionality of assimilation between onset and coda is less consistent with the order of acquisition.

Another issue addressed by the present study is the separation of true consonant-consonant assimilation from other context-free substitutions, an often undertreated issue. Applying a statistically-based method to the examined corpora reveals that a good many harmonic productions can be attributed to context-free assimilation and this may suggest that the abundance of CH in child language has been previously overrated.

---

1) Hansson (2001) provides a list of about 100 languages and dialects (including a few extinct ones) that have some form of CH (some have more than one type). He does not specify the number of languages examined in total but claims that the survey was extensive. If these data represent all existing cases of CH then only about 2% of the world's languages (6909 according to Lewis 2009) have CH. In any event, the claim of the present study is that child CH is substantially different from adult's CH so the exact abundance of adult's CH is not crucial.

One remarkable observation made in the present study is inter-child variation. The participants in the study differed from one another in several aspects: rate of development, extent of use of CH (and other processes), order of prosodic acquisition, etc. These differences highlight the individuality factor in the course of acquisition but also limit the possibility of reaching large-scale generalizations.

2. Literature Review

The fact that children harmonize words which are non-harmonic in the ambient language naturally brings up the question—why? The literature contains different proposals for the source of CH. These hypotheses depend much on the data available to the authors and on the theoretical framework they adopt. The latter was often a key factor in previous reviews of the phenomenon—studies were contrasted based on the formal treatment they proposed for CH, which often masked similar views of its cognitive source. This review attempts to bring previous studies to a common ground by "hiding" differences that stem from the choice of theoretical framework and adopting a functionalist point of view.

2.1. *The Source of Consonant Harmony*

CH has been proposed to be a type of simplification mechanism, which helps the child in handling the language acquisition task, by reducing the number of articulatory gestures (e.g. Waterson 1978, Klein 1981). Three main possible sources for CH have been suggested (see Gafni 2012 for a broader discussion): segmental, phonotactic and prosodic. Vihman (1978) and Berg (1992) propose that CH may stem from a segmental source, i.e. that it is used for substituting consonants that the child has not mastered yet. This claim is also raised in Leonard et al. (1980) with respect to CH in children with language disorders.

Many studies relate CH to phonotactic demands (though, not always as explicitly as suggested here), which can be either combinatorial or non-combinatorial. Combinatorial limitations mean that the child generally prefers harmonic over disharmonic productions or avoids the co-occurrence of certain feature sequences, such as [Coronal ... Labial] sequences (Menn 1983, Donahue 1986, Matthei 1989, Pater 1997, Bernhardt and Stemberger 1998, Pater and Werle 2001, Pater and Werle 2003, Vihman and Croft 2007, Gerlach 2010, Becker and Tessier 2011). Another type of combinatorial phonotactic account proposes that apparent cases of CH may in fact result from assimilation of a consonant to the adjacent vowel, for example, when the target word contains a front vowel only coronal consonants can be realized (Levelt 1994, Gafos 1999, Fikkert and Levelt 2008).

Non-combinatorial limitations refer to the preference to license (or align) certain features by certain prosodic positions (Goad 1997, Rose 2000, Kappa 2001, Goad 2001, Goad 2004, Fikkert and Levelt 2008, Qu 2011) or the tendency to avoid certain features in certain prosodic positions (Berg 1992). For example, Goad (1997) attributes the predominant dorsal harmony in child's English to a demand for word-initial dorsal. Note that CH stemming from non-combinatorial limitations is actually not a pure consonant-consonant interaction, but rather an "epiphenomenon" of more general licensing demands.

Finally, CH may be related to the development of prosody, where it simplifies the articulation to help the child focus on new prosodic positions or deal with long words (Vihman 1978, Keren-Portnoy et al. 2009). This is what Ben-David (2001) and Bat-El (2009) propose in their studies of CH in Hebrew. They observe a synchronism between CH and the development of prosody, where syllables in polysyllabic words are acquired from right to left, and onsets of newly acquired syllables are more likely to assimilate to onsets of more established syllables. Ben-David (2001) also refers to the interaction between CH and stress, noting that the first onset of disyllabic words is acquired (and assimilated) earlier when stress is penultimate while still omitted when the stress is ultimate. For example, in an early stage the child might utter *ˈsaba* 'grandpa' as [*ˈbaba*] but *saˈpa* 'sofa' as [*aˈpa*]. According to Bat-El (2009), the decrease in segmental faithfulness accompanying the expansion of the prosodic word reflects a "trade-off" effect whereby children simplify already acquired structures when they start producing new ones (Garnica and Edwards 1977, Donahue 1986, Berg and Schade 2000).

2.2. *Properties of Consonant Harmony*

Most studies have concentrated on the properties of CH and the interaction among them, in particular the consonants (features) participating in the process and directionality (see Gafni 2012 for other parameters).[2] Assessment of these parameters may shed light on the source of CH.

2.2.1. The Consonants

Much attention has been devoted to the properties of the consonants involved in CH—the *trigger* consonant (the one carrying the features that are "borrowed" in the process), and the *target* consonant (the affected consonant). Studies focusing on this aspect often argue that there is a certain hierarchy between triggers and

2) Here and everywhere else I use the term *process* in a descriptive way to refer to the change between the assumed target form and the child's production. I do not address the question of whether an actual phonological process is taking place as hypothesized in derivational theories.

targets, which may be universal, language-specific or partially both. Three main factors have been proposed to account for such hierarchies: (a) order of acquisition, (b) universal *markedness* (or *specification)* scales, and (c) language-specific input frequency or feature distributions. These proposals are often in conflict with one another and authors often provide counter evidence against each.

Lewis (1936/1951) proposes that the order of acquisition determines the hierarchy—late acquired segments are assimilated to well-established ones. This claim is contradicted by Cruttenden (1978) and Stoel-Gammon and Stemberger (1994). A more popular approach suggests that the strength hierarchy reflects universal markedness, i.e. that CH replaces unmarked (or underspecified) segments with marked (specified) ones. This proposal is based mostly on studies on English, where typically coronals are assimilated to labials and dorsals (Menn 1975, Cruttenden 1978, Stemberger and Stoel-Gammon 1991, Stoel-Gammon and Stemberger 1994, Pater and Werle 2003, Goad 2004 among others). However, this approach has it shortcomings as well. First, it has been shown that coronals can also trigger CH (Goad 1997, Pater and Werle 2003, Becker and Tessier 2011). Second, the relative strength of dorsals and labials is not agreed upon (e.g. Cruttenden 1978 vs. Pater and Werle 2003).

Cross-linguistic comparison of CH has led to the proposal that the strength trigger-target hierarchy is also affected, at least to some extent, by language-specific properties. Fikkert et al. (2002) note that in Dutch, unlike in English, labial harmony is far more common than dorsal harmony. They attribute this distinction to difference in place distributions between the ambient languages. Similarly, Berg (1992) accounts for the predominance of labial harmony in German-acquiring child by the high frequency of words containing labials in critical positions in her lexicon. Tzakosta (2007) reports that CH in Greek is triggered mostly by unmarked segments (i.e. coronals and stops) due to their high frequency in the language. Finally, Rose (2000) reports on a French-acquiring child that has the following strength hierarchy: labial > coronal > dorsal. The status difference of coronals between English and French leads him to propose that CH is not governed by a universal trigger-target hierarchy.

2.2.2. Directionality

The directionality of assimilation is perhaps the only parameter that gives cross-linguistic consistent results. CH is said to be *progressive* (left-to-right, or *perseveratory*) if the trigger precedes the target (e.g. *kæt* → [*kæg*] 'cat'), and *regressive* (right-to-left, or *anticipatory*) if the trigger follows the target (e.g. *dɔg* → [*gɔg*] 'dog'). All studies examining assimilation directionality report that regressive harmony is dominant compared to progressive harmony (Cruttenden 1978, Vihman 1978, Berg 1992, Pater 1997, Ben-David 2001, Tzakosta 2007).

This seeming universality of directionality has been attributed to different factors. Some studies attribute directionality to phonotactics; i.e. the child replaces segments in specific positions in order to avoid certain sequences or to assign specific features to specific prosodic positions (Stemberger and Bernhardt 1997, Bernhardt and Stemberger 1998, Rose 2000, Pater and Werle 2003, Goad 2001, Goad 2004, Gerlach 2010). For example, Pater and Werle (2003) account for the predominant regressive dorsal harmony in Trevor's data as the result of avoiding sequences of [no dorsal … dorsal]. Tzakosta (2007) claims that directionality does not result from segmental considerations in general, but cases of progressive harmony usually involve the replacement of marked segments. To sum, under phonotactic accounts, directionality is merely a consequence of limitations on utterance content.

Directionality can also be a consequence of prosodic limitations. Berg (1992) claims that CH in a German-acquiring child is mostly regressive "since she is comfortable with medial loci but initial loci are problematic for her" (p. 232). In terms of processing, Berg claims that the predominance of regressive harmony indicates *parallel processing*, i.e. that segments to come later in the word are planned simultaneously with those that come earlier. Similarly, according to Ben-David (2001), regressive harmony is the result of prosodic development, which starts at the right edge of the word and advances leftwards with newly acquired positions being assimilated to well-established ones. Kappa (2001) reports that directionality of CH in Greek is related to stress, namely, that consonants in unstressed syllables are more likely to assimilate to consonants in stressed syllables than vice versa (see also Bernhardt and Stemberger 1998, Ben-David 2001).

2.3. *Consonant Harmony in the Scope of Language Development*

CH is only one of many phonological processes attested in child's speech which is rare or completely absent from the ambient language. These processes (see Grunwell 1982/1984) include *consonant deletion* (e.g. *dʒuːs* → [*du*] 'juice'), *fricative stopping* (*feɪs* → [*peɪt*] 'face'), *velar fronting* (*bæk* → [*bæt*] 'back') and *reduplication* (*pʊdiŋ* → [*pʊpʊ*] 'pudding') among others.

Reduplication is of special interest to the study of CH since many productions are ambiguous in terms of CH or reduplication, as reduplication can be viewed as a combination of (full) CH and vowel harmony (Ferguson et al. 1973, Smith 1973, Leonard et al. 1980); e.g. *wɪndoʊ* → [*nono*] 'window'. In this study I will consider all instances of fully harmonized consonants as instances of CH and not reduplication.

In this context, it would be natural to ask what the relation between CH and other phenomena is. CH is claimed to replace or to be used in parallel to other strategies such as lexical selection, deletion and debuccalization, all "conspiring" to simplify the utterance. For example, Menn (1983) claims that a child may use CH or delete a segment in order to avoid disharmonic sequences (e.g. *dɔg* → [*gɔg*] 'dog' vs. geɪt → [*gej*] 'gate'). According to Berg and Schade (2000) and Ben-David (2001), CH is used in newly acquired prosodic structures which exhibited deletion on earlier stages. Vihman (1978) proposes that CH is a successor strategy to lexical selection—both are used to avoid words with difficult segments.

The relation between CH and other substitution (or feature changing) processes is extremely important to the present study. As is often the case, consonant substitution (e.g. stopping, fronting) resulting in a harmonic form can be described as either assimilatory or non-assimilatory substitution. Tzakosta (2007) explicitly addresses this issue and claims to use only clear cases of CH in her study. Similarly, in order to isolate CH from other phonological processes, Stoel-Gammon and Stemberger (1994) examine different types of feature change and note the number of subjects who use each type in assimilatory and non-assimilatory fashion. Klein (1981) provides a more detailed criterion for determining CH: first, context-free substitutions were identified in monosyllabic items that did not present the opportunity for the operation of assimilation processes. Then, after identifying these processes for each lexical item, CH was assessed with the requirement of two occurrences in separate lexical items. Finally, Fikkert and Levelt (2008) claim that many apparent cases of CH in child's Dutch can be explained away as incidental surface realizations of other phenomena that serve a common motivation (e.g. labial initial licensing).

In this study, I carefully attend to the distinction between context-free substitutions and CH which is context-dependent by definition. I will propose a statistically based method to separate genuine cases of CH from context-free consonant substitutions that occasionally result in harmonic productions.

3. The Study

3.1. *Database and Corpus Analysis*

The database for this study comprises transcribed speech samples from two typically-developing Hebrew-acquiring children. The participants were a boy (SR) between ages 1;02.00 and 2;03:24 years and a girl (RM) between ages 1;03.13—2;11.28 years. They were audio-recorded in weekly sessions for a period of several years while interacting with the investigators and occasionally additional participants (mostly family members). The data, mainly in the form of spontaneous speech samples and some elicitation tasks (picture naming and telling stories from picture-books) were collected and transcribed as part of the Tel Aviv University *Child Language Project*.[3]

For the purpose of this study, I examined in detail a large portion of each child's corpus. This includes most of the target words attempted by the child which are potential candidates for CH, namely, words with at least two non-adjacent consonants.[4] I considered only tokens for which a clear relation between input and output consonants could be established (at least under reasonable assumptions). For all the examined tokens, the relations between input and output consonants were coded according to different phonological processes. In addition, every consonant substitution occurring in a harmonic environment was marked as possible CH. For example, in *ken* → [*ten*] 'yes', the relation between target *k* and surface *t* was coded as velar fronting + possible CH, and the relation between target and surface *n* was coded as faithful.[5]

The following tables provide general details on the examined corpora. Table (1) analyzes the corpora sizes and the abundance of substitutions, specifically those resulting in harmony, and table (2) provides details on three major behavior types of consonants: faithful production, deletion, and substitution. To prevent confusion, I use the term *harmony* in reference to utterances that are harmonic with respect to a certain feature, regardless of the cause of harmony, and reserve the term *assimilation* when referring specifically to the process known as CH. Note that there are differences in token numbers between table (1) and (2) with respect to substitution and harmonic tokens. This is due to the fact that some tokens exhibit more than one type of substitution.

(1) General corpus analysis

	SR			RM		
	N	**% of tokens**	**% of subs.**	**N**	**% of tokens**	**% of subs.**
Tokens	13471	100%		19217	100%	
Substitution	687	5%		3462	18%	
Harmony	356	3%	52%	1017	5%	29%

3) The project was supported by ISF grant #554/04 with Outi Bat-El and Galit Adam as principal investigators.

4) Words that do not qualify as candidates to undergo CH are words with one consonant (e.g. *po* 'here') and words in which all consonants are clustered (e.g. *dli* 'bucket').

5) Assimilation to a string adjacent consonant is not considered as case of CH. This is true even for target words that contain a consonant with the relevant harmonic feature, which is not string adjacent to the changed consonant; e.g. *lif.'toaχ* → [*liʃ.'toaχ*] 'to open' is not CH even though the change *f* → [ʃ] could theoretically be triggered by *l*.

(2) Consonant production

	SR			RM		
	N	**% of total**	**% of subs.**	**N**	**% of total**	**% of subs.**
Total	38366	100%		53144	100%	
Faithful	32483	85%		42069	79%	
Deletion	5160	13%		7093	13%	
Substitution	723	2%		3982	7%	
Harmony	375	1%	52%	1210	3%	30%

From table (1) we can learn that the children have somewhat different developmental inclinations, even though they are both considered typical developers. RM is quite an average developer, showing a substantial number of substitutions (18%). SR, on the other hand, is a relatively fast learner, exhibiting a high rate of faithful productions and a marginal use of substitutions (5%). Within the class of substitutions, many instances result in harmonic productions (52% for SR and 30% for RM).

The difference between the children is also reflected in the segmental analysis. They delete consonants at the same rate, but SR has a higher rate of faithfully produced consonants and a lower rate of substitution. This difference between the children is important for the present study as will be demonstrated.

In addition to evaluating their individual development, this study aims to provide a comparative analysis of the children. However, since different children have different developmental rates and tracks (Waterson 1978, Vihman 1978, Klein 1981, Menn 1983, Menyuk et al. 1986, Macken 1995), and since the age ranges covered in the study are different, a scaling device is required. Following Adam and Bat-El (2009, Karni 2011), I compared the lexical development of the children, on the basis of cumulative target words attempted by the child. Stage 1 was defined as the period covering the first 10 words, and advanced stages were defined as integer multiples of 50 cumulative attempted target words. The lexical development scheme provides another evidence for the developmental gap between the children: SR's first word is recorded at the age of 1;02.00—a month and a half earlier than RM (1;03.13). What's more, SR reaches a lexicon size of about 1050 words nearly 8 months before RM (see Bat-El this volume for further comparison between these two children).

3.2. *Assimilatory vs. Non-Assimilatory Substitutions*

As discussed in §2.3, independently motivated context-free substitutions may occasionally result in harmonic productions which obscure the motivation behind CH. In order to determine whether a certain type of consonant substitution is assimilatory for a given child, I compared the developmental distributions of harmonic and non-harmonic occurrences of the given substitution. This was done in the following way: for every stage of lexical development, I counted the occurrences of the substitution in question in harmonic and non-harmonic environments. The counts were based on *production type per stage*, i.e. two productions of the same target word which are identical in consonants were listed as one entry if produced in the same stage and as two entries if produced in different stages (vowels are ignored). This practice was used in order to minimize token frequency effects (i.e. frequent use of certain words that may bias the analysis)[6] and also to create a basis for developmental comparison between the children (since their ages and recording periods are different).

For each substitution type, a two-tailed paired t test was run to check whether there was a significant difference in the distribution of the harmonic and non-harmonic instances with the null hypothesis that there was no difference (i.e. that the substitution is independent of consonantal environment). Substitution types for which there was no significant dependence on harmonic environment were excluded from the rest of the analysis. In addition, rare types of substitutions (i.e. found in less than 10 developmental stages) could not be evaluated reliably by a statistical test. In such cases, I had to rely on linguistic considerations alone (which usually meant giving the child maximum credit for assimilation).

The identification process applied here yielded 89 cases of CH for SR and 142 for RM. Counting all the tokens of CH (including repetitions within a stage) we get 176 tokens for SR and 145 RM. These will be analyzed in § 3.3. A full list of the CH tokens is provided in http://chengafni.files.wordpress.com/2012/11/ch_appendix.pdf.

Going back to (1), we can now estimate the status of CH in the children's grammars. Recall that 5 % of SR's tokens contain substitutions. The 176 assimilatory tokens equal to 26 % of his substitution cases but only to 1.3 % of his entire corpus. For RM, substitutions are found in 18 % of her data. Her total number of assimilatory tokens amount to only 4 % of all her substitution cases and to a negligible 0.8 % of her entire corpus. All in all, it seems that the need for harmony is not a major factor in the children's grammar. It might be the case that harmony is more important for SR than for RM, but since SR uses substitutions to a much lesser degree the results might be misleading.

3.3. *Consonant Harmony Analysis*

In the second part of the study I analyze the utterances that "passed" the identification process for assimilatory substitutions in order to seek generalizations that may shed light on the nature of CH.

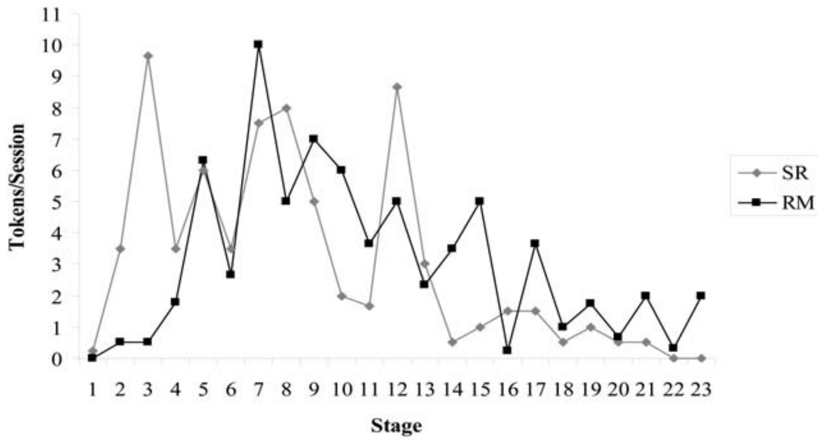
---

6) For example, some 50 productions of *ken* 'yes' as [*ten*] by RM, which give extra weight to velar fronting in harmonic environments.

3.3.1. Developmental Analysis

The chart in (3) illustrates the development of harmonic patterns with stage (thus age) for SR and RM. It indicates the average number of harmonic tokens per session produced by the children at a given stage.

(3) Development of Consonant Harmony



The chart above shows that CH is present in the children's productions throughout the study period, though not in a high dosage. The analysis presented here demonstrates again that the children develop at different paces—SR's CH virtually disappears around the age of 1;11.16 (stage 14) while RM continues to use CH until nearly the age of 3 (the end of recorded data).

3.3.2. Consonants

In this section I examine the properties of the consonants involved in the assimilation process (i.e. triggers and targets), starting with place of articulation (PoA). Table (4) presents a paired analysis of place triggers and targets (including assimilations that change both place and manner).[7] For instance, *ken* → [*nen*] 'yes'

---

[7] The analysis in this section is based on total production type analysis, i.e. excluding multiple occurrences of the same consonant substitution in the same target word (even if produced on different stages). Throughout this study I ignore changes in voice, as the statistical analysis (and also the literature, e.g. Vihman 1978, Tzakosta 2007) suggests that they are rather independent of segmental context (besides, of course, contact voicing assimilation, which was not considered here to begin with).

(RM 1;08,27) is analyzed as a paired coronal trigger and a dorsal target (disregarding manner change). Note that the analysis in this section is based on total production type analysis, i.e. I exclude multiple occurrences of the same consonant substitution in the same target word (even if produced on different stages).

(4) Place of articulation: Paired triggers and targets

Trigger	Target	SR		RM	
Labial	Coronal	10	20%	19	22%
Coronal	Labial	17	35%	18	21%
Dorsal	Coronal	7	14%	14	16%
Coronal	Dorsal	5	10%	20	23%
Labial	Dorsal	4	8%	5	6%
Dorsal	Labial	5	10%	5	6%
Dorsal	Glottal	1	2%	0	0%
Coronal	Glottal	0	0%	6	7%
Total		49		87	

The analysis above gives the impression that there is no true bias towards a certain PoA. For example, in RM's data there is almost an equal number of coronal harmony affecting labials as there are labial harmony affecting coronals. The fact that there are more coronal triggers (and to some extent more coronal targets) than other types could be attributed to some property of the language.

The following table presents the distribution of place targets and triggers. These distributions are also compared to PoA frequencies in the target words attempted by the children and to the PoA frequencies in Hebrew as calculated by Schocken (2008).[8] The analysis is performed over 38,370 consonants for SR and 53,141 for RM.

(5) Consonant Harmony and PoA

		SR			RM		
Place	**Language Frequency**	**Corpus Frequency**	**Triggers**	**Targets**	**Corpus Frequency**	**Triggers**	**Targets**
Labial	25%	22%	29%	45%	20%	28%	26%
Coronal	49%	45%	44%	35%	49%	50%	38%
Dorsal	23%	28%	27%	18%	27%	22%	29%
Glottal	3%	5%	0%	2%	4%	0%	7%

As we can see in (5), the distributions of place frequency in the attempted target words are similar for the children, and they seem to adequately represent the

8) The language frequency data are drawn from a corpus of the 99,808 most frequent words in Hebrew appearing in randomly selected internet sites during 2003.

input frequency of the language. The rates of coronal triggers are quite close to their frequencies in the input and the rates of coronal target are somewhat lower for both children. In addition, with the exception of high rates of labial targets for SR, labials and dorsal seem to be close to their input frequency both as triggers and as targets. Given these observations, it seems reasonable to conclude that input frequency is responsible, to some extent, for the trigger-target distribution for the subjects in this study.

Next, let us turn to investigating the properties of manner harmony. As with the place analysis, I start with a paired trigger-target distribution, which is shown in table (6). Again, both single- (manner only) and multi-feature (manner and place) harmonies are included.

(6) Manner of articulation: Paired triggers and targets

Trigger	**Target**	**SR**		**RM**	
Stop	Fricative	0	0%	10	14%
Stop	Affricate	1	3%	0	0%
Stop	Nasal	3	10%	4	6%
Stop	Liquid	4	13%	13	18%
Stop	Glide	0	0%	1	1%
Affricate	Nasal	1	3%	1	1%
Fricative	Stop	3	10%	3	4%
Fricative	Affricate	0	0%	2	3%
Fricative	Nasal	2	6%	8	11%
Fricative	Liquid	2	6%	12	17%
Fricative	Glide	0	0%	2	3%
Nasal	Stop	5	16%	1	1%
Nasal	Fricative	2	6%	2	3%
Nasal	Liquid	2	6%	1	1%
Nasal	Glide	0	0%	1	1%
Liquid	Stop	0	0%	4	6%
Liquid	Fricative	3	10%	2	3%
Liquid	Nasal	1	3%	2	3%
Liquid	Glide	1	3%	1	1%
Glide	Fricative	1	3%	2	3%
Total		31		72	

The table above provides interesting findings. The children seem to be somewhat different regarding their trigger and target preferences. SR does not show a particular preference for a certain hierarchy, reducing sonority in 52% of the cases and increasing in 48%. RM, however, shows a rather strong tendency to assimilate more sonorants to less sonorants, reducing sonority in 75% and increasing in 25%. The following sonority scale is assumed for Hebrew (Clements 1990, Bat-El 1996, Parker 2002):

(7) Sonority Scale for Hebrew

Glides > Liquids[9] > Nasals > Fricatives > (Affricates) > Stops

Do the results of manner distribution have some correlation with MoA frequency in the ambient language? Table (8) compares the trigger and target rates with the MoA frequency in SR's and RM's target words and the MoA frequencies in the language (Schocken 2008).

(8) Consonant Harmony and manner frequency

		SR			RM		
Manner	Language Frequency	Corpus Frequency	Triggers	Targets	Corpus Frequency	Triggers	Targets
Stop	29%	32%	26%	26%	31%	38%	11%
Fricative	27%	25%	23%	19%	27%	38%	22%
Affricate	2%	3%	3%	3%	4%	1%	3%
Nasal	20%	19%	29%	23%	19%	7%	21%
Liquid	19%	18%	16%	26%	17%	13%	36%
Glide	3%	2%	3%	3%	3%	3%	7%

As we saw in the place analysis, the MoA frequency distribution in the target words is similar for both children and the numbers are close to the language frequency. Here again, it seems that SR's choice of triggers and targets is guided mostly by input frequencies. On the other hand, RM shows a notable bias from the input frequencies; obstruents appear as triggers at a considerably higher rate than as targets, while the opposite is true for sonorants. Thus, it seems that the trigger-target sonority difference provides the best generalization regarding RM's data, while input frequency best accounts for SR's data. It is important to note, however, that the data are rather small (especially for SR) to enable clear-cut conclusions to be drawn.

3.3.3. Prosody

In this section, I inspect the correlation between CH and prosodic properties: stress pattern, prosodic positions and number of syllables. Here, I use slightly different data than in the previous two sections by including tokens of the same target word with the same type of harmony but different prosodic structure (e.g. *hipopo'tam* → [*to.'tam*]/['*to.tam*]/['*ta.ta*] 'hippopotamus'). However, I disregard vowel length, as it is not phonemic in Hebrew (e.g. *bej.'tsa* → [*ta.'tϑa*] ~ [*ta.'tϑa:*] 'egg'). Table (9) analyzes paired trigger-target indicating whether they have different degrees of stress. The label "Trigger > Target" is given to cases

[9] The Hebrew rhotic is a uvular approximant ʁ̞. I represent it with ʁ for convenience.

such as *ʃa.ˈχoʁ* → [*χa.ˈχoʁ*] 'black ms.sg.' (SR 1;09.27) in which the trigger *χ* is in a stressed syllable and the target *ʃ* is in an unstressed syllable. The label "Trigger = Target" covers all the cases in which the trigger and the target are equally stressed, including tautosyllabic harmony and harmony between consonants in separate unstressed syllables.

(9) Paired stress analysis

Hierarchy	**SR**		**RM**	
Trigger > Target	35	47%	36	31%
Trigger < Target	18	24%	28	24%
Trigger = Target	22	29%	52	45%
Total	75		116	

The table above does not provide conclusive evidence regarding the interaction between stress and CH. It seems that when the trigger and the target have different stress degrees, a stressed trigger is preferred over an unstressed trigger, especially for SR. Yet, a relatively large portion of the documented cases (29% for SR, 45% for RM) do not involve stress differences between the trigger and the target. Thus, it seems that stress has some interaction with CH but to different degrees for the children.

Next, I examine the interaction between CH and word length. Table (10) describes the proportions of CH instances occurring in monosyllables, disyllables etc. Note that, the number of syllables is calculated with respect to the production and not the target word; e.g. *hi.po.po.ˈtam* → [*ta.ˈta*] 'hippopotamus' (SR 1;04.17) is counted as disyllabic and not quadrisyllabic.

(10) Consonant Harmony and number of syllables

Syllables	**SR**		**RM**	
1	7	9%	13	11%
2	48	64%	47	41%
3	17	23%	48	41%
4	3	4%	7	6%
5	0	0%	1	1%
Total	75		116	

The table demonstrates that the majority of CH cases occur in up to trisyllabic words, as reported in Bat-El (2009); only 4% of SR's and 7% of RM's CH occur in quadrisyllabic and longer words. However, the table also shows a remarkable difference between the children: most of SR's CH occurs in disyllabic words, and only 27% of the cases in trisyllabic and longer words. RM, in contrast, assimilates trisyllables as much as she does disyllables. This finding is another indication of their different phonological developments.

3.3.4. Directionality

The subjects in this study showed both *progressive* (left-to-right) CH (e.g. *va.'rod* → [*va.'vod*] 'pink', RM 1;11.18), and *regressive* (right-to-left) CH (e.g. *ʃo.'xe.vet* → [*ʃo.'fe.fet*] 'she lies down', RM 2;03.01). The proportion of progressive vs. regressive CH can be seen in (11).

(11) Directionality

Directionality	**SR**		**RM**	
Regressive	57	76%	75	65%
Progressive	17	24%	41	35%
Total	75		116	

We can see that regressive harmony is dominant in both children, as expected from previous results (cf. Cruttenden 1978, Vihman 1978, Berg 1992, Ben-David 2001). In what follows, I attempt to find correlations between directionality and other parameters, starting with the participating consonants.

In order to determine whether CH is driven by sequencing limitations, I analyzed the directionality in different PoA configurations. Each row in (12) presents a sequence of two PoAs in the attempted targets, and the number of assimilatory cases. The table is divided according to directionality (the table is constructed based on the segmental analysis in 3.3.2). For example, *ko.'χav* → [*ko.'fav*] 'star' (SR 1;06.26) is a [dorsal … labial] sequence exhibiting regressive CH.

(12) Directionality and PoA

Directionality	**Configuration**	**SR**		**RM**	
Regressive	Labial-Coronal	11	(31%)	8	(15%)
	Coronal-Labial	6	(17%)	13	(25%)
	Coronal-Dorsal	5	(14%)	5	(10%)
	Dorsal-Coronal	4	(11%)	16	(31%)
	Dorsal-Labial	3	(9%)	1	(2%)
	Labial-Dorsal	5	(14%)	4	(8%)
	Glottal-Coronal	0	(0%)	5	(10%)
	Glottal-Dorsal	1	(3%)	0	(0%)
	Total	35		52	

Directionality	**Configuration**	**SR**		**RM**	
Progressive	Labial-Coronal	4	(29%)	6	(19%)
	Coronal-Labial	6	(43%)	9	(28%)
	Coronal-Dorsal	1	(7%)	3	(9%)
	Dorsal-Coronal	2	(14%)	8	(25%)
	Dorsal-Labial	0	(0%)	1	(3%)
	Labial-Dorsal	1	(7%)	4	(13%)
	Dorsal-Glottal	0	(0%)	1	(3%)
	Total	14		32	

Looking at the data, it seems that there is not much evidence that directionality is determined by the need to avoid certain orders of PoAs, as CH applies in both directions for most configurations. Given that regressive is the "default" direction for CH (Tzakosta 2007), we might expect that progressive CH to involve special configurations. However, this is not the case; the most common two groups involve both coronal triggers and coronal targets. All in all, I can say with some caution (since data amounts are small) that directionality of CH is not much affected by the participating PoAs. I propose to conduct further research to examine sequencing limitations in the acquisition of Hebrew. Such a study should take into consideration additional phenomena such as lexical selection strategies and metathesis.

Next, the combined analysis of directionality and manner is shown in (13). Recall that RM tends to use manner assimilation to decrease sonority, and therefore the table is constructed based on sonority order configurations. For example, *ʁak* → [*kak*] 'only' (RM 2;09.17) is a manner harmony that decreases the sonority of *ʁ*.

(13) Directionality and MoA

Directionality	**Output configuration**	**SR**		**RM**	
Regressive	Decreased Sonority	10	(43%)	31	(74%)
	Increased Sonority	13	(57%)	11	(26%)
	Total	23		42	
Progressive	Decreased Sonority	6	(75%)	21	(75%)
	Increased Sonority	2	(25%)	7	(25%)
	Total	8		28	

The results of this cross-analysis confirm to some degree the findings in § 3.3.2: RM harmonizes to decrease sonority in both directions, while SR much less so.

Next, I analyze the interaction between directionality and prosody. The relation between directionality and stress is presented in (14). For every type of stress hierarchy (e.g. Trigger > Target) the table indicates the number of regressive and progressive cases of CH.

(14) Directionality and stress hierarchy

Stress Hierarchy	**Directionality**	**SR**		**RM**	
Trigger > Target	Regressive	29	(83%)	29	(81%)
	Progressive	6	(17%)	7	(19%)
	Total	35		36	
Trigger < Target	Regressive	10	(56%)	15	(56%)
	Progressive	8	(44%)	12	(44%)
	Total	18		28	
Trigger = Target	Regressive	17	(77%)	31	(58%)
	Progressive	5	(23%)	22	(42%)
	Total	22		53	

The table shows that regressive harmony is preferred in all configurations. However, when the trigger is in an unstressed syllable and the target is in a stressed syllable, directionality is more even. Note that RM has a relatively large number of progressive CH cases where stress is neutralized (i.e. tautosyllabic or between two unstressed syllables). To further explore the link between directionality and prosody, I analyze the correlation between directionality and the number of syllables. The results are presented in table (15).

(15) Directionality and number of syllables

Syllables	**Directionality**	**SR**		**RM**	
1	Regressive	3	(4%)	5	(4%)
	Progressive	4	(5%)	8	(7%)
2	Regressive	37	(49%)	33	(28%)
	Progressive	11	(15%)	14	(12%)
3	Regressive	14	(19%)	33	(28%)
	Progressive	3	(4%)	15	(13%)
4	Regressive	2	(3%)	4	(3%)
	Progressive	1	(1%)	3	(3%)
5	Regressive	0	(0%)	0	(0%)
	Progressive	0	(0%)	1	(1%)
	Total	75		116	

Here we see again that regressive harmony is dominant with any number of syllables, except for monosyllabic productions. The data on polysyllabic words are compatible with Ben-David's (2001) claim that CH is related to prosodic development; syllables are acquired from right to left and new onsets are more susceptible to CH than old ones. In monosyllabic words, the onset is usually acquired before the coda, but Ben-David reports that CH usually occurs regressively nonetheless, probably due to segmental effects. In the present study, CH in monosyllabic words is mostly progressive, which seems to support the old-to-new direction found in polysyllabic words. However, the number of examples is too small to allow firm conclusions. To see whether these results indeed reflect general properties of prosodic development, I analyze the general behavior of different prosodic positions in the children's productions.

The following table shows the percentages of faithful productions of consonants in different prosodic positions in the examined corpora (unfaithful productions can be either deletion or substitution). For this illustration, I chose mono- di- and trisyllabic target words of the most commonly used structures.

(16) Faithfulness by prosodic position

Prosodic Structure		**SR**			**RM**	
	Total	**Position**	**Faithfulness**	**Total**	**Position**	**Faithfulness**
C_1VC_2	3212	1	84%	4025	1	79%
		2	90%		2	56%
$C_1V.C_2V$	1751	1	55%	3523	1	68%
		2	71%		2	82%
$V.C_1VC_2$	433	1	81%	649	1	87%
		2	95%		2	81%
$C_1V.C_2VC_3$	2502	1	66%	3212	1	71%
		2	82%		2	85%
		3	89%		3	81%
$C_1VC_2.C_3V$	348	1	54%	376	1	68%
		2	60%		2	54%
		3	68%		3	72%
$C_1VC_2.C_3VC_4$	526	1	75%	581	1	56%
		2	44%		2	58%
		3	86%		3	73%
		4	78%		4	78%
$C_1V.C_2V.C_3V$	481	1	49%	876	1	62%
		2	57%		2	77%
		3	78%		3	80%
$C_1V.C_2V.C_3VC_4$	779	1	52%	1101	1	60%
		2	74%		2	78%
		3	85%		3	85%
		4	92%		4	84%

The data above roughly support Ben-David's (2001, this volume) claim that the prosodic word in Hebrew is acquired from right to left, and newly acquired positions tend to be less faithful than well-established positions. According to Ben-David, the order of acquisition is as follows: onset of final syllable → coda of final syllable ↔ onset of non-final syllable → coda of non-final syllable (where ↔ indicates inter-child variation). Both children follow the scheme when considering onsets and codas separately; onsets/codas on the right are more faithful than onsets/codas on the left. The only discrepancy is found in mixed configurations where RM usually conforms to the generalization (with the exception of CVC.CVC words), i.e. onsets are more faithful than tautosyllabic codas, while the opposite is true for SR.

This deviation from Ben-David's findings may highlight once again the different paths that children may take during acquisition. However, this can also be an artifact of the present analysis; Ben-David's generalizations are based on dynamic developmental analysis, while the present analysis is static with no differentiation of stages of development. It is likely that the current results are somewhat skewed and do not truly reflect the prosodic development of the children.

It is worth examining whether the above findings are reflected in the CH data. The following table cross-analyzes directionality and prosodic configuration. If CH follows the same patterns as prosodic faithfulness, we would expect to find more regressive than progressive assimilations between identical positions, and mixed tendencies in mixed configurations.

(17) Directionality and prosodic configuration[10]

Configuration		**Directionality**	**SR**		**RM**	
Onset	Onset	Regressive	38	(54%)	36	(36%)
		Progressive	12	(17%)	20	(20%)
Coda	Coda	Regressive	0	(0%)	1	(1%)
		Progressive	0	(0%)	1	(1%)
Onset	Coda	Regressive	15	(21%)	24	(24%)
		Progressive	5	(7%)	19	(19%)
Total			70		101	

The results confirm those in earlier studies, that regressive assimilation is more abundant than progressive assimilation in all configurations. In onset-onset assimilation the right-to-left (regressive) direction correlates with the new-to-old

[10] These data exclude cases where CH skips identical positions (e.g. assimilation between C1 and C3 in C1V.C2VC3 or C1V.C2V.C3V) and where there is more than one potential trigger (e.g. *me.χa.'jeχ* 'smiles ms.sg' → *χe.'ʁaχ* (RM: 2;00.16)).

direction. In onset-coda assimilation, regressive assimilation does not correlate with old-to-new since onsets are acquired before codas. This suggests that directionality is mostly right-to-left (regressive) regardless of the order of acquisition of the prosodic positions. The validity of the findings is, however, limited due to the low amount of data. Note that coda-coda assimilations are hardly attested, probably since productions containing two codas appear relatively late, when the segmental system is developed enough to save the need for simplification.

3.3.5. Discussion

In this part of the study, I examined the properties of CH in the corpus. The segmental analysis of place harmony indicates that it is governed by input frequency and involves coronals more than other types of PoA. This is in contrast to the findings in Ben-David (2001), who notes that place assimilation is triggered mostly by labials and dorsals in the acquisition of Hebrew. Interestingly, the exact same conflict is reported in Tzakosta (2007); while her study reveals that coronal harmony is dominant in the acquisition of Greek, Kappa (2001) reports that labial harmony is the most frequent in her data. Such conflicting evidence from children acquiring the same language may suggest that place harmony is not governed by a universal (or even language-specific) trigger-target hierarchy.

With respect to manner harmony, the picture is less clear—for SR the trigger-target distributions seems to reflect input frequency, and as a consequence there is no clear trigger-target hierarchy (some of the MoAs have close input frequencies). RM, on the other seems to often use CH in order to reduce the sonority of the target, whether for segmental or phonotactic reasons.

The present study indicates that CH might be related to prosodic development. The directionality of assimilation seems to go hand in hand with the path of prosodic development; CH tends to operate between identical positions (i.e. onset-onset assimilation) from old to new which is also from right to left (regressive). In addition, CH appears more in short (disyllabic and trisyllabic) productions than in longer productions. This, according to Bat-El (2009), indicates the synchronization between segmental and prosodic development; by the time the children start producing long words their segmental and prosodic systems are developed enough to eliminate the need to harmonize. Finally, the affect of stress on CH is not entirely clear. Although nearly 50 % of SR's CH cases are from a stressed to an unstressed syllable, there are still many cases in which stress is irrelevant. RM tends much less to favor a trigger that is more stressed than the target (31 %), and the majority of cases (45 %) in her corpus involve neutralized stress.

4. Conclusion

This study is devoted to CH in the acquisition of Hebrew. I started the discussion with a quantitative identification method for CH, required for cases in which the production is ambiguous and can be analyzed both as CH and as a context-free substitution (e.g. velar fronting). The proposed method estimates the probability that a given consonant substitution depends on a harmonic environment, and by applying it to the data I claim to show that CH is a marginal phenomenon for the child subjects in this study. Nevertheless, I argue that the identification of CH is inherently problematic since there is no way to know the exact motivation behind any instance of consonant substitution; even when the child uses a process that is generally context-free, we cannot know for certain that he is not motivated by harmony as well. Further research is needed in order to test the proposed method on data from different languages and with children that are claimed to be productive "harmonizers".

The analysis of the properties of CH indicated the major effect of prosodic factors. Directionality of assimilation between identical prosodic positions converges in most cases (right-to-left) with the direction of acquisition (i.e. old-to-new). However, in onset-coda assimilation, while the right-to-left is still the dominant direction, it is not consistent with the order of acquisition.

The segmental influence on CH seems to be rather marginal in the present study. The analysis of place harmony indicates that trigger-target hierarchy is likely to be related to input frequency and even to individual factors. This finding together with conflicting evidence from previous studies does not support the repeated claim in the literature that place CH is governed by a universal markedness hierarchy. Regarding manner harmony, SR's data suggest that his trigger-target choice is also determined by input frequency. On the other hand, RM's manner harmony usually reduces the sonority of the target. In summary, it seems that for SR, CH is determined mainly by prosodic factors, while for RM, segmental influence is also noticeable.

A final remark concerns inter-child variation (further studies on variation between SR and RM are presented by Bat-El this volume and Cohen this volume). Although the children in this study are considered typical developers, they are nonetheless quite different in several respects. SR is a fast developer, showing little use of consonant substitutions from the beginning and developing a large lexicon quite rapidly. He also stops using CH rather early—CH mostly affects his disyllabic productions. In addition, his use of CH reflects the frequency of place and manner features in the input. By contrast, RM is a more average developer and uses consonant substitution much more frequently. Her phonological repertoire is so rich that most of her harmonized productions are suspected to result from context-free substitutions. She uses CH to a later stage than SR, and often in trisyllabic words. RM is also somewhat different from SR with respect to manner harmony, as she seems to use CH rather consistently to reduce the sonority of the target. While inter-child variation is a known phenomenon in the study of language acquisition, further research is needed to examine the scope and limits of the variation in CH.

References

Adam, Galit, and Outi Bat-El. 2009. When do universal preferences emerge in language Development? The acquisition of Hebrew stress. *Brill's Annual of Affroasiatic Languages and Linguistics* 1:255–282.

Bat-El, Outi. 1996. Selecting the best of the worst: The grammar of Hebrew blends. *Phonology* 13:283–328.

Bat-El, Outi. 2009. Harmonic domains and synchronization in typically and atypically developing Hebrew-speaking children. *Language Sciences* 31:117–135.

Becker, Michael, and Anne-Michelle Tessier. 2011. Trajectories of faithfulness in child-specific phonology. *Phonology* 28:163–196.

Ben-David, Avivit. 2001. *Language Acquisition and Phonological Theory: Universal and Variable Processes Across Children and Across Languages*. Ph.D. Dissertation, Tel-Aviv University [in Hebrew].

Berg, Thomas. 1992. Phonological harmony as a processing problem. *Journal of Child Language* 19:225–257.

Berg, Thomas, and Ulrich Schade. 2000. A local connectionist account of consonant harmony in child language. *Cognitive Science* 24:123–149.

Bernhardt, Barbara, and Joseph Stemberger. 1998. *Handbook of Phonological Development: From the Perspective of Constraint-based Nonlinear Phonology*. San Diego: Academic Press.

Clements, George. 1990. The role of the sonority cycle in core syllabification. In J. Kingston and M. Beckman (eds), *Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech*, 283–333. Cambridge, MA: Cambridge University Press.

Cruttenden, Alan. 1978. Assimilation in child language and elsewhere. *Journal of Child Language* 5:373–378.

Donahue, Mavis. 1986. Phonological constraints on the emergence of two-word utterances. *Journal of Child Language* 13:209–218.

Ferguson, Charles, David Peizer, and Thelma Weeks. 1973. Model-and-replica phonological grammar of a child's first words. *Lingua* 31:35–65.

Fikkert, Paula, Clara Levelt, and Joost van de Weijer. 2002. Input, intake, and phonological development: The case of consonant harmony. A paper presented at GALA, Utrecht.

Fikkert, Paula, and Clara Levelt. 2008. How does place fall into place? The lexicon and emergent constraints in the developing phonological grammar. In P. Avery, E. Dresher, and K. Rice (eds), *Contrast in phonology: Perception and Acquisition*, 231–268. Berlin: Mouton.

Gafni, Chen. 2012. *Consonant Harmony in the Scope of Language Development*. M.A. Thesis, Tel-Aviv University.

Gafos, Adamantios. 1999. *The Articulatory Basis of Locality in Phonology*. New York: Garland Publishing, Inc.

Garnica, Olga, and Mary Louise Edwards. 1977. Phonological variation in children's speech: The trade-off phenomenon. *Papers in Psycholinguistics and Sociolinguistics. Working Papers in Linguistics*, No. 22. Ohio State University.

Gerlach, Sharon. 2010. *The Acquisition of Consonant Feature Sequences: Harmony, Metathesis and Deletion Patterns in Phonological Development*. Ph.D. dissertation, the University of Minnesota.

Goad, Heather. 1997. Consonant harmony in child language: An Optimality-Theoretic account. In S. Hannahs and M. Young-Scholten (eds), *Focus on Phonological Acquisition*, 113–142. Amsterdam: John Benjamins.

Goad, Heather. 2001. Assimilation phenomena and initial constraint ranking in early grammars. In A. Do, L. Domínguez, and A. Johansen (eds), *Proceedings of the 25th Annual Boston University Conference on Language Development*, 307–318. Somerville, MA: Cascadilla Press.

Goad, Heather. 2004. Consonant harmony in early grammars revisited: Domains, licensing and directionality. A paper presented at JEL 2004, Nantes France.

Grunwell, Pamela. 1982/1984. *Clinical Phonology*. London and Canberra: Croom Helm

Hansson, Gunnar. 2001. *Theoretical and Typological Issues in Consonant Harmony*. Ph.D. Dissertation, University of California Berkeley.

Kappa, Ioanna. 2001. Alignment and consonant harmony: Evidence from Greek. In A. Do, L. Domínguez, and A. Johansen (eds), *Proceedings of the 25th Annual Boston University Conference on Language Development*, 401–412. Somerville, MA: Cascadilla Press.

Karni, Noa. 2011. *Minimal Violation of Faithfulness: Chain Shift and Local Conjunction in the Acquisition of Hebrew Onsets*. M.A. Thesis, Tel-Aviv University.

Keren-Portnoy, Tamar, Marinella Majorano, and Marilyn Vihman. 2009. From phonetics to phonology: The emergence of first words in Italian. *Journal of Child Language* 36:235–267.

Klein, Harriet. 1981. Productive strategies for the pronunciation of early polysyllabic lexical items. *Journal of Speech and Hearing Research* 24:389–405.

Leonard, Laurence, Judith Miller, and Heather Brown. 1980. Consonant and syllable harmony in the speech of language-disordered children. *Journal of Speech and Hearing Disorders* 45:336–345.

Lewis, Morris. 1936/1951. *Infant Speech*. London: Routledge & Kegan Paul.

Lewis, Paul (ed.). 2009. *Ethnologue: Languages of the World* (16th edition). Dallas: SIL International.

Macken, Marlys 1978. Permitted complexity in phonological development: One child's acquisition of Spanish consonants. *Lingua* 44:219–253.

Macken, Marlys. 1995. Phonological Acquisition. In J. Goldsmith (ed.), *Handbook of Phonological Theory*, 671–696. Oxford: Blackwell.

Matthei, Edward. 1989. Crossing boundaries: More evidence for phonological constraints on early multi-word utterances. *Journal of Child Language* 16:41–54.

Menn, Lise. 1975. Counter example to 'fronting' as a universal of child phonology. *Journal of Child Language* 2:293–296.

Menn, Lise. 1983. Development of articulatory, phonetic, and phonological capabilities. In B. Butterworth (ed.), *Language Production* v2, 3–50. London: Academic Press.

Menyuk, Paula, Lise Menn, and Ronnie Silber. 1986. Early strategies for the perception and production of words and sounds. In P. Fletcher and M. Garman (eds), *Language Acquisition* (2nd edition), 198–222. Cambridge University Press.

Parker, Stephen 2002. *Quantifying the Sonority Hierarchy*. Ph.D. Dissertation, University of Massachusetts.

Pater, Joe. 1997. Minimal Violation and Phonological Development. *Language Acquisition* 6(3), 201–253.

Pater, Joe, and Adam Werle. 2001. Typology and variation in child consonant harmony. In C. Féry, A. Green, and R. van de Vijver (eds), *Proceedings of the Holland Institute of Linguistics: Phonology 5*, 119–139. Potsdam: University of Potsdam.

Pater, Joe, and Adam Werle. 2003. Direction of assimilation in child consonant harmony. *Canadian Journal of Linguistics* 48:385–408.

Qu, Chen. 2011. Prosodic licensing, elaboration of segmental structure and child consonant harmony. In L. Armstrong (ed.), *Proceedings of the 2011 Annual Conference of the Canadian Linguistic Association*.

Rose, Yvan. 2000. *Headedness and Prosodic Licensing in the L1 Acquisition of Phonology*. Ph.D. dissertation, McGill University.

Schocken, Rebecca. 2008. *Characterization and Evaluation of Speech-Reading Support Systems for Hard-of Hearing People*. Ph.D. Dissertation, Tel-Aviv University [in Hebrew].

Smith, Neilson V. 1973. *The Acquisition of Phonology: A Case Study*. Cambridge: University Press.

Stemberger, Joseph and Barbara Bernhardt. 1997. Optimality Theory. In M. Ball and R. Kent (eds), *The New Phonologies: Developments in Clinical Linguistics*, 211–245. San Diego, CA: Singular Publishing Group.

Stemberger, Joseph, and Carol Stoel-Gammon. 1991. The underspecification of coronals: Evidence from language acquisition and performance errors. In C. Paradis and J-F. Prunet (eds), *Phonetics and Phonology v2*: *The Special Status of Coronals*, 181–199. Academic Press.

Stoel-Gammon, Carol, and Joseph Stemberger. 1994. Consonant harmony and phonological underspecification in child speech. In Yavas Mehmet (ed.), *First and Second Language Phonology*, 63–80. San Diego: Singular Publishing Group.

Tzakosta, Marina. 2007. Genetic and environmental effects in L1 phonological acquisition: The case of consonant harmony in Greek child speech. *Journal of Greek Linguistics* 8:5–30.

Vihman, Marylin. 1978. Consonant harmony: Its scope and function in child language. In J. Greenberg (ed.), *Universals of Human Language 2: Phonology*, 281–334. Stanford: Stanford University Press.

Vihman, Marylin, and William Croft. 2007. Phonological development: Toward a "radical" templatic phonology. *Linguistics* 45:683–725.

Waterson, Natalie. 1978. Growth of complexity in phonological development. In N. Waterson and C. Snow (eds), *The Development of Communication*, 415–442. Chichester: John Wiley and Sons.

BRILL Brill's Annual of Afroasiatic Languages and Linguistics 4 (2012) 55–79 brill.com/baall

BAALL

The Development of Prosodic Structure: Evidence from Typical Longitudinal Data*

Avivit Ben-David
Department of Communication Disorders, Hadassah Academic College
avivitb@hadassah.ac.il

Abstract
The paper provides an analysis of the acquisition of prosodic structure, including prosodic words (number of syllables), feet, syllables and sub-syllabic units (i.e. nucleus, onset and coda). The analysis, couched within the theory of prosodic phonology (Selkirk 1984, Nespor and Vogel 1986), accounts for the developmental path of each prosodic unit as well as developmental interactions among the units. Particular attention is devoted to the markedness of the prosodic units and the relationship between unmarked prosodic structures (e.g. CV syllables, trochaic feet) and early development of these structures. The data are drawn from a longitudinal study of the early speech of 10 monolingual Hebrew-acquiring children from the age of 1;2 years till 2;10 (Ben-David 2001), the age when all prosodic units considered in the study were produced correctly. The analysis revealed two main findings. (i) Although children's productions usually progress from the unmarked to the more marked structures during the course of development, the role of universal markedness is not always recognized. (ii) Children "build" their words from right to left. Since the majority of words in Hebrew have final or penultimate stress, both stressed and final syllables are located at the end of the word and are rarely omitted. However, while the final syllable is not subject to prosodic changes (except for coda deletion at the beginning of the developmental process), the penultimate syllable is. Even in Strong-Weak (SW) words, which occur very early in the child's productions, cases of initial consonant deletion and harmony of the nuclei and the onset of the first syllable can be detected.

Keywords
prosodic development; phonological acquisition; markedness; foot; syllable structure; Hebrew

1. Introduction

Studies on the development of prosodic structure address the relation between markedness and the order of development of the various prosodic units, on the basis of data from languages such as Dutch (Fikkert 1994, Levelt, Schiller and

*) I would like to thank Outi-Bat-El and Galit Adam for their helpful feedback and valuable comments. The paper also benefited from the comments of two anonymous reviewers.

 DOI: 10.1163/18776930-00400003

Levelt 2000) English (Demuth and Fee 1995, Demuth 1996, Kehoe and Stoel-Gammon 1997, Gnanadesikan 2004), European Portuguese (Fikkert and Freitas 1997), and French (Rose 2000). It has long been assumed that children's productions progress from unmarked to more marked structures during the course of development (Jakobson 1941/68). However, most studies in this area analyze data from children acquiring languages in which some of the predominant prosodic structures are considered unmarked (e.g. trochaic feet in English and Dutch).

Somewhat lesser attention has been given to the interaction among simultaneously developing prosodic units (e.g. the prosodic word and the syllable). Studies on interactions in the development of different prosodic units have focused mainly on the relationship between rhymes (nuclei and codas), moras and prosodic words, and described these relationship mainly in languages with a phonological distinction between short and long vowels and a large number of monosyllabic words compared to polysyllabic words (Fikkert 1994 for Dutch, Kehoe and Stoel-Gammon 1997 for English). Furthermore, the relationship between onset and prosodic word development has not yet been studied to date.

Hebrew has different prosodic characteristics compared to the abovementioned languages:

a. The stress system in nouns is rather complex; although the majority of nouns bear final stress, there are quite a few that take penultimate stress. In addition, in most nouns, stress shifts to the final syllable when a suffix is added, but there are others where stress remains on the stems (Bolozky 1982, Bat-El 1993).
b. As opposed to some of the more investigated languages (e.g. English and Dutch), the predominant length of prosodic words in Hebrew open class words is disyllabic, both in the language in general (Cohen-Gross 1997) and in Child Directed Speech in particular (Segal et al. 2008).
c. Hebrew is considered a quantity insensitive language, since vowel length is not distinctive, and there is no evidence that CVC syllables attract stress more than CV syllables. This implies that Hebrew does not provide evidence for the role of the mora in the prosodic system of the language.

These unique prosodic characteristics of Hebrew offer the opportunity to study the development of prosodic structures and their relationship in a different linguistic environment, and to investigate the role of universal markedness in that development in this linguistic context.

In this paper I describe the development of the prosodic word, foot and syllable in Hebrew, and analyze the developmental paths in the light of the universal markedness relations (see also Ben-David 2001). The analysis reveals that although markedness is a major influential component in prosodic development, some requirements for structural simplicity also play a role in the development of the prosodic units.

In addition, I describe the relationship between syllable and prosodic word development and show that although each prosodic unit has its own developmental path, there are strong connections among the different prosodic structures (e.g. the development of sub-syllabic units of the initial syllable of the prosodic word is much slower than that of the final syllable).

I begin in § 2 with a brief theoretical background of the prosodic hierarchy and its units (§ 2.1), followed by a short description of the prosodic structures in Hebrew (§ 2.2). Details regarding the research method and the database are presented in § 3. In § 4 I describe and analyze the developmental path of the various prosodic units: Stages of prosodic word development are determined (§ 4.1) with reference to the effect of universal markedness on the developmental path. The discussion on the development of the syllable structure (§ 4.2) attends to each of the subsyllablic units (nucleus, onset and coda), with emphasis on the connection of the development of these units to the development of the prosodic word. The conclusion in § 5 provides a summary and discuss on the main findings of this study.

2. Theoretical Background

This section briefly outlines the prosodic structure of words and their markedness relations in general (§ 2.1), and in Hebrew (§ 2.2) in particular.

2.1. *Prosodic Units and Markedness*

Following the theory of prosodic phonology, words are organized in a hierarchical arrangement, called the Prosodic Hierarchy, which assumes dominance relations among the prosodic units (Selkirk 1984, Nespor and Vogel 1986). The units relevant to the present study include the mora, the syllable, the foot, and the prosodic word.

(1) The prosodic hierarchy at and below the prosodic word

Prosodic Word (PW)
|
Foot (Ft)
|
Syllable (σ)
|
Mora (μ)

Moras are weight units; light syllables have one mora and heavy syllables have two moras (Hyman 1985, Hayes 1986). Languages differ in whether they regard coda consonants as moraic, so in some languages CVC is considered a heavy syllable while in others it is considered a light syllable.

An alternative way of representing subsyllabic structure is the Onset-Rhyme representation. The onset comprises the prevocalic consonant(s). The rhyme contains the nucleus (i.e. the sonorous peak of the syllable) and the coda, where the latter contains the postvocalic consonants.

Syllables are grouped together into feet, which are units of rhythm that determine the stress pattern of the word. Feet are usually binary at some level (i.e. contain either two syllables or one bimoraic syllable), and can have the stressed syllable on the left or right. Left-headed feet are trochaic ($[\sigma_s\sigma_w]_{Ft}$) and right-headed feet are iambic ($[\sigma_w\sigma_s]_{Ft}$).[1] In a word with an odd number of syllables, there will be one unfooted syllable in some languages ($[\sigma[\sigma\sigma]_{Ft}]_{PW}$) or a degenerate (monosyllabic) foot in others ($[[\sigma]_{Ft}[\sigma\sigma]_{Ft}]_{PW}$).

Feet are organized into prosodic words, which can contain one foot or more ($[[\sigma\sigma]_{Ft}]_{PW}$ or $[[\sigma\sigma]_{Ft}[\sigma\sigma]_{Ft}]_{PW}$).

Each prosodic unit has various possible structures, organized in markedness relations. Below is the least marked structure for each unit:

(2) The unmarked structures of the prosodic units

a. Prosodic Word: A word consists of at least one foot
b. Foot: (i) A binary foot (disyllabic or bimoraic)
(ii) A trochaic foot
c. Syllable: CV (a simple onset + a rhyme consisting of a short vowel and no coda)

The combination of (2a) and (2b-i) creates the structure of the Minimal Word (McCarthy and Prince 1986), which consists of only one binary foot. This minimal size restriction is evident in several languages, such as Bengali (Fitzpatrick-Cole 1991), Dutch (Fikkert 1994), English (Demuth and Fee 1995), and Sesotho (Demuth and Fee 1995), where there are no open class words smaller than a foot (moraic or syllabic).

2.2. *Prosodic Structure in Hebrew*

2.2.1. Syllable Structure

The most common types of syllable in Hebrew are CV and CVC (e.g. *xilazón* 'snail'), although consonant clusters may appear in onset position (mostly word initial), and to a lesser extent in coda position (word final). Syllables with no

---

1) σ_s indicates the strong syllable in a foot and σ_w indicates the weak syllable in a foot.

consonants at all (e.g. *tauyót* 'mistakes') are rare (Laufer 1992). Hebrew does not make phonological distinction between short and long vowels nor between light and heavy syllables (CVC syllables do not attract stress more than CV syllables). This implies that Hebrew does not provide evidence for the role of the mora in the prosodic system of the language.

2.2.2. Prosodic Word Structure

The predominant size of prosodic words in Hebrew open class words is disyllabic, both in the language in general (Cohen-Gross 1997) and in Child Directed Speech (Segal et al., 2008). Trisyllabic words are fairly common, but words of more than three syllables are less common. Since Hebrew does not distinguish between light and heavy syllables, there are monosyllabic words which are monomoraic (e.g. *dli* 'bucket', *sus* 'horse', *kviʃ* 'road') and these are sub-minimal words. However the percentage of monosyllabic words in the Hebrew dictionary is only 0.5% (Adam and Bat-El 2010, based on Bolozky and Becker's 2006 dictionary).

2.2.3. Stress Pattern

Hebrew has mainly word-final stress (e.g. *jaldá* 'girl', *xilazón* 'snail'). However numerous words have non-final stress, mainly penultimate (*sávta* 'grandmother', *rakévet* 'train'), and some loan words with antepenultimate stress (*ótobus* 'bus', *télefon* 'telephone'). The percentage of nouns with final stress is about 70% both in the language as a whole (Adam and Bat-El 2010, based on Bolozky and Becker's 2006 dictionary) and in Child Directed Speech (Segal et al. 2008). In addition, in most nouns, stress shifts to the final syllable when a suffix is added, but there are others where stress remains on the stems (Bolozky 1982, Bat-El 1993).

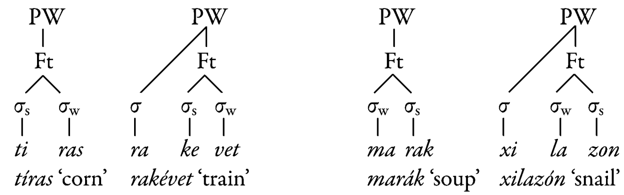
The above description suggests that Hebrew stress patterns are quite complex and likely to be challenging to acquire. In the prosodic word level, the final foot is the strong foot (except for polysyllabic loan words with antepenultimate stress). However, as a consequence of the complex stress pattern, there is a disagreement as to what type of foot the stress system employs (see Bat-El 2005). I follow Bolozky (1982) and Graf and Ussishkin (2003) in assuming that the strong foot in Hebrew words (with the exception of words with antepenultimate stress) is aligned with the right edge of the prosodic word, and it can be either trochaic (3a) or iambic (3b).[2]

---

2) For further discussion see Adam and Bat-El (2008, 2009).

(3) Foot structures in Hebrew

a. Trochaic foot b. Iambic foot



3. Research Method

The data were drawn from 10 typically developing Hebrew-speaking children and were collected in two ways: (i) spontaneous speech sampling from three children, transcribed once a week, and (ii) a structured test devised specifically for this study and administered once a month to the same three children and to seven others.

In order to examine the production of the common phonological units of Hebrew, the constructed test consisted of words with different number of syllables (from mono- to quadrisyllabic) and with various stress patterns (final, penultimate, and antepenultimate). The syllables, in turn, were with various types of onsets (empty, simple, and biconsonantal), and codas (empty and simple). All the language's segments were examined in various prosodic positions. The test was based on pictures and everyday objects depicting the stimuli words.

The children were tested from the appearance of their first words, at the time when each child produced approximately 10 words in the first session (average age 1;2, age range 0;10–1;5) until the stage when all phonological units considered in the study were produced correctly, disregarding interdental production of sibilants (average age 2;10, age range: 2;5–3;6).

4. Developmental Patterns

As shown in this section, the development of the prosodic word is highly connected to the stress pattern of the target words. Interestingly, although Hebrew has quite an irregular and complicated stress system (see § 2.2), the findings show that children hardly ever misplace stress in their productions. This implies that Hebrew stress is acquired lexically, and serves as anchor for further development.

4.1. *Development of the Prosodic Word*

Stages of prosodic word development are defined in terms of the number of syllables, and foot structure.[3] In this study, I followed the increase in the number of syllables in the word and the changes in stress pattern in the child's output productions, with reference to the theory of prosodic phonology (§ 2.1). Each change in these units is analyzed as a new stage in the development of the prosodic word.

As noted in § 2.1, the unmarked structure of the prosodic word is the minimal word and the unmarked foot structure is a trochaic binary foot. As these structures are considered universally unmarked, it is expected that these would be the initial word and foot structures produced by children. This was indeed found in some studies, which reported that minimal words with trochaic feet were found in early stages of development (Demuth and Fee 1995, Fikkert 1994).

In examining the production of monosyllabic target words throughout the development process, no evidence suggesting that Hebrew-speaking children attempt to produce minimal words as a minimal form was found. During the whole process of development, target words with a (C)CV structure (e.g. *lo* 'no', *pe* 'mouth', *dli* 'bucket') were not augmented in order to generate a minimal word, neither by prolonging the vowel nor by adding a syllable. This is in contrast to examples such as *kópi* for English 'cup' (Demuth et al. 2006) and *tee* for Japanese *te* 'hand' (Ota 2001). Moreover, in target words with a (C)CVC structure, the coda, which could be considered by the children as an additional mora, is deleted, (e.g. *kos* → [*ko*] 'glass', *ken* → [*ke*] 'yes').[4] The production of subminimal words for monosyllabic target words was found in languages like French (Demuth and Johnson 2003), European Portuguese (Vigário et al. 2006), and English (Demuth et al. 2006). This issue will be further discussed below, after presenting Stage I of the polysyllabic words development.

The findings of this study show that the early productions of Hebrew-speaking children of polysyllabic targets are also not entirely consistent with the prediction based on universal markedness.

---

[3] In this paper, the notion of stage is considered as a minimal qualitative phonological change between earlier and later productions.

[4] Although Hebrew is considered a quantity insensitive language, it is not clear whether the children have this knowledge in early stages of phonological development, and thus whether they consider a CVC syllable as bimoraic, thus a minimal word. Most languages with iambic systems are predicted to be quantity-sensitive (Hayes 1995). Since Hebrew has an iambic system but at the same time is a quantity-insensitive language, these two conflicting properties can make it difficult for children to gain the knowledge on the native language's metrical system.

Below are the five stages of prosodic word development found in this study, where the productions in each stage are analyzed with reference to the markedness value of the prosodic units.

4.1.1. Stage I—Monosyllabic Productions

During Stage I, polysyllabic target words (mainly disyllabic) were produced as monosyllabic. When the target words had final stress, the children produced the final syllable, and when the target word had non-final stress they sometimes produced the final syllable and other times the stressed syllable. The productions were mainly CV syllables, as can be seen in Table 1.

Table 1: Stage I: Monosyllabic productions

Target structure	**Child**		**Final stress targets** Output	Target		**Non-final stress targets** Output	Target	
2σ:	AR	1;7	du	kadúr	'ball'	to	plúto	'Pluto (name)'
	EZ	1;5	ma	nigmár	'finished'	ma	íma	'mother'
	NV	1;3	da	jaldá	'girl'	ta	sáfta	'grandmother'
	GL	1;2				ma	máim	'water'
3σ:	AR	1;7	ja	ugijá	'cookie'			
	EZ	1;5				pa	télefon	'telephone'
	NV	1;4				bu	ótobus	'bus'
	KL	1;2				to	liftóax	'to open'

This stage was quite short and there were only few examples of the monosyllabic productions of non-final stress targets. In eight out of 13 targets with non-final stress, the children produced the final syllable and only in five cases the stressed syllable had been produced. The selection of stressed syllables for monosyllabic productions seems obvious due to their perceptual prominence (Echols and Newport 1992, Smith 2002). However, positional prominence of word edge is also known to be a psycholinguistic component affecting child language (Echols and Newport 1992, Beckman 1998, Pater 1997, Walter 2002). The data from this research may suggest that the final syllable is more prominent than the stressed one, but more data are needed to support this. Adam and Bat-El (2008) suggest that segmental effects, in particular the preference for the vowel *a*, also play a role in the selection of the syllables children produce at this stage.

Production of monosyllabic CV words at the outset of development indicates that there is a stage in which children prefer to produce these productions over binary feet comprising the unmarked minimal word. This stage, where only a single syllable, mostly CV, corresponds to various target words, is termed "the core syllable stage" or "the sub-minimal stage", and was found in studies on development of other languages, such as English (Demuth and Fee 1995, Salidis and

Johnson 1997), Dutch (Fikkert 1994, Lohuis-Weber and Zonnenveld 1996), Spanish (Garrett 1998), French (Demuth and Johnson 2003), and European Portuguese (Vigário, Freitas, and Frota 2006).

Demuth and Fee (1995) suggest that during this stage, the children's output forms are constrained due to a lack of access to the full prosodic hierarchy. Demuth (1996) further argues that children's early words take the unmarked form of the syllable as a strategy for avoiding the issue of how to construct feet in their language.

Alternatively, I suggest that the preference for monosyllabic CV productions may stem from the simple fact that the monosyllabic foot is less complex; that is, it contains less structure than the unmarked binary foot. This then suggests that before adhering to universal markedness constraints, the children's primary preference is for as limited structures as possible. This suggestion will be discussed further in the next sections.

4.1.2. Stage II—A Trochaic Foot

During this stage, the children begin to produce binary trochaic feet from target words with non-final stress (i.e. SW pattern, where S indicates the strong/stressed syllable in the word and W indicates the weak/unstressed syllable in the word). However, they continue to produce monosyllabic feet (many of them CV) for target words with final stress. The syllables selected for production are usually the final syllable and the stressed syllable, as shown in Table 2.

Table 2: Stage II: The trochaic foot

			Non-final stress			**Final stress**		
	Child		**Output**	**Target**		**Output**	**Target**	
2σ:	MN	1;5	da	todá	'thank you'	ála	gíla	'Gila (name)'
	EL	1;3	du	kadúr	'ball'	áta	sáfta	'grandmother'
	KL	1;5	ma	nigmár	'finished'	ége	régel	'leg'
3σ:	KL	1;4	ja	ugijá	'cookie'	téfo	télefon	'telephone'
	EZ	1;6	te	matató	'broom'	nána	banána	'banana'
	AR	2;2	it	masaít	'truck'	téti	spagéti	'spaghetti'
4σ:	GN	1;4	tam	hipopotám	'hippo-potamus'	tína	klementína	'tangerine'
	NV	1;5	ni	duvdevaním	'cherries'	zíza	televízja	'television'

The effect of universal markedness is apparent during this stage, where the unmarked foot structure is observed for the first time. When the target words have non-final stress, the children produce a binary trochaic foot, i.e. the unmarked foot. The markedness limitations inhibit the production of iambic feet, even though many target words do comprise this type of foot. An additional phenomenon, which provides evidence for the preference for trochaic feet, is that children attempt more target words with penultimate stress than with final stress. This finding which may suggest a selection and avoidance strategy (Schwartz and Leonard 1982) strengthens the claim that children prefer trochaic feet at this stage, since neither the frequency of trochee in Hebrew nor the frequency of trochee in Child Directed Speech give priority to the trochaic foot (Cohen-Gross 1997, Segal et al. 2008; see also Adam and Bat-El 2008, 2009 for further discussion on this topic). The fact that there are no productions longer than two syllables at this stage may be due to the markedness constraints on the prosodic word, since prosodic words that comprise only one foot are unmarked.

The productions corresponding to iambic targets show that foot markedness is more prominent in the children's grammar than prosodic word markedness. Therefore, they prefer producing non-binary feet (marked prosodic words) than binary iambic feet (marked feet).[5] In addition, there were no instances of stress shift so as to create a binary trochaic foot for target words with final stress, as reported in Fikkert (1994) for Dutch (e.g. *balón* → [*bóme*] 'balloon'). These findings support the claim that the minimal word structure is not so basic in the first stages of the development of the prosodic word in Hebrew.

The production of the trochaic foot accompanied by the truncation of target words with final stress to monosyllabic forms has been documented extensively in many languages, such as English (Echols and Newport 1992, Gerken 1994, Allen and Hawkins 1978, 1980), Dutch (Fikkert 1994), German (Grijzenhout and Joppen 1999), French (Demuth and Johnson 2003), European Portuguese (Vigário, Freitas, and Frota 2006), and Catalan (Prieto 2006).

4.1.3. Stage III—Iambic Foot

During this stage, children begin to produce two syllables for target words with final stress (i.e. WS words) as well as for target words with penultimate stress (i.e. SW words). The additional syllable chosen for production is usually the penultimate one, since it is adjacent to the final stressed syllable, and it seems likely that there is a preference for producing syllables that are adjacent in the input. This requirement for adjacent units in the input to be adjacent in the output, also

[5] Although productions of final stressed targets do not change between stages I and II, it is claimed that these productions in stage II are not remnants from the previous stage since they stay stable for a period of several months. Conversely, most productions of targets with non-final stress become disyllabic in stage II, so this seems like a different stage with different constraints influencing it.

termed "contiguity constraint" is well documented in child phonology (Bernhardt and Stemberger 1998, Van der Pas 2004, Yildiz 2005).

During stage III, the development is limited to the production of target words with final stress. There is no change in the production of target words with non-final stress as shown in Table 3.

Table 3: Children's productions in stage III: The Iambic foot

			Final stress			**Non-final stress**		
	Child		**Output**	**Target**		**Output**	**Target**	
2σ:	NV	1;8	ulám	kulám	'everybody'	tías	tíras	'corn'
	GN	1;3	awáf	xaláv	'milk'	óko	ʃóko	'cocoa drink'
	EZ	1;11	apík	maspík	'enough'	óto	óto	'car'
3σ:	DA	1;1	alá	agalá	'stroller'	téfo	télefon	'telephone'
	NV	1;8	taté	matatá	'broom'	bája	ambátja	'bath'
	GL	1;3	uká	metuká	'sweetheart'	téti	spagéti	'spaghetti'
4σ:	GN	1;8	otám	hipopotám	'hippo-potamus'	tína	klemantína	'tangerine'
	EZ	2;0	kijá	xanukijá	'menorah'	kádo	avokádo	'avocado'

It is during this stage that children produce a non-final and unstressed syllable for the first time. It can be assumed that the children finally reached the point where they produce the unmarked structure of the minimal word in all their polysyllabic productions. However, an alternative view of this stage is that the children progress in the production of the prosodic word and are now more faithful to the target word and that the minimal word structure is not relevant to this production pattern.

All productions are restricted to maximally disyllabic words regardless of the number of syllables in the input because the prosodic word is still limited to the unmarked structure, that is, to comprise a single foot that is binary at most. Evidence for a maximal disyllabic word stage was reported in other research as well (Demuth and Fee 1995, Fikkert 1994, Kehoe 1999/2000, Pater 1997, Pater and Paradis 1996).

4.1.4. Stage IV—Trisyllabic Productions

During this stage, the children begin producing trisyllabic words, thus exhibiting a further development towards production of the target word. These productions are possible when the markedness requirement prohibiting prosodic words from containing unfooted syllables is removed. While all syllables of trisyllabic target words are produced at this stage, only three syllables (usually the last ones) are produced for quadrisyllabic target words, as is shown in Table 4.

Table 4: Children productions during stage IV: the trisyllabic productions

	Child		Final stress Output	Target		Non-final stress Output	Target	
3σ:	GN	1;8	ataná	mataná	'present'	ókolat	ʃókolad	'chocolate'
	NV	1;10	alím	agilím	'earrings'	agévet	magévet	'towel'
	KL	1;7	vivivón	sevivón	'dreidel'	abáta	ambátja	'bath'
4σ:	DA	1;10	popotám	hipopotám	'hippo-potamus'	atína	klemantína	'tangerine'
	AR	2;4	akijá	xanukijá	'menorah'	gagólet	tarnególet	'hen'
	NV	1;11	afefón	melafefón	'cucumber'	ikóter	helikópter	'helicopter'

During this stage, children no longer show more exclusivity to produce words containing only one binary foot, and they start producing more marked word structures containing unfooted syllables. However, words containing two feet are still forbidden and this is why trisyllabic productions precede quadrisyllabic productions.

The findings were inconclusive as to whether trisyllabic productions of target words with non-final stress preceded trisyllabic productions of target words with final stress.

The production of trisyllabic outputs after the minimal word stage (i.e. disyllabic outputs) has also been found in Spanish (Lleo 2006), European Portuguese (Vigário, Freitas and Frota 2006), and another study on the prosodic development in Hebrew (Adam 2002). However, in languages like Dutch and English, quadrisyllabic productions preceded trisyllabic productions (Fikkert 1994, Demuth and Fee 1995).

The order found in Hebrew supports, once again, the preference for producing less structure (more simple structure) before developing a more complex s.

4.1.5. Stage V—The Final Stage (around Age 2;2)

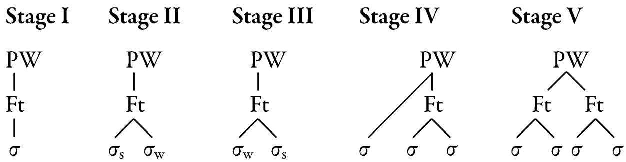
During this stage, the children produce all four syllables from quadrisyllabic target words.[6] The children no longer show consideration for the unmarked structures of the prosodic word and the feet, and they produce words that are faithful to the target words. All target words and children's productions show a final (i.e. right) strong foot as is common in Hebrew.

[6] Since target words with five syllables or more are not part of Hebrew-speaking children's lexicon, they were not tested in this study and there is no way of knowing how they would have been produced at this stage.

4.1.6. Summary

The five stages of prosodic word development in Hebrew are illustrated below:

(4) Stages in prosodic word development



The findings from prosodic word development reveal that there is a strong connection between the order of development and the markedness of the prosodic structures (e.g. a trochee foot is produced before an iambic foot, prosodic words with one binary foot (maximal words) were produced before prosodic words with two feet). However, there is less support for the role of the minimal word as an unmarked structure in the prosodic word development in Hebrew. During Stage I and Stage II, when children truncate target words to monosyllabic productions, there is no evidence for attempts to reach the minimal word structure; on the contrary, the children delete coda consonants and turn potential minimal words into subminimal structures. This is because the requirements that the child's productions be as simple as possible and that no codas be produced are more effective than the markedness requirement that a minimal word be produced.[7]

Two interesting findings derive from these data: (a) Hebrew-speaking children expand the size of the prosodic word from right-to-left, one syllable at a time, starting with the rightmost syllable in words with final stress, and the two rightmost syllables in words with penultimate stress, and (b) The rightmost syllables are the most salient syllables in Hebrew target words, since they are stressed or final, and consequently, they are particularly likely to be produced in first productions.

4.2. *The Development of Syllable Structure within the Evolved Prosodic Word*

The unmarked syllable structure is CV, due to the markedness requirement that every syllable contain an onset and to the prohibition on the production of codas.

---

7) Other investigators also claim that the 'Minimal Word' structure is less evidenced in child language and provide evidence from the phonological phenomena like vowel lengthening (Song and Demuth 2008) and vowel epenthesis (Taelman and Gillis 2008).

This syllable structure is also the most common in early productions of children acquiring different languages. Like other studies, the present study found that CV syllables are very common in early phonological development and more complex syllables, such as CVC or CCV(C), are simplified to the CV structure (e.g. *kmo* → [*mo*] 'like', *gdi* → [*di*] 'young goat', *kos* → [*ko*] 'cup', *jad* → [*ja*] 'hand'). From this stage on, children develop more complex syllable structures while acquiring codas and clusters.[8]

When analyzing the syllable structure of the children's early productions, an interesting phenomenon has been revealed; initial syllables were produced less faithfully to the target syllables than non-initial syllables (mainly final syllables). That is, target syllables with similar structure were produced differently, depending on their position in the word.

Table 5: The relation between syllable structure and position within the word

Child		Syllabic constituent	Final syllable Output	Target	Output	Initial syllable Target		
AR	2;3	Nucleus	d**u**	kad**ú**r	'ball'	tána	t**ú**na	'tuna fish'
GL	1;5	Onset	í**m**a	í**m**a	'mother'	arák	**m**arák	'soup'
MN	1;6	Onset	**d**u	ka**d**úr	'ball'	**b**úbi	**d**úbi	'teddy bear'
KL	1;6	Coda	axá**m**	xaxá**m**	'smart'	bába	bá**m**ba	'type of crisps'

As mentioned above, children expand the prosodic word from right-to-left, and add one syllable at a time. In this section I show that the new syllable is not added as a unit, but rather in stages, first the nucleus, then the onset and finally the coda. Additionally, each one of these sub-syllabic units is not added as the target segment, but is also developed in stages.

The following sub-sections describe the developmental stages of each of the sub-syllabic units, while connecting these stages to the development of the prosodic word.

4.2.1. Syllable Nucleus

The nucleus was the first sub-syllabic unit appearing when a new syllable was added to the prosodic word (e.g. *ʃulxán* → [*axán*] 'table'). In many cases, the vowels of the target words failed to surface in initial syllables, whether stressed

---

[8] For the acquisition of Hebrew word initial clusters, see Ben-David (2001), Bloch (2011), Becker (this volume) and Karni (this volume). For the acquisition of Hebrew codas, see Ben-David (2001), Bat-El (2012, this volume), Becker (this volume), and Adi-Bensaid (this volume).

or unstressed. In this position, some occurrences of vowel harmony were found, as shown in Table 6 below (see Cohen this volume). It is important to clarify that nuclei were usually produced correctly in final syllables and in monosyllabic productions and vowel harmony was rare in these positions. The only cases where the correct vowel was not produced in these positions were when this vowel was not part of the child's segmental inventory (i.e. the production of that vowel has not been mastered yet).

Table 6: Vowel harmony in initial nuclei

Stressed syllables			**Unstressed syllables**		
Output	**Target**		**Output**	**Target**	
áma	íma	'mother'	agá	ugá	'cake'
ála	gíla	'Gila (name)'	adá	todá	'thank you'
éne	íne	'here'	eék	masrék	'comb'
anána	ʃoʃána	'Shoshana (name)'	egegól	tarnegól	'rooster'
evévet	laʃévet	'to sit'	ululáʃ	meʃuláʃ	'triangle'

As noted above, the first disyllabic productions were only words with penultimate stress (i.e. SW words, corresponding to stage II of the prosodic word development). Consequently, the targets of the vowel harmony were only initial stressed syllables, which will be referred to as reduplicated nuclei. Only during the next stage of prosodic word development, when the children started producing disyllabic words with final stress (i.e. WS words, corresponding to stage III of the prosodic word development), the targets of the vowel harmony were initial unstressed syllables. During this stage, a decline in the number of SW productions with vowel harmony was observed. The same pattern appeared again when the children advanced to the next stage of prosodic word development (stage IV) and started producing trisyllabic words. Here again, a decline was observed in the number of vowel harmony cases in WS productions, and vowel harmony appeared in the first syllable of the children's trisyllabic productions. In other words, harmony in the nucleus appeared every time the child produced a new syllable at the level of the prosodic word. No cases of vowel harmony were found in quadrisyllabic productions in the data collected for this study.

When integrating the development of the nuclei with the development of the prosodic word, we can see the stages of Table 7.

Table 7: The development of the nuclei and the prosodic word (PW)[9]

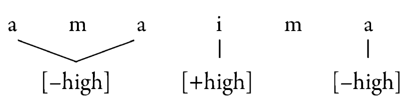
Stage	PW development	Nuclei development	Output	Target	
I	Monosyllabic productions	Correct	to	liʃtót	'to drink'
			ke	ken	'yes'
II	SW productions	A: Reduplicated nucleus	áma	íma	'mother'
		B: Correct	íma		
III	WS productions	A: Reduplicated nucleus	adá	todá	'thank you'
		B: Correct	odá		
IV	Trisyllabic productions	A: Reduplicated nucleus	amalá	nemalá	'ant'
			opóax	efróax	'chick'
		B: Correct	emalá		
			efróax		
V	Quadrisyllabic productions	Correct	melafefón	melafefón	'cucumber'
			avokádo	avokádo	'avocado'

This integration shows that vowel harmony is a stage in the development of the nuclei, before correct production of the nuclei appears.

Vowel harmony is hardly reported in studies of typical phonological development (see Cohen this volume). The reasons could be (i) that children usually acquire vowels earlier than consonants, (ii) that the number of vowel harmony cases according to this study was quite small, and (iii) that there are more appearances of vowel harmony in WS words, which are less frequent in English and Dutch (the two most studied languages).

Vowel harmony can be considered as having a less complex structure. Two identical vowels in adjacent syllables share the same features and therefore comprise less structure in the word than two different vowels, each having a separate set of features.

(5) Harmonic vs. non-harmonic structure: *íma* 'mother'



The tendency towards less complex structures described in the previous section, as it relates to prosodic word development, is shown again here when analyzing syllable structure development (see further discussion in § 5).

[9] Overlap between stages apeared as in every developmental path.

4.2.2. Syllable Onset

Similarly to the findings on the syllable nucleus, the onset of the target word was also usually produced correctly in final syllables and monosyllabic productions (unless the consonant in the onset was not part of the child's consonant inventory). In initial syllables, the onset consonants appeared shortly after the syllable has been produced containing only a nucleus. Thus, the first stage of initial onset development can be considered an onset deletion (e.g. *légo* → [*égo*] 'Lego', *dúbi* → [*íbi*] 'teddy bear').[10] Deletion appeared for all segments, including those that the children have already mastered and which were found in non-initial onset position. Thus, it is more likely that these cases of deletion are due to prosodic factors than to segmental ones.

Afterwards, children began producing consonants in initial onset position, but these were identical to the onset of the following syllable; i.e. the children's productions exhibit consonant harmony (see Gafni this volume), similar to the vowel harmony described in the development of the nucleus (e.g. *légo* → [*gégo*] 'Lego', *dúbi* → [*bíbi*] 'teddy bear'). The majority of the consonant harmony cases was onset-to- onset regressive harmony, and the target was the initial onset, which is referred to here as the "reduplicated onset". It seems like consonant harmony functions as a simplification strategy (as was claimed for vowel harmony), which appears whenever a new onset is developed.

Finally, children began producing the target consonant in onset position. The consonants were pronounced according to the child's segmental abilities, but considered faithful from a prosodic point of view (e.g. *légo* → [*jégo*] 'Lego' (where *l* → [*j*] in other prosodic positions), *dúbi* → [*dúbi*] 'teddy bear').[11]

Similar to the development of the nucleus, these three stages reappeared every time the child progressed in the development of the prosodic word. Initial onset deletion first appeared in SW words, since these were the only polysyllabic words produced at the beginning of the phonological development (stage II). Then consonant harmony appeared in initial onsets, and finally, faithful onsets were produced. Each time the children produced a new syllable at the level of the prosodic word, the same three stages of onset development reoccurred, as shown in Table 8.

---

[10] In many cases, variation between initial onset deletion and replacement of the initial target consonant by a glottal stop can be seen in the same child and within the same words. Sometimes, a glottal stop can be heard at the beginning of a single word but it disappears when the word is in non-initial position in a phrase. Thus, it is more likely that the glottal stop is inserted after the deletion as a phonetic process since phrases cannot be vowel-initial.

[11] Complex onsets are not produced at this stage and still need to be developed, but this development is beyond the scope of this paper.

Table 8: Stages of onset development

Stage	PW development	Onset development		Output	Target	
I	Only monosyllabic productions	Correct		ja ko pi	jad kos kapít	'hand' 'cup' 'teaspoon'
II	SW productions	A:	Initial onset deletion	ésa	pétsa	'wound'
		B:	Initial onset reduplication	sésa		
		C:	Correct	pésa		
III	WS productions	A:	Initial onset deletion	itá	mitá	'bed'
		B:	Initial onset reduplication	titá		
		C:	Correct	mitá		
IV	Trisyllabic productions	A:	Initial onset deletion	ataná abólet	mataná karbólet	'present' 'crest of a male bird'
		B:	Initial onset reduplication	tataná babólet		
		C:	Correct	mataná kabólet		
V	Quadrisyllabic productions	Correct		makaróni televíza	makaróni televízja	'macaroni' 'television'

It is important to add that not all three stages of initial onset development faded before the child moved to the next stage of prosodic word development. There are many overlaps between stages, but the developmental pattern is retained.

No cases of initial onset deletion or consonant harmony were found in quadrisyllabic productions in the data collected for this study.

Since CV is the unmarked syllable structure, we would expect children to produce onset consonants in all their syllables even newly added ones. Fikkert (1994) reported that Dutch speaking children not only produce initial consonants in all their syllables, but they also add onset consonants to target words with empty initial onsets at the beginning of their initial onset development (e.g. *auto* → [*tó:to:*] 'car'). Similar findings were reported for Greek (Kappa 2002), French (Rose 2000) and English (Cruttenden 1978). Studies such as these led investigators to conclude that initial consonant deletion is an atypical and non-developmental phonological process.

However, other studies found that initial consonant deletion exists in the earlier periods of development in Hebrew (Karni 2011, this volume), Maltese

(Grech 2006), Finnish (Savinainen-Makkonen 2000), Putonghua (Hua 2006), and German (Grijzenhout and Joppen-Hellwig 2002). Different explanations were provided to this peculiar phenomenon. Some studies argue that onset deletion results from segmental difficulty, i.e. children delete initial consonants like liquids or fricatives because of their articulatory complexity (Grijzenhout and Joppen-Hellwig 2002, Costa and Freitas 1996, Stoel-Gammon and Dunn 1985). Vihman and Croft (2007) provide a different explanation, that when children are learning pronunciation of another part of the word (e.g. the lengthening of a medial consonant or final vowel) their attention is drawn away from the initial segment.

The findings of this study support to some extent Vihman and Croft's "learning explanation" since, as was emphasized earlier, (i) no segmental difficulty effect was found in the data, and (ii) children are learning to produce the prosodic word at the same stage in which they delete the initial onsets. However, it is important to note that when they begin to develop the onset, the development process is graduated according to the complexity of the production. At first, no consonant in onset position, then reduplicated consonant, which is less complex due to feature sharing with the next onset, and finally the correct consonant. This is additional evidence that in the initial stages of phonological development, children prefer to produce as simple structures as possible, even if these are not the unmarked ones.

4.2.3. Syllable Coda

The coda was initially deleted from almost all the children's productions (e.g. *sús* → [*sú*] 'horse', *tanín* → [*ní*] 'crocodile'). Coda production followed the production of the onset and the onset production almost always preceded the coda production within the same syllable.

In final syllables, no specific prosodic stage was recognized, i.e. after the deletion stage the coda appeared with some segmental preferences which will not be described here (see Ben-David 2001). Later, children produced the coda in non-final syllables, but only in syllables within the word's strong (final) foot. Thus, the coda in the second syllable (C_2) of a $CVC_1.CVC_2.CV$ word was produced, but that in the first syllable (C_1) was not (e.g. *abátja* for *ambátja* 'bath'). Finally, codas are produced correctly in all syllables.

At the beginning of coda production in non-final syllables, a few examples were found for coda-to-coda consonant harmony (e.g. *lidfók* → [*likfók*] 'to knock', *sandál* → [*saldál*] 'sandal'). Another finding from these examples is that in their first non-final coda productions, some children produced target words with identical consonants in final and non-final positions (e.g. [*bakbúk*] 'bottle', [*lixlúx*] 'dirt'), and there was also one case of metathesis that resulted in identical coda consonants (e.g. *zormím* → [*zomrím*] 'flow ms.pl.'). These productions suggest that there is an intermediate stage between deletion and correct production of codas in non-final syllables (i.e. coda reduplication) similar to the findings for onsets and nuclei development. Although these were only a few examples and though the same findings have not been attested in other studies on the development of non-final codas by Hebrew-speaking children (Kaltum-Roisman 2008, Gishri 2009), it seems that this coda-to-coda harmony is a phenomenon which cannot be ignored. The harmony was found in half of the children in this study (i.e. 5 out of 10), and for every such child there was more than one example during the same developmental stage, which is at the beginning of non-final coda production. Perhaps the small amount of evidence of this type of consonant harmony is due to the fact that medial codas in Hebrew are acquired at a late stage in the developmental process, when development is more rapid and details are obscured. The coda reduplication stage is similar to the reduplication strategies described for the nucleus and for the onset and provides further evidence to the finding that sub-syllabic units are developed gradually. Unfortunately, the small number of examples does not enable us further analysis of coda harmony with reference to stress or word length.

The stages of coda development are summarized below:

(6) Stages of coda development

Stage I:	Coda deletion in all prosodic positions
Stage II:	Faithful production of word-final and stressed codas only
Stage III:	Faithful production of all word-final codas
Stage IV:	Non-final coda reduplication
Stage V:	Faithful production of medial codas in the penultimate syllable
Stage VI:	Faithful production of all medial codas

5. General Discussion

The above analysis of the prosodic development in the speech of Hebrew-speaking children revealed two main findings. The first is that although children's output productions usually progress from unmarked to more marked structures during the course of development, the role of universal markedness is not always recognized. One example of this was the evidence that the role of minimal word structure is not of paramount importance in prosodic word development, unlike what has been described for some other languages. In fact, in Hebrew there is no crucial evidence that the minimal word influences the development path at all, other than to function as a maximal word during Stage III of the prosodic word development. It is not argued that markedness constraints do not affect the developmental process; on the contrary, many markedness constraints influence this process (e.g. trochaic foot, codaless syllables), but some do not.

Another example of the non-influence of universal markedness on the development is the initial onset deletion process, which runs counter to the markedness requirement that every syllable has an onset (see further discussion in Karni 2011, this volume).

The commonality of these two processes is that both require a structure to be produced (i.e. the minimal word requires words to contain two syllables or moras, and onset requires syllables to have an onset). On the other hand, almost all other markedness constraints restrict the structures (e.g. the requirement that syllables do not have a coda or a branching structure, the requirement that the prosodic word does not have more than one foot). The evidence from Hebrew prosodic development reveals that children's structure at the beginning of the development is affected more by the restricting constraints than by those requiring structure.

This leads to the conclusion that children show preference for structural simplicity aimed at simplifying their early productions as much as possible. Whenever this need for simplicity corresponds to the markedness structures (i.e. no coda), it is impossible to decide whether it was the universal markedness that influenced the productions or the need to produce as simple a structure as possible. However, when these two factors conflict, the evidence indicates that the children give preference to structural simplicity rather than to universal markedness.

The second finding of this study is that children "build" their words from right to left. Since the majority of words in Hebrew have final or penultimate stress, both stressed and final syllables are located at the end of the word and are rarely omitted. However, while the final syllable is not subject to prosodic changes (except for coda deletion at the beginning of the developmental process), the penultimate syllable is. Even in SW words, which occur very early in the child's productions (stage II), cases of initial consonant deletion and harmony of the nuclei and the onset of the first syllable can be detected. As described above, whenever a syllable is added to the prosodic word, it is added towards the beginning of the word.

When syllables are added to the prosodic word, they are not added as a unit but rather, in stages—first the vowel and then the onset; the coda is usually the last to be realized. The graded order of syllable building is realized (onsets and codas) in deletion and reduplication, which are the building stages of the initial sub-syllabic units of the syllable just added to the prosodic word. Thus, it is almost impossible to separate prosodic word development from syllable development. Even though the strategies for syllable building are not unique to Hebrew development, some of the strategies are more prominent due to language-specific characteristics.

References

Adam, Galit. 2002. *From variable to optimal grammar: Evidence from language acquisition and language change*. Ph.D. dissertation, Tel-Aviv University.

Adam, Galit, and Outi Bat-El. 2008. Segmental effects on syllable selection: Evidence from Hebrew. In A. Gavarró, and M. Freitas (eds), *Language Acquisition and Development: Proceedings of GALA 2007*, 1–11. Newcastle: Cambridge Scholars Publishing.

Adam, Galit and Outi Bat-El. 2009. When do universal preferences emerge in language development? The acquisition of Hebrew stress. *Brill's Annual of Afroasiatic Languages and Linguistics* 1:255–282.

Adi-Bensaid, Limor. this volume. The role of prominence and position in the acquisition of codas in the speech of hearing-impaired children.

Allen, George, and Sarah Hawkins. 1978. The development of phonological rhythm. In A. Bell and J. Hooper (eds), *Syllables and Segments*, 173–185. Amsterdam: North-Holland Publishing Company.

Allen, George, and Sarah Hawkins. 1980. Phonological rhythm: Definition and development. In G. Yeni-Komshian, J. Kavanagh, and C. Ferguson (eds), *Child phonology: Production*, 227–256. New York: Academic Press.

Bat-El, Outi. 1993. Parasitic metrification in the Modern Hebrew stress system. *The Linguistic Review* 10:189–210.

Bat-El, Outi. 2005. The emergence of the trochaic foot in Hebrew hypocoristics. *Phonology* 22:1–29.

Bat-El, Outi. 2009. Harmonic domains and synchronization in typically and atypically developing Hebrew-speaking children. *Language Sciences* 31:117–135.

Bat-El, Outi. 2012. The role of sonority in the acquisition of Hebrew word final codas. In S. Parker (ed.), *The Sonority Controversy*. Berlin: Mouton de Gruyter.

Bat-El, Outi. this volume. Phonological constraints on morphological development: The acquisition of Hebrew verb inflectional suffixes.

Becker, Michael. this volume. Target selection in error selective learning.

Beckman, Jill. 1998. Positional Faithfulness. Ph.D. dissertation, University of Massachusetts Amherst.

Ben-David, Avivit. 2001. *Language Acquisition and Phonological Theory: Universal and Variable Processes Across Children and Across Languages*. Ph.D. Dissertation, Tel-Aviv University. [in Hebrew].

Bernhardt, Barbara and Joseph P. Stemberger. 1998. *Handbook of Phonological Development: From the Perspective of Constraint-based Nonlinear Phonology*. San Diego, Academic Press.

Bloch, Tamar. 2011. *Simplification Patterns in the Acquisition of Word Initial Consonant Clusters in Hebrew*. M.A. thesis, Tel-Aviv University.

Bolozky, Shmuel. 1982. Remarks on rhythmic stress in Modern Hebrew. *Journal of Linguistics* 18: 275–289.

Bolozky, Shmuel and Michael Becker. 2006. *Living Lexicon of Hebrew Nouns*. Ms., University of Massachusetts Amherst. Available at http://becker.phonologist.org/LLHN.

Cohen-Gross, Dalia. 1996. *The morphological-syllabic structure of Modern Hebrew*. Ph.D. dissertation, Bar-Ilan University. [in Hebrew].

Costa, João, and Maria João Freitas. 1998. V and CV as unmarked syllables: Evidence from the acquisition of Portuguese. A paper presented at the conference on the syllable typology and theory, Tübingen, July.

Cruttenden, Alan. 1978. Assimilation in child language and elsewhere. *Journal of Child Language* 5:373–378.

Demuth, Katherine. 1996. The prosodic structure of early words. In J. Morgan and K. Demuth (eds), *Signal to Syntax: Bootstrapping from Speech to Grammar in Early Acquisition*, 171–184. Mahwah, NJ: Lawrence Erlbaum.

Demuth, Katherine, Jennifer Culbertson and Jennifer Alter. 2006. Word-minimality, epenthesis, and coda licensing in the acquisition of English. *Language and Speech* 49:137–174.

Demuth, Katherine, and Jane Fee. 1995. Minimal prosodic words in early phonological development. Ms., Brown University and Dalhousie University.

Demuth, Katherine, and Mark Johnson. 2003. Truncation to subminimal words in early French. *Canadian Journal of Linguistics* 48:211–241.

Echols, Catharine, and Elissa Newport. 1992. The role of stress and position in determining first words. *Language Acquisition* 2:189–220.

Fikkert, Paula. 1994. *On the Acquisition of Prosodic Structure*. Dordrecht: ICG Printing.

Fikkert, Paula, and Maria João Freitas. 1997. Development of syllable structure constraints: Evidence from Dutch and Portuguese. In A. Sorace, C. Heycock and R. Shillock (eds), *Language Development: Knowledge Representation and Processing: Proceedings of GALA '97*, 217–222. Edinburgh: Edinburgh University Press.

Fitzpatrick-Cole, Jennifer. 1991. The Minimal Word in Bengali. In A. Halpern (ed.), *Proceedings of the West Coast Conference on Formal Linguistics 9*, 157–170. Stanford, CA: CSLI Publications.

Garrett, Susan. 1998. Positional Faithfulness and Truncation in Child Speech. In P. Tamanji and K. Kusumoto (eds), *Proceedings of the North East Linguistic Society 28*, 63–76. Amherst, MA: GLSA.

Gerken, LouAnn. 1994. A metrical template account of children's weak syllable omissions. *Journal of Child Language* 21:565–584.

Gishri, Michal. 2009. *The Role of Prominence in the Acquisition of Medial Codas in Hebrew: Evidence from a Slow Developer*. M.A. thesis, Tel-Aviv University.

Gnanadesikan, Amalia. 2004. Markedness and faithfulness constraints in child phonology. In R. Kager, J. Pater, and W. Zonneveld (eds), *Constraints in Phonological Acquisition*. Cambridge: Cambridge University Press.

Goad, Heather. 1997. Consonant harmony in child language: An Optimality-Theoretic account. In S. Hannahs and M. Young-Scholten (eds), *Focus on Phonological Development*, 113–142. Amsterdam: John Benjamins.

Graf, Dafna, and Adam Ussishkin. 2003. Emergent iambs: Stress in Modern Hebrew. *Lingua* 113:239–270.

Grech, Helen. 2006. Phonological Development of Maltese-Speaking Children. In Z. Hua and B. Dodd (eds), *Phonological Development and Disorders in Children: A Multilingual Perspective*, 135–178. Clevedon: Multilingual Matters.

Grijzenhout, Janet and Sandra Joppen. 1999. First steps in the acquisition of German consonants: Minimal constraint demotion. Ms., Heinrich-Heine-Universität Düsseldorf.

Grijzenhout, Janet, and Sandra Joppen-Hellwig. 2002. The Lack of Onsets in German Child Phonology. In I. Lasser (ed.), *The Process of Language Acquisition*, 319–339. Frankfurt am Main: Peter Lang Verlag.

Hayes, Bruce. 1986. Inalterability in CV phonology. *Language* 62: 321–351.

Hua, Zhu. 2006. The normal and disordered phonology of Putonghua (Modern Standard Chinese)-speaking children. In Z. Hua and B. Dodd (eds), *Phonological Development and Disorders in Children: A Multilingual Perspective*, 81–108. Clevedon: Multilingual Matters.

Hyman, Larry. 1985. *A Theory of Phonological Weight*. Dordrecht: Foris.

Jakobson, Roman. 1941/1968. *Child Language, Aphasia, and Phonological Universals*. Mouton: The Hague and Paris.

Kaltum-Roisman, Keren. 2008. *Word-position, Length and Manner of Articulation Effects on Coda Production by Hebrew-speaking Children*. M.A. thesis, Tel-Aviv University. [in Hebrew].

Karni, Noa. this volume. Minimizing faithfulness violation in the acquisition of Hebrew onsets.

Kappa, Ioanna. 2002. On the acquisition of syllable structure in Greek. *Journal of Greek Linguistics* 3:1–52.

Karni, Noa. 2011. *Chain Shift and Local Constraint Conjunction in the Acquisition of Hebrew Onsets*. M.A. thesis, Tel-Aviv University.

Kehoe, Margaret. 1999/2000. Truncation without shape constraints: The latter stages of prosodic acquisition. *Language Acquisition* 8:23–67.

Kehoe, Margaret, and Carol Stoel-Gammon. 1997a. The acquisition of prosodic structure: An investigation of current accounts of children's prosodic development. *Language* 73:113–144.

Laufer, Asher. 1992. *Introduction to Linguistics: Phonetics and Phonology*. Tel-Aviv: The Open University. [in Hebrew].

Levelt, Clara, Niels Schiller, and Willem Levelt. 2000. The acquisition of syllable types. *Language Acquisition* 8:237–264.

Lleó, Conxita. 2006. The Acquisition of prosodic word structures in Spanish by monolingual and Spanish-German bilingual children, *Language and Speech* 49:207–231.

Lohuis-Weber, Heleen, and Wim Zonneveld. 1996. Phonological acquisition and Dutch word prosody. *Language Acquisition* 5:245–283.

McCarthy, John and Alan Prince. 1986. *Prosodic morphology*. Ms., University of Massachusetts, Amherst, and Brandeis University, Waltham, Mass.

Nespor, Marina, and Irene Vogel. 1986. *Prosodic Phonology*. Dordrecht: Foris.

Ota, Mitsuhiko. 2001. Phonological theory and the acquisition of prosodic structure: Evidence from child Japanese. *Annual Review of Language Acquisition* 1:65–118.

Pater, Joe. 1997. Minimal violation and phonological development. *Language Acquisition* 6:201–253.

Pater, Joe, and Johanne Paradis. 1996 Truncation without templates in child phonology. In *Proceedings of the 20th annual Boston University Conference on Language Development*. Cascadilla Press, Somerville, MA.

Prieto, Pilar. 2006. The relevance of metrical information in early prosodic word acquisition: A comparison of Catalan and Spanish. *Language and Speech*. 49:233–261.

Rose, Yvan. 2000. *Headedness and Prosodic Licensing in the L1 Acquisition of Phonology*. Ph.D. dissertation, McGill University.

Salidis, Joanna, and Jacqueline Johnson. 1997. The production of minimal words: A longitudinal case study of phonological development. *Language Acquisition* 6:1–36.

Savinainen-Makkonen, Tuula. 2000. Word-initial consonant omissions: A developmental process in children learning Finnish. *First Language* 20:161–185.

Segall, Osnat, Bracha Nir-Sagiv, Liat Kishon-Rabin and Dorit Ravid. 2009. Prosodic patterns in Hebrew child-directed speech. *Journal of Child Language* 36:629–656.

Schwartz, Richard, and Laurence B. Leonard. 1982. Do children pick and choose? *Journal of Child Language* 9:319–336.

Selkirk, Elizabeth. 1984. *Phonology and Syntax: The Relation between Sound and Structure*. Cambridge, MA: MIT Press.

Smith, Jennifer. 2002. *Phonological Augmentation in Prominent Positions*. Ph.D. dissertation, University of Massachusetts, Amherst.

Song, Jae Yung, and Katharine Demuth. 2008. Compensatory vowel lengthening for omitted coda consonants: A phonetic investigation of children's early representations of children's early representations of prosodic words. *Language and Speech* 51:385–402.

Stoel-Gammon, Carol, and Carla Dunn. 1985. *Normal and Disordered Phonology in Children*. Austin, TX: Pro-Ed.

Taelman, Helena, and Steven Gillis. 2008. Is epenthesis a means to optimize feet? A reanalysis of the CLPF database. *Journal of Child Languag*, 35: 439–452.

Van der Pas, Brigit. 2004 Contiguity in phonological acquisition. In J. van Kampen and S. Baauw (eds), *Proceedings of Generative Approaches to Language Acquisition v2*, 353–364. Utrecht: LOT Occasional Series 3.

Vigário, Marina, Maria João Freitas and Sónia Frota. 2006. Grammar and frequency effects in the acquisition of the prosodic word in European Portuguese. *Language and Speech* 49:175–203.

Vihman, Marilyn, and William Croft. 2007. Phonological development: Toward a 'radical' templatic phonology. *Linguistics* 45:683–725.

Walter, Mary-Ann. 2002. Final position, prominence, and licensing of contrasts. A handout for a talk delivered at 2nd Annual Conference on Contrast and Complexity in Phonology. Toronto.

Yildiz, Yasemin. 2005. The structure of initial /s/-clusters: Evidence from L1 and L2 acquisition. In M. Tzakosta, Cl. Levelt and J. van der Weijer (eds), *Developmental Paths in Phonological Acquisition*, 163–187. Special issue of *Leiden Papers in Linguistics*. 2.1.

BAALL
BRILL Brill's Annual of Afroasiatic Languages and Linguistics 4 (2012) 80–103 brill.com/baall

Minimizing Faithfulness Violation in the Acquisition of Hebrew Onset*

Noa Karni
Department of Linguistics, Tel-Aviv University
noakar@post.tau.ac.il

Abstract
Data obtained in a longitudinal study of three Hebrew-acquiring children indicate the existence of a stage in which target words with word-initial simple onsets are produced without an initial onset, while target words with an initial complex onset are produced with a simple onset. This is a case of chain shift, where the output of cluster simplification ($_{w}$[CCV → $_{w}$[CV) is the input of onset deletion ($_{w}$[CV → $_{w}$[V), but forms derived from cluster simplification do not result in onset deletion ($_{w}$[CCV → *[V). Assuming the constraint-based framework of Optimality Theory (Prince and Smolensky 1993/2004), the main question to be addressed is how can we account for different outputs for input-simple onsets compared to input-complex onsets during the same stage of phonological development? In addition, given the principles of universal markedness and their role in language acquisition, how can we account for the production of onsetless syllables for targets with onsets? I argue that the underlying motivation for omission is an increase in prosodic complexity, and propose an analysis based on local constraint conjunction (Smolensky 1993) to provide a unified developmental account of simple and complex onsets.

Keywords
language acquisition; phonology; onsets; chain shift; optimality theory; local conjunction

1. Introduction

This paper is concerned with chain shift effects in the acquisition of word-initial onsets in Hebrew. Data obtained from three children acquiring Hebrew indicate the existence of a stage in which polysyllabic target words with word-initial simple onsets are produced without an initial onset (e.g. *giná* 'garden' → *iná*), while target words with an initial complex onset are realized with a simple onset

*) I am grateful to Outi Bat-El, Galit Adam, Evan Cohen, Avivit Ben-David, Michael Becker, Suhair Abed Elghani, Chen Gafni, Hadas Yeverechyahu, Hadass Zaidenberg, Avi Mizrachi, and Ezer Rasin for their valuable insights. I would also like to thank the two anonymous reviewers for their helpful comments, as well as the participants of the 2011–2012 TAU phonology circle.

 DOI: 10.1163/18776930-00400004

(e.g *gviná* 'cheese'→ *giná*). This state of affairs falls within the criteria of a chain shift (Kirchner 1995, 1996, Dinnsen and Barlow 1998), whereby the output of cluster simplification (*gviná* → *giná*) is identical to the input of onset deletion (*giná* → *iná*).

Within a rule-based framework (Chomsky and Halle 1968), a chain shift effect can be accounted for using a counterfeeding order of rules. However, it poses a challenge to the non-derivational framework of Optimality Theory (Prince and Smolensky 1993/2004). In Optimality Theory, surface forms are selected according to a language specific constraint ranking. The two major types of constraints are markedness constraints, representing conditions on the well-formedness of surface structures, and faithfulness constraints, acting to preserve lexical contrast through correspondence between input and output forms (McCarthy and Prince 1995). The process of language acquisition involves the gradual reranking of these universal constraints towards the hierarchy in the target language (Tesar and Smolensky 1996), and each stage in development is characterized by a single ranking of constraints. Therefore, if the input *giná* is produced as *iná* due to markedness constraints, the input *gviná* is expected to be produced as *iná* as well during the same stage. Under the assumption of strict domination (Prince and Smolensky 1993/2004), the same ranking between the anti-omission constraint and the conflicting markedness constraint cannot account for the different outputs *iná* and *giná* during the same stage of phonological development.

This paper offers an analysis based on local constraint conjunction (Smolensky 1993), which has been employed in Kirchner's (1995,1996) account of synchronic chain shifts. This notion refers to the combined effect of two conjoined constraints as opposed to the effect of each constraint independently. Under this approach, ranking the self-conjoined faithfulness constraint prohibiting consonant deletion (along with the markedness constraint prohibiting clusters) above the markedness constraint prohibiting onsets will correctly predict the omission of one, but not two onset consonants in complex-onset targets.

The production of onsetless forms for target words that have an initial onset poses another challenge, as it results in the substitution of the universally unmarked CV syllable structure with the relatively marked V structure. This is surprising because child grammar is usually characterized by processes that reduce relative markedness, not increase it. A closer look at the data reveals the omission of onsets to be systematic, as well as context-specific; while all three children omit the onset in polysyllabic productions, two of the children do not omit the onset in monosyllables. Although one child did omit the onset in monosyllables, the omission rate was significantly lower in these productions compared to the omission rate in polysyllabic productions. I will argue that this context-specific omission implies the process is triggered by an increase in prosodic complexity (see also Ben-David 2001, this volume). This is further substantiated by the omission of word-initial onsets in later attempted tri- and quadrisyllabic targets.

In § 2, I provide quantitative and qualitative data, which allow to draw generalizations regarding the stages of simple and complex onset development in Hebrew. I then propose an Optimality Theoretic analysis in § 3, which provides a unified developmental account. Concluding remarks are provided in § 4.

2. The Development of Simple and Complex Onsets

After providing details regarding data collection and quantitative evaluation (§ 2.1), I introduce the phenomenon of simple onset deletion (§ 2.2), with emphasis on the distinction between mono- and polysyllabic productions (§ 2.3). Then I discuss complex onset simplification (§ 2.4) and proceed with the main issue of this paper, i.e. chain shift effects in the development of onsets (§ 2.5).

2.1. *Research Method*

The data are drawn from a longitudinal study of three monolingual children: RM (1;04–2;03 girl), SR (1;02–2;0 boy), and YV (1;03–2;10 boy), where the latter was diagnosed with mild Pervasive Developmental Disorder (PDD).[1] The children were recorded during hour-long sessions on a weekly basis in their natural environment, starting from the pre-speech (babbling) stage. Recordings include spontaneous speech as well as naming tasks. Stimuli in naming tasks were designed to elicit all segments and possible prosodic structures and stress patterns in Hebrew. The recordings were transcribed using the CHAT transcription format designed for CHILDES. Sessions with each child were recorded and transcribed by the same investigator, with the exception of one child, RM, who was recorded by one investigator and transcribed by another for the most part. The transcribers, trained linguists, held frequent meetings and followed the same guidelines and conventions as directed by the project supervisors. Transcripts include a specified account of the children's productions and the intended targets in phonemic and phonetic (IPA font) transcription, and phonemic transcription of utterances made by the investigator or other participants when preceding/following or otherwise relating to the children's utterances.

Only words with clear targets were taken into account in the analysis. Since the phenomenon under discussion refers to the onset position, cases that could result in re-syllabification were excluded (i.e. non-utterance-initial productions,

---

[1] The data are drawn from the database of the Adam and Bat-El Child Language Project (ISF grant #554/04).

such as *ʃel óni → ʃe.lo.ni* for the target *ʃel ʁóni* 'of (possess.) Roni'). Non-major lexical items (e.g. *zé* 'this', *kazé* 'like this one') and onomatopoeic productions (e.g. *gága* 'duck quack', *kwakwa* 'frog croak') were also excluded, as well as glottal initial targets (e.g. *hipopotám* 'hippopotamus') as glottals are often omitted in speech (*hipopotám ~ ipopotám*).

The count is based on productions per session. Repetitions within the same session (not necessarily immediate) were counted only once. For the purpose of calculating the rate of omission, faithful productions were defined as productions that included a word-initial onset consonant, regardless of the quality of the consonant. That is, if the child substituted one consonant for another in word-initial onset position in two productions of the same target word, the productions were not counted twice (e.g. *sipúr* and *tipúr* for *sipúr* 'story', *pláster* and *kláster* for *pláster* 'band-aid'). Productions that differed in the number of syllables were not considered repetitions and were counted separately (e.g. *púax* and *tapúax* for *tapúax* 'apple').

I adopted Adam and Bat-El's (2008, 2009) methodological tool of the division of periods on the basis of lexical development. The lexical development is measured by cumulative target attempts on a scale of approximately 50 new word types per period. Under this approach, the data are evaluated and compared based on the children's lexical development, eliminating the effect of age-related differences.

2.2. *Simple Onset Omission*

All three children produced word-initial onsetless syllables. The examples in Table 1 suggest that onset omission affected all types of segments, although, as shown in § 2.3, sonorants exhibit the highest omission rate.

Table 1: Productions of word-initial onsetless syllables

Child	**Age**	**Target onset**	**Output**	**Target**	
RM	1;08.07	d	éve	dévek	'glue'
RM	1;05.29	k	adú	kadúʁ	'ball'
YV	2;00.26	k	éʃet	kéʃet	'arch'
SR	1;05.15	ʃ	émeʃ	ʃémeʃ	'sun'
RM	1;10.13	m	ətá	mitá	'bed'
SR	1;06.20	m	itá	mitá	'bed'
YV	2;01.22	m	áka	málka	'Malka (name)'
SR	1;05.04	n	úki	pinúki	'Pinuki (name)'
SR	1;07.09	l	aʃón	laʃón	'tongue'
RM	2;00.16	l	éxem	léxem	'bread'
YV	2;03.19	l	et͡sá	leyt͡sán	'clown'
YV	1;06.05	ʁ	úwaa	ʁúax	'wind'

Table 2 below presents for each child the overall proportion of simple onset omission and preservation in all 14 periods combined.[2]

Table 2: Faithful and onsetless polysyllabic productions

			Target		**Output**			
Child	**Period**	**Age**	**Structure**	**Total**	**$_w$[CV**		**$_w$[V**	
RM	1–14	1;04–2;03	$_w$[CV	728	625	85.9%	103	14.1%
SR	1–14	1;02–2;00	$_w$[CV	1075	879	81.8%	196	18.2%
YV	1–14	1;03–2;10	$_w$[CV	750	571	76.1%	179	23.9%

The highest rate of omission ($_w$[V) is found in YV's productions. Recall that YV had been diagnosed with mild PDD and is considered to be a slow developing child (Gishri 2009). His development differs from that of RM and SR in several aspects, as will be shown in the following sections.

The substitution of the unmarked CV syllable with the relatively marked V syllable is unexpected, given the typology of syllable structure, and that this pattern is unattested in fully developed languages. While it is true that languages that permit onsetless syllables often do so in word-initial position, the process of omitting an underlying onset is, it seems, unique to child language (excluding omission in cluster simplification processes).[3]

The omission of onsets is even more unexpected considering the loss of lexical information borne by consonants (compared to vowels) and contextual strength relations. This notion refers to the asymmetry in the behavior of phonological elements in different positions, specifically prominent vs. non-prominent positions (Casali 1996, Beckman 1998, Lombardi 1999, Smith 2000). Cross linguistically, phonological units in certain positions tend to maintain contrast and resist processes of neutralization. Such positions include roots, initial position (in syllable, foot or word), and stressed positions, and are perceived as more salient. In contrast, units in perceptually weak positions (e.g. medial and unstressed positions) are more likely to undergo such processes. In light of these observations, the omission of word-initial onset consonants seems to contradict the natural tendency to preserve information in prominent positions.

---

2) The rate of onset omission per period reached 45% (19/42; 31/69 respectively) in RM and YV's productions and 35% (53/149) in SR's productions at the highest point. Following McReynolds and Elbert's (1981) proposal, these numbers meet the criteria for defining an active process (occurrence in at least 20% of target words).

3) Although it is widely agreed upon that languages that allow onsetless syllables also allow syllable onsets but not necessarily vice versa, there have been arguments in support of syllabification of consonants as codas rather than onsets in the central Australian language of Arrernte (Breen and Pensalfini 1999).

Nevertheless, a closer look at child phonology reveals more such 'unnatural' processes. Dinnsen and Farris Trimble (2009) as well as Buckley (2003) present evidence of voice, manner and place contrasts being reduced in onset position while maintained in coda position. Inkelas and Rose (2008) discuss velar fronting and lateral gliding in word-initial and/or stressed onsets. Neutralization in these prosodically-prominent positions is prevalent in child, but not adult language. Another significant fact is that the omission of onsets during acquisition is consistently observed cross linguistically. Apart from Hebrew, children acquiring Portuguese, English, German, French and Italian have been reported to omit onset consonants (see Ben-David 2001, Buckley 2003, Dinnsen and Farris-Trimble 2009, and references therein). This leads us to conclude that there must be an underlying motivation for the children's production of word-initial onsetless syllables.

The next section investigates the possible effect of prosodic complexity on the production of word-initial onset consonants.

2.3. *Monosyllabic vs. Polysyllabic Words*

The comparison between monosyllabic and polysyllabic productions in the context of onset omission will focus on the class of sonorants. This is due to the fact that for all three children, sonorants exhibit the highest omission rate. The overall omission rate of sonorants in the children's productions is 41 % (275/673) while the omission rate of obstruents is 10 % (178/1795). Corresponding to the Sonority Sequencing Principle (Clements 1990), the selection of a low sonority onset contributes to the optimization of syllable structure as it maximizes the rise in sonority from onset to nucleus (see also Topintzi 2005 on the relation between onset sonority, syllable well-formedness and moraicity). The lower omission rate of obstruents compared to sonorants, exhibited in the productions of all three children, is naturally predicted in this context. The omission rate in monosyllabic compared to polysyllabic productions is provided in Table 3.

Table 3: Omission rate in monosyllabic vs. polysyllabic productions

RM	ʁ		l		j		m		n	
Polysyllabic	11/29	38 %	11/36	31 %	10/36	28 %	15/81	19 %	5/35	14 %
Monosyllabic	0/14	0 %	0/3	0 %	11/29	38 %	0/12	0 %	0/15	0 %
SR	**j**		**ʁ**		**l**		**n**		**m**	
Polysyllabic	24/44	55 %	30/56	54 %	17/42	40 %	12/32	38 %	18/85	21 %
Monosyllabic	0/12	0 %	2/18	11 %	0/0	0 %	0/5	0 %	0/10	0 %
YV	**l**		**m**		**ʁ**		**n**		**j**	
Polysyllabic	16/21	76 %	68/92	74 %	17/24	71 %	15/32	47 %	6/28	21 %
Monosyllabic	9/26	35 %	4/22	18 %	25/43	58 %	6/39	15 %	25/51	49 %

The figures above indicate a difference in the rate of omission between polysyllabic and monosyllabic productions. In fact, SR seems to avoid producing onsetless monosyllabic words altogether (Fisher's exact test determined $p<0.0001$ for SR and $p=0.139$ for RM). Although there is a higher rate of [j] omission in RM's monosyllabic productions, omissions occur in the same word (*jeʃ* 'there is'), possibly pointing to a different cause in this case. The same cannot be said for YV, as there is no apparent reason for the higher omission rate of [j] in his monosyllabic productions. However, apart from [j], the relatively low rate of omission in monosyllabic compared to polysyllabic words is evident in YV's productions as well ($p<0.0001$).

This difference could imply that the context for omission is a higher level of prosodic complexity. The children do not produce these forms because of syllable well-formedness, they produce them *in spite* of it. Following Jakobson (1941/1968), the prediction regarding markedness and acquisition is that unmarked structures will be produced prior to relatively marked ones. However, when it comes to the acquisition of prosodic structures, a slightly different generalization can be made: Where markedness and prosodic complexity do not conform, complexity prevails. Thus, children produce sub-Minimal Words before producing the universally unmarked binary foot (Demuth 1995, Demuth and Fee 1995, Ben-David 2001, this volume, Adam 2002). As Ben-David (2001, this volume) notes, the nucleus is the minimal syllabic unit. Vowels are also more perceptually prominent and require minimal effort in production compared to consonants. Therefore, each new syllable that is added will initially consist of a vowel.

This claim is supported by the omission of onsets in productions of longer target words, observed in Ben-David (2001, this volume) and the present study. However, the number of onsetless tri- and quadrisyllabic productions is smaller compared to disyllabic productions, indicating the transition between stages of prosodic development is faster at this point in development.

Table 4: Productions of tri- and quadrisyllabic targets

Child	Age	Output	Target	
RM	1;08.27	edáim	jadáim	'hands'
RM	1;09.18	abáim	garbáim	'socks'
RM	1;09.27	emíma	jemíma	'Yemima (name)'
RM	2;01.27	átat͡sim	nát͡snat͡sim	'sparkles'
RM	2;02.04	avaním	levaním	'white ms.pl.'
SR	1;06.12	ipaʁáim	mispaʁáim	'scissors'
SR	1;06.26	anána	banána	'banana'
SR	1;07.17	itijá	mitʁijá	'umbrella'
SR	1;07.23	ókolad	ʃókolad	'chocolate'
SR	1;10.26	agafáim	magafáim	'boots'

Child	Age	Output	Target	
YV	2;04.09	ekuká	mekulkál	'out of order'
YV	2;05.00	efúax	tapúax	'apple'
YV	2;06.04	ifét͡set	miflét͡set	'monster'
YV	2;08.27	atosím	metosím	'airplanes'
YV	2;10.07	ikafáim	miʃkafáim	'glasses'

When children begin to produce a new grammatical form, we sometimes witness a regression in their grammar, referred to as a "trade-off" regression (Garnica and Edwards 1977, Bernhardt and Stemberger 1998, Stemberger et al. 1999, Bat-El 2012). In this case, prosodic complexity increases (words consisting of more syllables) at the expense of segmental faithfulness (onset omission).[4]

Two anonymous reviewers raised additional factors that could possibly contribute to the difference in omission between monosyllabic and polysyllabic words. These are the influence of stress and minimality considerations. As monosyllabic words consist of only one syllable, that syllable is stressed by default. In comparison, in polysyllabic words the initial syllable is not necessarily stressed, as stress in Modern Hebrew may be final, penultimate or antepenultimate. Therefore, a plausible claim would be that the relative resistance of monosyllabic words to omission may be due to their prominence. Comparison of omitted onsets in stressed and unstressed syllables in Table 5 shows that while RM and YV tend to preserve the onset in stressed syllables to a greater extent, SR's productions indicate the opposite; he actually omits it more in this position.

Table 5: Omission in stressed vs. unstressed syllables

			Target			Output	
Child	**Period**	**Age**	**Structure**	**Stress**	**Total**	$_{w}$[V	
RM	1–14	1;04–2;03	$_{w}$[CV	+	179	16	**8.9%**
				–	549	87	**15.8%**
SR	1–14	1;02–2;00	$_{w}$[CV	+	333	76	**22.8%**
				–	742	120	**16.2%**
YV	1–14	1;03–2;10	$_{w}$[CV	+	217	34	**15.7%**
				–	533	145	**27.2%**

[4] An increase in syllabic complexity is another context we might expect to witness a similar "trade-off". Therefore, when the child begins to produce word-medial coda consonants, the omission of onsets is still expected to take place even if the onset consonant is already produced in word-initial position faithfully. Indeed, such productions can be found in the data. For example, in *ʃaʁʃéʁet* → *ʃeʃéʁet* 'necklace' (RM 2;00.16) the medial coda [ʁ] is omitted when the onset is preserved, but in *gaʁbáim* → *əʁbáim* 'socks' (RM 1;11.18) the medial coda [ʁ] is preserved when the onset is omitted.

Fisher's exact test confirms this observation with values of p=0.026, 0.0006 and 0.01 for RM, YV and SR respectively. Recall, however, that the difference between omission in monosyllabic vs. polysyllabic words was most evident in SR's productions (he did not omit the onset in monosyllables at all). Based on the figures in Table 5 this difference cannot be attributed to the effect of stress.

The second factor to consider is contrast (Grijzenhaut and Joppen 1999). Since coda consonants are often absent from children's early productions, omission of the onset in monosyllabic productions will result in consonant-free words, i.e. words consisting of vowels only (Adi-Bensaid and Tubul-Lavy 2009). Such productions minimize lexical contrast and are therefore usually avoided in typical development. These considerations are likely to contribute to the preservation of onset consonants in monosyllabic words; however as shown in Table 4, onset omission is also characteristic of later stages in prosodic development where the number of syllables increases.

Addressing the matter of contextual strength, how can we account for a process of reduction in a prominent position?

Dinnsen and Farris-Trimble (2009) argue for the early prominence of rhymes over onsets in developing grammars. Final positions, along with stressed positions, have been shown to be salient to young children, based on patterns of preservation in truncated productions (Echols and Newport 1992). In a picture naming experiment combining phonological priming, Brooks and MacWhinney (2000) determine that there is a shift in response to rhyme-priming vs. onset-priming over the course of development. Results indicated a significant effect of rhyme-based phonological priming for young children compared to older children and adults and to a greater extent than onset-based priming. The performance of the older age groups was strongly influenced by onset-based, but not rhyme-based priming. Brooks and MacWhinney take this to be an indication of differences between children and adults in speech production strategies involving the role of onsets in lexical activation. It is important to note that the youngest participants in the experiment were five year-olds. By that age, the majority of children will have mastered the acquisition of prosodic structures. The persisting effect of rhymes supports the argument for the early prominence of rhymes over onsets.

The disparity between child and adult language reflects the different considerations, limitations and priorities of developing systems compared to fully developed ones. In contrast to adult language, where the importance of word-initial position is reflected cross linguistically, children are preoccupied with the task of acquisition and are subject to other considerations, both perception and production-related. As pointed out by Bat-El (2009), early speech development is governed mostly by perceptual and articulatory facilitation (see also Goad 1997 on consonant harmony), thus giving priority to perceptually prominent positions.

2.4. *Complex Onset Simplification*

As shown in § 2.2, all three children produced word-initial onsetless syllables at a rate of 14%-23% for target words with word-initial simple onsets. However, their productions corresponding to targets with word-initial complex onsets reveal a different pattern.[5] Table 6 compares the realization of simple onsets with that of complex onsets.

Table 6: Rate of faithful and onsetless polysyllabic productions: Simple vs. complex onsets

			Target		**Output**					
Child	**Period**	**Age**	**Structure**	**Total**	**${}_{w}$[CCV**		**${}_{w}$[CV**		**${}_{w}$[V**	
RM	1–14	1;04–2;03	${}_{w}$[CV	728	–		625	85.9%	103	14.1%
			${}_{w}$[CCV	96	53	55.2%	42	43.8%	1	1.0%
SR	1–14	1;02–2;00	${}_{w}$[CV	1075	–		879	81.8%	196	18.2%
			${}_{w}$[CCV	86	6	7.0%	75	87.2%	5	5.8%
YV	1–14	1;03–2;10	${}_{w}$[CV	750	–		571	76.1%	179	23.9%
			${}_{w}$[CCV	62	6	9.7%	44	71.0%	12	19.3%

The data clearly show that the number of onsetless productions for target words with initial complex onsets is significantly lower than for target words with initial simple onsets. RM and SR tend to reduce clusters to a single onset, but do not omit them entirely. In contrast, YV's productions include both omissions and reductions, implying the existence of an initial stage in which onset clusters are not produced at all.[6]

---

5) The present study does not attend to the strategies of cluster reduction in the acquisition of Hebrew. For this issue see Ben-David (2001) and Bloch (2011).

6) The relatively low number of cluster-initial target words in the data makes it difficult to determine the status of complete cluster omission in YV's development. The proportions in the data are close to the proportions of cluster-initial targets compared to simple-onset initial targets in Hebrew. In Becker and Bolotzky's (2006) dictionary, there are 1189 targets of ${}_{w}$[CCV structure vs. 8084 targets of ${}_{w}$[CV structure, excluding word-initial glottal consonants. Based on omission rates reaching 36% (4/11) per period during YV's development, as well as previous observations made by Ben-David (2001) and Greenlee (1974), I assume it is an active process.

Table 7: Omission of simple vs. complex onset

Child	Output	Target		
YV (2;02.28–2;05.28)	ixá	mixál	'Michal (name)'	Initial stage
YV (1;10.09)	exá	smixá	'blanket'	
RM (1;10.28–2;03.01)	ixá	mixál	'Michal (name)'	
RM (2;00.16)	mixá	smixá	'blanket'	

Although only YV provides substantial evidence of this stage, this does not mean it is unique to atypical development. Adi-Bensaid and Tubul-Lavy (2009) report on production of consonant-free words by hearing-impaired children acquiring Hebrew. Despite the fact that such productions are rarely documented in typical development, the authors maintain that they are not limited to atypically developing children, but rather characterize the transition stage between babbling and speech. They claim that the distinction between typical and atypical development lies in the degree of overlap between the stages. This claim is highly relevant in the present context. In this view, the assumption is that RM and SR went through the same stages of development as YV, including total omission of onsets for both simple and complex-onset targets, but due to their relative quick progress the overlap is very small. This gradual pathway of development coincides with the observations of Ben-David (2001) and Greenlee (1974) regarding the acquisition of clusters.

In this particular instance, what may seem at first glance as an idiosyncratic property of YV's atypical development could in fact reflect what we might achieve if we could examine typical development in slow motion. YV, who has previously been established as a slow developer (Adam and Bat-El 2008, Gishri 2009) provides additional quantitative (as his development stretches over a longer period of time) and qualitative data (evident in the production of onsetless monosyllabic words as well as complex-onset targets), enabling us to observe in more detail the processes that take place.[7]

2.5. *Chain Shift Effect in the Acquisition of Onset Clusters*

As the (near-)minimal pairs in Table 8 show, the same segments that are omitted in productions of simple-onset targets are realized faithfully in productions of onset clusters:

---

[7] A similar assumption could be made for the production of onsetless monosyllables; i.e. YV's productions are an indication of an initial stage where such forms are produced in typical development as well. However, even if such words are produced, the rate of production compared to polysyllabic words is expected to be significantly lower (as evident in YV's productions), indicating a clear trend.

Table 8: Omission of simple and complex onsets—(near-)minimal pairs

Child	**Segment**	**Output**	**Target**	
RM (1;10.28–2;03.01)	m	ixá	mixál	'Michal (name)'
RM (2;00.16)		mixá	smixá	'blanket'
SR (1;09.00)	n	améʁ	naméʁ	'tiger'
SR (1;07.09)		naí	snaí	'squirrel'
YV (2;05.21)	g	azén	gaʁzén	'ax'
YV (2;05.00)		gadím	bgadím	'clothes'

The observation outlined above falls within the criteria of a chain shift. The effect of a chain shift refers to a state in which two processes, where the output of one can be the input of the other, occur synchronically. In a chain shift of the form a → b → c, a unit /a/ surfaces as [b], and /b/ surfaces as [c]. However, the process b → c does not affect the [b] forms derived from /a/, and thus both [b] and [c] exist on the surface, resulting in opacity (Kirchner 1995, 1996).

In the present case, $_w$[CCV → $_w$[CV (*gviná* → *giná*) and $_w$[CV→$_w$[V (*giná* → *iná*), but $_w$[CV derived from $_w$[CCV does not result in $_w$[V (*gviná* → **iná*). The generalization in terms of the process taking place is that only one consonant can be omitted. However, in terms of surface forms it is puzzling why the disfavored onset in one form (*giná* → *iná*) is accepted in another (*gviná* → *giná*).

Similar instances of this pattern have been reported in Chemehuevi (Press 1979) and Hidatsa (Harris 1942, Kenstowicz and Kisseberth 1977) with reference to a chain shift of the form $V_1V_2]_w \rightarrow V_1]_w \rightarrow \varnothing]_w$, where a word-final vowel is deleted, but in the case of two consecutive vowels only one is deleted. In language acquisition, well documented chain shifts include the s → θ → f chain (Dinnsen and Barlow 1998) and the famous 'puzzle-puddle-pickle' chain (Smith 1973; see also Dinnsen et al. 2001 and Jesney 2005). As McCarthy (2010) notes, the term chain shift is somewhat misleading since the two processes do not chain together.

The stages of onset acquisition that emerge from the findings presented above are summarized in Table 9.

Table 9: Stages of onset acquisition

Stage		**$_w$[CCV**	***gviná* 'cheese'**	**$_w$[CV**	***giná* 'garden'**	**Periods**		
						RM	**SR**	**YV**
I	No onset	$_w$[V	iná	$_w$[V	iná	–	–	1–14
II	One C deleted	$_w$[CV	giná	$_w$[V	iná	1–7	1–10	–
III	Simple onset	$_w$[CV	giná	$_w$[CV	giná	7–14	10–14	–
IV	Faithful	$_w$[CCV	gviná	$_w$[CV	giná	–	–	–

During stage I, target words with both simple and complex word-initial onsets are produced without an initial onset. This stage was observed only in YV's productions, while RM and SR provided evidence of the next two stages. During stage II, target words with word-initial simple onsets are produced without an initial onset while word-initial clusters are reduced to a simple onset. In this stage, a chain shift effect is observed. During stage III, word-initial simple onsets are produced while word-initial clusters are still reduced to a singleton. In the final stage both simple and complex word-initial onsets are produced. By the end of period 14 (the last period) the children have not reached the final stage of faithful productions yet.

The next section incorporates these stages of development into an Optimality Theory based analysis.

3. Optimality Theoretic Analysis

In the constraint based framework of Optimality Theory (Prince and Smolensky 1993/2004, henceforth OT) the grammar comprises a system of universal constraints organized in a language-specific hierarchy, according to which possible outputs for a given input are evaluated. The winning candidate (the actual surface representation) is the one that best satisfies the constraint hierarchy of the language. In classic OT, the generation and evaluation of candidates is performed in parallel, i.e. without intermediate derivational steps.[8] Language acquisition in OT involves gradual reranking of constraints, in order to achieve the ranking in the target language (Tesar and Smolensky 1996).[9] The relevant constraints are provided in (1):

(1) a. Markedness constraints

*COMPLEX	No more than one C or V may associate to any syllable position node (e.g. no CCV syllables)
$_{w}$[V	Align the left edge of the prosodic word with the head of a syllable

b. Faithfulneses constraints

MAX-SEG	Every segment in the input has a correspondent in the output

The markedness constraint *COMPLEX, which prohibits clusters, and the faithfulness constraint MAX-SEG, which prohibits deletion, are active in both child and adult language. However, evidence of the activity of the constraint $_{w}$[V in fully developed grammars is scarce (§2.2). This raises once again the issue of child-specific constraints (Goad 1997 and Pater 1997). This paper does not offer

[8] See, however, McCarthy (2007) for a review of gradual approaches to evaluation within OT.

[9] There are different views as to how this reranking is achieved. Some propose demotion of constraints (e.g. Tesar and Smolensky 1996), while others argue for the promotion of constraints (e.g. Gnanadesikan 1995/2004).

a solution to this problem, though it does raise questions regarding the status of the constraint $_{W}$[V. This constraint belongs to the family of alignment constraints (McCarthy and Prince 1993). The alignment of a vowel with the left edge of a word (or a syllable) is, indeed, rarely documented. However, other variations of alignment of consonants and vowels with edges are widely attested. There are languages requiring obligatory onsets, such as Arabic (McCarthy 1979, 1983, McCarthy and Prince 1990a, 1990b) or Lardil (Klokeid 1976, Prince and Smolensky 1993/2004), languages that avoid codas, such as many Bantu languages (Werner 1919), and languages that prefer word or stem-final consonants over vowels, such as Lardil (Klokeid 1976, Wilkinson 1988), some Micronesian languages (Kennedy 2003) and Arabic (McCarthy and Prince 1990a, 1990b). This typological asymmetry is summarized below:

(2) Typological asymmetry of alignment[10]

Consonant-initial	**Vowel-final**	**Consonant-final**	**Vowel-initial**
✓	✓	✓	?

The lack of evidence supporting the role of this constraint goes against typological predictions.

3.1. *Stage I: Total Omission (Markedness >> Faithfulness)*

As evident in YV's productions, during this initial stage the onset is omitted, regardless of the input. Consequently, productions of simple and complex onset targets do not contrast. The tableaux in (3) demonstrate the constraint ranking during this stage of development:

(3) Simple and complex onset omission

a. Target: Simple onset

Input: gina	*Complex	$_{W}$[V	Max-Seg
a. gina		*!	
b. ☞ ina			*

b. Target: Complex onset

Input: gvina	*Complex	$_{W}$[V	Max-Seg
a. gvina	*!	**	
b. gina		*!	*
c. ☞ ina			**

10) The table does not reflect what is *allowed*, but rather what is *preferred* by some languages, i.e. it is not the case that languages do not allow vowel-initial syllables, they simply do not prefer them.

Since $_{W}$[V (markedness) outranks Max-Seg (faithfulness), the winning candidate is the onsteless form, whether the target-onset is simple (3a) or complex (3b). There is no evidence at this point for crucial ranking of *Complex with respect to $_{W}$[V, and therefore the constraint ranking during this stage of development is *Complex, $_{W}$[V >> Max-Seg.

3.2. *Stage II: Simple Onset Omission & Cluster Reduction (Markedness~Faithfulness)*

This stage of development is characterized by onsetless productions for targets with a simple onset (*giná* → *iná*) and simple onset productions for targets with a complex onset (*gviná* → *giná*). The tableau in (4) demonstrates the constraint ranking yielding the output for simple onset targets:

(4) Simple onset omission

Input:	gina	*Complex	$_{W}$[V	Max-Seg
a.	gina		*!	
b. ☞	ina			*

The selection of candidate (b) over (a) in (4) is an indication that $_{W}$[V still outranks Max-Seg. However, this ranking cannot account for the output in the case of targets with a complex onset, as shown in (5):

(5) Complex onset omission—wrong output

Input:	gvina	*Complex	$_{W}$[V	Max-Seg
a.	gvina	*!	**	
b. ☹	gina		*!	*
c. ☛	ina			**

While the expected output in (5) is candidate (c), indicated by the ☛ symbol, the actual form is (b), indicated by the ☹ symbol.

It would be possible to claim that this inconsistent ranking reflects an intermediate stage, i.e. where two rankings are active: the ranking of stage I (*Complex, $_{W}$[V >> Max-Seg) and the ranking of stage III (*Complex >> Max-Seg >> $_{W}$[V). However, if this were the case, we would expect to see onsetless syllables for target words with both simple and complex onsets. The consistency in which the children reduce target complex onsets to simple onsets as opposed to omitting them entirely (recall the rate of onset omission in simple vs. complex onsets discussed in § 2.4) is not compatible with the pattern of free variation characteristic of transition stages.

This leads to the conclusion that there must be another constraint favoring candidate (b) over (c) in (5). To put it simply, there is a constraint preventing *gviná* → *iná*, thus creating a chain shift effect.

Kirchner (1995, 1996) proposes the use of local constraint conjunction of two faithfulness constraints in order to account for synchronic chain shifts. Kirchner (1995) refers to the notion of *Distantial Faithfulness*, later adopted by Dinnsen and Barlow (1998) in their account of chain shifts in acquisition. Under this notion, the distance between the input and output candidates is evaluated along a certain scale. The larger the distance between the input and output candidate on that scale, the more violations of the constraint demanding minimization of this distance are incurred. The concept underlying local conjunction of constraints (Smolensky 1993) refers to the combined effect of conjoined constraints as opposed to the effect of each constraint independently. That is, simultaneous violation of two conjoined constraints leads to the elimination of a candidate whereas a violation of each constraint alone does not (see Moreton and Smolensky 2002 for a discussion of typological predictions of local constraint conjunction). Self-conjunction is a special case of constraint conjunction, where the conjoined constraints are identical (Ito and Mester 1998). This is the case here.

The mechanism of constraint conjunction has received criticism, mainly due to the lack of restrictiveness and the problem it poses for acquisition (see Jesney 2005, McCarthy 2007 and Tihonova 2009 for discussion). One proposed alternative is Optimality Theory with Candidate Chains, or OT-CC (McCarthy 2007). In this model of OT, the candidates are chains of forms, rather than a single output. Starting from the fully faithful form, each form in the chain differs minimally from the preceding one. In order for the chain to be valid, the change must improve the relative harmony of that form. OT-CC also introduces a new type of constraints: Precedence constraints, which favor certain precedence relations among the forms in the chain. While this model of OT seems capable of accounting for both counterbleeding and counterfeeding opacity effects (McCarthy 2007, Tihonova 2009, Dinnsen et al. 2011), the chain shift presented here differs from those discussed so far, such as the s → θ → f chain shift (Dinnsen and Barlow 1998, Dinnsen et al. 2011) and the 'puzzle-puddle-pickle' chain (Smith 1973, Dinnsen et al. 2011). These chains involve two separate processes: dentalization and labialization in the former, and stopping and velarization in the latter. The chain presented here involves only one process: onset omission. In terms of constraints, the s → θ → f and 'puzzle-puddle-pickle' chains incur violations of separate faithfulness constraints, but the $_{w}$[CCV→ $_{w}$[CV → $_{w}$[V chain incurs two violations of the same faithfulness constraint (Max-Seg), which constitutes a problem for determining precedence relations.

Another alternative to constraint conjunction is a model of additive constraint evaluation, or a model of OT with weighted constraints (Pater 2009). In this model, strict rankings are replaced by assigning numeric weights to constraints. The winning candidate is the candidate with the lowest sum of weighted violations. The additive approach manages to successfully capture 'ganging up' effects (i.e. where lower ranked constraints gang up to overcome a higher ranked constraint), however as explained in Michaels (2010), capturing a chain shift using the standard principle of constraint summation leads to a weighting paradox. In the present case, in order for $_{w}$[CV to surface as $_{w}$[V, the weight of the constraint $_{w}$[V must be higher than the weight of Max-Seg. However, in order for $_{w}$[CCV to surface as $_{w}$[CV and not as $_{w}$[V, the sum of $_{w}$[V + Max-Seg must be lower than the sum of Max-Seg + Max-Seg. This is impossible if the weight of $_{w}$[V is higher than the weight of Max-Seg. In order to formalize the intuition that multiple violations of the same type of constraint can be worse than a single violation of a mixture of constraint types, Albright et al. (2008) propose the Split Additive Model, where markedness and faithfulness violations are evaluated separately. Implementation of this model to the 'puzzle-puddle-pickle' chain shift shows promising results (see Michaels 2010). Further research and testing will determine whether it could serve as a viable alternative for the mechanism of constraint conjunction.

I apply constraint conjunction to demonstrate a unified account of simple and complex onset acquisition in Hebrew, as it reflects in a straightforward and intuitive manner the observation made here, namely—that one, but not two, consonants may be omitted in onset position. The problem of restrictiveness does not arise in the present case since in this instance the conjunction is of the same constraint.

The tableaux in (7) demonstrate the constraint interaction under the approach of constraint conjunction, introducing the self-conjunction of Max-Seg, as defined in (6):

(6) Self conjunction of Max-Seg

Max-Seg$^{2}_{ONS}$ Max-Seg$^{2}_{ONS}$ is violated if there are two violations of Max-Seg in the domain of onset.

(7) Constraint conjunction

a. Target: Simple onset

Input: gina	*Complex	Max-Seg$^{2}_{ONS}$	$_{w}$[V	Max-Seg
a. gina			*!	
b. ☞ ina				*

b. Target: Complex onset

Input: gvina	*Complex	Max-Seg$^{2}_{ONS}$	$_{w}$[V	Max-Seg
a. gvina	*!		**	
b. ☞ gina			*	*
c. ina		*!		**

When the input has a simple onset (7a), MAX-SEG$^2_{ONS}$ is not relevant and thus the ranking $_W$[V >> MAX-SEG gets to select the onsetless optimal candidate *ina*. This same candidate is, however, eliminated by MAX-SEG$^2_{ONS}$ when the input has a complex onset (7b), suggesting the crucial ranking MAX-SEG$^2_{ONS}$ >> $_W$[V. There is no evidence for the ranking between *COMPLEX and $_W$[V, since $_W$[V alone can eliminate the candidate with complex onset in (7b), given the two segments between the left edge of the vowel and the left edge of the prosodic word (compared with one segment in the optimal candidate).

Thus, by introducing the conjoined constraint, we are able to correctly predict the output for both simple and complex onset targets. Although this interaction is somewhat opaque (*giná* is produced in some, but not all contexts), it is important to note that unlike stage I, contrast is retained in this stage between targets with simple and complex onsets.

The constraint ranking during this stage of development is thus *COMPLEX, MAX-SEG$^2_{ONS}$ >> $_W$[V >> MAX-SEG. With the addition of MAX-SEG$^2_{ONS}$, the hypothesized ranking for the initial stage is *COMPLEX, $_W$[V >> MAX-SEG$^2_{ONS}$, MAX-SEG (markedness above faithfulness).

3.3. *Stage III: Faithful Simple Onsets & Cluster Reduction*

During stage III, the children produce simple onsets faithfully, while still reducing clusters to singletons. The tableaux in (8) illustrate the predicted outputs for targets with simple and complex onsets.

(8) Faithful simple onset and reduced complex onset

a. Target: Simple onset

Input: gina	*COMPLEX	MAX-SEG$^2_{ONS}$	MAX-SEG	$_W$[V
a. ☞ gina				*
b. ina			*!	

b. Target: Complex onset

Input: gvina	*COMPLEX	MAX-SEG$^2_{ONS}$	MAX-SEG	$_W$[V
a. gvina	*!			**
b. ☞ gina			*	*
c. ina		*!	**	

The winning candidate in (8a) violates $_W$[V, thus providing evidence of the re-ranking of MAX-SEG above $_W$[V. From the selection of candidate (b) over (a) in (8b) we conclude that *COMPLEX still outranks MAX-SEG. Therefore the ranking during this stage of development is *COMPLEX, MAX-SEG$^2_{ONS}$ >> MAX-SEG >> $_W$[V.

3.4. *Stage IV: Faithful Productions (Faithfulness >> Markedness)*

When they reach the final stage, the children produce all target onsets faithfully, as illustrated in (9).

(9) Faithful productions

a. Target: Simple onset

Input: gina	MAX-SEG$^2_{ONS}$	MAX-SEG	*COMPLEX	$_W$[V
a. ☞ gina				*
b. ina		*!		

b. Target: Complex onset

Input: gvina	MAX-SEG$^2_{ONS}$	MAX-SEG	*COMPLEX	$_W$[V
a. ☞ gvina			*	**
b. gina		*!		*
c. ina	*!	**		

When the children reach the final stage, faithfulness constraints outrank markedness constraints, i.e. MAX-SEG$^2_{ONS}$, MAX-SEG >> *COMPLEX, $_W$[V, and thus both simple and complex onsets are produced faithfully.

An important note with regards to variability in acquisition must be made. When examining the omission of simple onsets over time for each child, omission does not exceed 50 % at the highest point, i.e. the majority of onsets are realized faithfully. Taelman and Gillis (2002) found high degree of intra-word variation throughout the development, and concluded that it is an essential characteristic of development (see also Bloch 2011 regarding the nature of variation in cluster simplification). The purpose of the analysis provided above was to demonstrate the constraint interaction underlying onset omission. The full spectrum of the children's productions as evident in the data can be formally accounted for within an OT model of stochastic evaluation (see Boersma 1997, 1998, Boersma and Hayes 2001 and Hayes 2000 regarding gradient ranking and gradual learning). This model assumes a continuous ranking scale rather than the classic OT strict ranking between pairs of constraints, and thus allows for the variable outputs and the gradual learning characterizing acquisition.

4. Conclusion

During the course of simple and complex onset acquisition, children go through a stage in which they omit word-initial consonants. Quantitative and qualitative data obtained from two typically developing children (RM and SR) and one atypically-developing child (YV) confirm this observation, previously made by Ben-David (2001).

The omission of onsets is unexpected, considering the prominence of word-initial position and the relative markedness of the resulting V syllable compared to the target CV syllable. However, the data clearly show that the omission is systematic and previous research has shown it occurs in other languages as well (Ben-David 2001, Buckley 2003, and references therein). This strongly suggests the involvement of considerations other than the well-formedness of syllable structure, originating in the difference between developing systems and fully developed ones.

Data analysis showed the omission to be context-specific, in particular a clear tendency for omission in polysyllabic, as opposed to monosyllabic productions. This implies that the process is triggered by an increase in prosodic complexity. This argument is supported by the omission of word-initial onsets in later attempted tri- and quadrisyllabic targets, although to a lesser extent.

A developmental account of simple and complex onset acquisition revealed the existence of a stage during which simple onsets are omitted (e.g. *giná* → *iná* 'garden'), while complex onsets are reduced to singletons rather than omitted entirely (e.g. *gviná* → *giná* 'cheese'). This creates a chain shift of the form $_{\mathrm{w}}$[CCV → $_{\mathrm{w}}$[CV → $_{\mathrm{w}}$[V, where the output of cluster simplification (*gviná* → *giná*) is the input of onset deletion (*giná* → *iná*), but forms derived from cluster simplification do not result in onset deletion (*gviná* → **iná*). Where a classic OT analysis fails to account for this state of affairs, the existence of both forms in the same stage of phonological development has been resolved by using local constraint conjunction (Smolensky 1993), which refers to the combined effect of conjoined constraints as opposed to the effect of each constraint independently. Incorporating the notion of constraint conjunction enables a unified Optimality Theoretic account of the acquisition of simple and complex onsets in Hebrew.

References

Adam, Galit. 2002. *From Variable to Optimal Grammar: Evidence from Language Acquisition and Language Change*. Ph.D. dissertation, Tel-Aviv University.

Adam, Galit, and Outi Bat-El. 2008. Segmental effects on syllable selection: Evidence from Hebrew. In A. Gavarró and J. Freitas (eds) *Language Acquisition and Development: Proceedings of Gala 2007*, 1–11. Newcastle: Cambridge Scholars Publishing.

Adam, Galit, and Outi Bat-El. 2009. When do universal preferences emerge in language development? The acquisition of Hebrew stress. *Brill's Annual of Afroasiatic Languages and Linguistics* 1:1–28.

Adi-Bensaid, Limor, and Gila Tubul-Lavy. 2009. Consonant-free words: Evidence from Hebrew speaking children with cochlear implants. *Clinical Linguistics and Phonetics* 23:122–132.

Albright, Adam, Giorgio Magri, and Jennifer Michaels. 2008. Modeling doubly marked lags with a Split Additive Model. In H. Chan, H. Jacob and E. Kapia (eds), *Proceedings of the Boston University Conference on Language Development (BUCLD) 32*, 36–47. Somerville, MA: Cascadilla Press.

Bat-El, Outi. 2009. Harmonic domains and synchronization in typically and atypically developing Hebrew-speaking children. *Language Sciences* 31:117–135.

Bat-El, Outi. 2012. The role of sonority in the acquisition of Hebrew word final codas. In S. Parker (ed.), *The Sonority Controversy*. Berlin: Mouton de Gruyter.

Beckman, Jill. 1998. *Positional Faithfulness*. Ph.D. dissertation, University of Massachusetts, Amherst.

Ben-David, Avivit. 2001. *Language Acquisition and Phonological Theory: Universal and Variable Processes Across Children and Across Languages*. Ph.D. dissertation, Tel-Aviv University. [in Hebrew].

Ben-David, Avivit. this volume. The development of prosodic structure: Evidence from typical longitudinal data.

Bernhardt, Barbara, and Joseph Stemberger. 1998. *Handbook of Phonological Development: From the Perspective of Constraint-Based Nonlinear Phonology*. San Diego: Academic Press.

Bloch, Tamar. 2011. *Simplification Patterns in the Acquisition of Word Initial Consonant Clusters in Hebrew*. M.A. thesis, Tel-Aviv University.

Boersma, Paul. 1997. How we learn variation, optionality, and probability. *Proceedings of the Institute of Phonetic Sciences of the University of Amsterdam* 21:43–58.

Boersma, Paul. 1998. *Functional Phonology: Formalizing the Interactions between Articulatory and Perceptual Drives*. Ph.D. dissertation, University of Amsterdam. The Hague: Holland Academic Graphics.

Boersma, Paul, and Bruce Hayes. 2001. Empirical tests of the Gradual Learning Algorithm. *Linguistic Inquiry* 32:45–86.

Bolozky, Shmuel, and Michael Becker. 2006. Living Lexicon of Hebrew Nouns. Ms., University of Massachusetts, Amherst.

Breen, Gavan, and Rob Pensalfini. 1999. Arrernte: A language with no syllable onsets. *Linguistic Inquiry* 30:1–25.

Brooks, Patricia, and Brian MacWhinney. 2000. Phonological priming in children's picture naming. *Journal of Child Language* 27:335–366.

Buckley, Eugene. 2003. Children's unnatural phonology. In P. Nowak, C. Yoquelet and D. Mortensen (eds), *Proceedings of the Berkeley Linguistic Society (BLS) 29*, 523–534. Berkeley, University of California: Berkeley Linguistic Society.

Casali, Roderic. 1996. *Resolving Hiatus*. Ph.D. dissertation, University of California, Los Angeles.

Clements, George. 1990. The role of the sonority cycle in core syllabification. In J. Kingston and M. Beckman (eds), *Papers in Laboratory Phonology 1: Between the Grammar and Physics of Speech*, 283–333. New York: Cambridge University Press.

Chomsky, Noam, and Morris Halle. 1968. *The Sound Pattern of English*. New York: Harper & Row.

Demuth, Katherine. 1995. Markedness and development of prosodic structure. In J. Beckman (ed.), *Proceedings of the North East Linguistic Society 25*, 13–25. Amherst: University of Massachusetts, GLSA.

Demuth, Katherine, and Jane Fee. 1995. Minimal prosodic words in early phonological development. Ms., Brown University and Dalhousie University.

Dinnsen, Daniel, and Jessica Barlow. 1998. On the characterization of a chain shift in normal and delayed phonological acquisition. *Journal of Child Language* 25:61–94.

Dinnsen, Daniel, Kathleen O'Connor, and Judith Gierut. 2001. The puzzle-puddle-pickle problem and the Duke-of-York gambit in acquisition. *Journal of Linguistics* 37:503–525.

Dinnsen, Daniel, Christopher Green, Judith Gierut, and Michele Morrisette. 2011. On the anatomy of a chain shift. *Journal of Linguistics* 47:275–299.

Dinnsen, Daniel, and Ashley Farris-Trimble. 2009. Developmental shifts in phonological strength relations. In K. Nasukawa and P. Backley (eds), *Strength Relations in Phonology*, 113–149. New York: Mouton de Gruyter.

Echols, Catharine, and Elissa Newport. 1992. The role of stress and position in determining first words. *Language Acquisition* 2:189–220.

Garnica, Olga, and Mary Louise Edwards. 1977. Phonological variation in children's speech: The trade-off phenomenon. In O. Garnica (ed.), *Ohio State University Working Papers in Linguistics 22*, 81–87. Columbus: Ohio State University, Department of Linguistics.

Gishri, Michal. 2009. *The Role of Prominence in the Acquisition of Medial Codas in Hebrew: Evidence from a Slow Developer*. M.A. thesis, Tel-Aviv University.

Gnanadesikan, Amalia. 1995/2004. Markedness and faithfulness constraints in child phonology. In R. Kager, J. Pater and W. Zonneveld (eds), *Constraints in Phonological Acquisition*, 73–108. Cambridge: Cambridge University Press. (Revision of 1995 ms., University of Massachusetts, Amherst).

Goad, Heather. 1997. Consonant harmony in child language: An optimality-theoretic account. In S. Hannahs and M. Young-Scholten (eds), *Focus on Phonological Acquisition*, 113–142. Amsterdam: John Benjamins.

Greenlee, Mel. 1974. Interacting processes in the child's acquisition of stop-liquid clusters. *Papers and Reports on Child Language Disorders* 7:85–100.

Grijzenhaut, Janet and Sandra Joppen. 1999. First Steps in the Acquisition of German Phonology: A case study. Ms., ROA-304, http://roa.rutgers.edu.

Harris, Zellig. 1942. Morpheme alternants in linguistic analysis. *Language* 18:169–180.

Hayes, Bruce. 2000. Gradient well-formedness in Optimality Theory. In J. Dekkers, F. van der Leeuw and J. van de Weijer (eds), *Optimality Theory: Phonology, Syntax, and Acquisition*, 88–120. Oxford: Oxford University Press.

Inkelas, Sharon, and Yvan Rose. 2008. Positional neutralization: A case study from child language. *Language* 83:707–736.

Ito, Junko, and Armin Mester. 1998. Markedness and word structure: OCP effects in Japanese. Ms., University of California, Santa Cruz. Ms., ROA-255, http://roa.rutgers.edu.

Jakobson, Roman. 1941/1968. *Child Language, Aphasia and Phonological Universals*. The Hauge: Mouton.

Jesney, Karen. 2005. *Chain Shift in Phonological Acquisition*. M.A. thesis, University of Calgary.

Kennedy, Robert. 2003. *Confluence in Phonology: Evidence from Micronesian Reduplication*. Ph.D. dissertation, University of Arizona.

Kenstowicz, Michael, and Charles Kisseberth. 1977. *Topics in Phonological Theory*. New York: Academic Press.

Kirchner, Robert. 1995. Going the distance: synchronic chain shifts in Optimality Theory. Ms., ROA-66, http://roa.rutgers.edu.

Kirchner, Robert. 1996. Synchronic chain shifts in Optimality Theory. *Linguistic Inquiry* 27:341–350.

Klokeid, Terry Jack. 1976. *Topics in Lardil Grammar*. Ph.D. dissertation, MIT.

Lombardi, Linda. 1999. Positional faithfulness and voicing assimilation in Optimality Theory. *Natural Language and Linguistic theory* 17:267–302.

McCarthy, John. 1979. Formal Problems in Semitic Phonology and Morphology. Ph.D. dissertation, MIT.

McCarthy, John. 1983. A Prosodic account of Arabic broken plurals. In I. Dihoff (ed.), *Current Approaches to African Linguistics 1*, 289–320. Dordrecht: Foris.

McCarthy, John. 2007. *Hidden Generalizations: Phonological Opacity in Optimality Theory*. London: Equinox.

McCarthy, John. 2010. Harmonic Serialism supplement to doing OT. The selected works of John J. McCarthy. Available at: http://works.bepress.com/john_j_mccarthy/108.

McCarthy, John, and Alan Prince. 1990a. Foot and word in prosodic morphology: The Arabic broken plural. *Natural Language and Linguistic Theory* 8:209–283.

McCarthy, John, and Alan Prince. 1990b. Prosodic morphology and templatic morphology. In M. Eid and J. McCarthy (eds), *Perspectives on Arabic Linguistics 2: Papers from the Second Annual Symposium on Arabic Linguistics*, 1–54. Amsterdam: John Benjamins.

McCarthy, John, and Alan Prince. 1993. Generalized Alignment. In G. Booij and J. van Marle (eds), *Yearbook of Morphology 1993*, 79–153. Dordrecht: Kluwer.

McCarthy, John and Alan Prince. 1995. Faithfulness and Reduplicative identity. In J. Beckman, S. Urbanczyk and L. Walsh (eds), *University of Massachusetts Occasional Papers in Linguistics 18: Papers in Optimality Theory*, 249–384. Amherst: Graduate Linguistic Student Association.

Michaels, Jennifer. 2010. Summing up constraint learning: Chain shifts in additive models. In J. Costa, A. Castro, M. Lobo and F. Pratas (eds), *Language Acquisition and Development: Proceedings of Gala 2009*, 288–300. Newcastle: Cambridge Scholars Publishing.

Moreton, Elliott, and Paul Smolensky. 2002. Typological consequences of local constraint conjunction. In L. Mikkelsen and C. Potts (eds), *Proceedings of the West Coast Conference on Formal Linguistics (WCCFL) 21*, 306–319. Somerville, MA: Cascadilla Press.

Pater, Joe. 2009. Weighted constraints in generative grammar. *Cognitive Science* 33:999–1035.

Press, Margaret. 1979. *Chemehuevi: A Grammar and Lexicon*. University of California Publications in Linguistics volume 92. Berkeley: University of California Press.

Prince, Alan, and Paul Smolensky. 1993/2004. *Optimality Theory: Constraint Interaction in Generative Grammar*. Malden: Blackwell. (Revision of 1993 technical report, Rutgers University Center for Cognitive Science).

Smith, Jennifer. 2000. Prominence, augmentation and neutralization in phonology. In L. Conathan, J. Good, D. Kavitskaya, Al. Wulf and A. Yu (eds), *Proceedings of the Berkeley Linguistic Society (BLS) 26*, 247–257. Berkeley: University of California, Berkeley Linguistic Society.

Smith, Neilson. 1973. *The Acquisition of Phonology: A Case Study*. Cambridge: Cambridge University Press.

Smolensky, Paul. 1993. Harmony, markedness, and phonological activity. Paper presented at Rutgers Optimality Workshop 1, Rutgers University. ROA-87, http://roa.rutgers.edu.

Stemberger, Joseph, Barbara Bernhardt, and Carolyn Johnson. 1999. "Regressions" ("u"-shaped learning) in the acquisition of prosodic structure. Poster presented at the 6th International Child Language Congress.

Taelman, Helena, and Steven Gillis. 2002. Variation and consistency in children's truncation patterns. In J. Costa and J. Freitas (eds), *Proceedings of Gala 2001*, 263–270. Lisbon: Associação Portuguesa de Linguística.

Tesar, Bruce, and Paul Smolensky. 1996. Learnability in Optimality Theory (long version). Technical Report JHU-CogSci-96–3. Department of Cognitive Sciences, John Hopkins University, Baltimore, MD. ROA-156, http://roa.rutgers.edu.

Tihonova, Olga. 2009. *Acquisition and Opacity*. M.A. thesis, Univesity of Tromsø.

Topintzi, Nina. 2005. On sonority, onsets and stress in Arabela. In G. Chatzidamianos, G. Chi, L. Frey, K. Hargreaves, T. Kraš, N. Novakovič and V. Beltrán (eds), *Proceedings of the University of Cambridge 3rd Postgraduate Conference in Language Research*, 279–286. Cambridge: Cambridge Institute of Language Research.

Werner, Alice. 1919. *Introductory Sketch of the Bantu Languages*. London: K. Paul, Trench, Trubner & Co., Ltd.

Wilkinson, Karina. 1988. Prosodic structure and Lardil phonology. *Linguistic Inquiry* 19: 325–334.

BRILL Brill's Annual of Afroasiatic Languages and Linguistics 4 (2012) 104–119 brill.com/baall
BAALL

The Role of Prominence and Position in the Acquisition of Codas in the Speech of Hearing-impaired Children*

Limor Adi-Bensaid
Department of Communication Sciences and Disorders, Ono Academic College
limorbensaid@ono.ac.il

Abstract
The paper describes the developmental phases in the acquisition of codas in the speech of Hebrew-acquiring hearing-impaired children, with reference to prosodic properties—the prominence (stress) and the position of the syllable hosting the coda. The participants were 10 hearing-impaired children using cochlear implant or conventional hearing aid device, ranging in age from 1;5 to 3;5 years old in their first recording session. Data collection continued until each child completed the acquisition of codas. A prosodic analysis of the phases of coda acquisition reveals a similarity between hearing impaired children and typically developing hearing children acquiring Hebrew, as well as other languages. The results suggest that the position of the syllable in the word (final, penultimate, antepenultimate) plays a major role in the development of codas, whereas stress has no significant effect.

Keywords
language acquisition; codas; hearing impairment; cochlear implant; Hebrew

1. Introduction

Phases of coda acquisition in the speech of typically developing children are described in various studies, such as Ingram (1981) for English, Fikkert (1994) for Dutch, Ben-David (2001) for Hebrew, Kappa (2002) for Greek, and Lleó (2003) for Spanish. Fewer studies describe the phases of coda acquisition in atypical development; for example, Bernhart and Stemberger (1998) for various English-acquiring children, Tubul-Lavy (2005) for Hebrew-acquiring dyspraxic children, and Gishri (2009) for a Hebrew-acquiring slow developing child. Also, there are many studies dealing with phonological development of hearing-impaired children in various languages, such as West and Weber (1973), Oller and Kelly (1974), Dodd and So (1994), Meline (1997), Tobin (1997), and

*) I would like to thank the two anonymous reviewers for their valuable comments and suggestions. Also, special thanks to the children, who participated in the study, and their families.

DOI: 10.1163/18776930-00400005

Huttunen (2001). However, these studies usually describe the phonological inventory of the children as well as their phoneme production in terms of phonological processes. As far as I know, there is no study describing the development of codas in the speech of hearing impaired children in general, and in terms of developmental phases in particular.

This study fills this gap, with a detailed description of the developmental phases in the acquisition of codas in the speech of hearing-impaired Hebrew-acquiring children. In terms of phonological structure, the study refers to the effect of prosodic properties on the acquisition of codas—the prominence (stress) of the syllables hosting the codas and their position in the word. It aims to reveal the properties that play a role in the acquisition of codas, and to examine the interaction between universal and language specific characteristics (see also Bat-El this volume on the interaction of coda development with the acquisition of verb inflectional suffixes).

I start with details on the data source of the hearing-impaired children as well as the typically developing ones (§ 2). Then, data and analysis of the phases in coda acquisition is presented, distinguishing between codas in stressed and unstressed syllables as well as codas in final and non-final syllables (§ 3). A summary is then provided (§ 4).

2. Research Method

2.1. *Participants*

Ten monolingual children acquiring Hebrew participated in the study, 5 boys and 5 girls, with prelingual hearing impairment and bilateral sensorineural hearing loss. These children participated in Adi-Bensaid's (2006) broader study of the development of the prosodic word. The children were divided into two groups according to the type of hearing device: CI (Cochlear Implant) users and HA (conventional Hearing Aid) users.

The CI group (Cochlear Implant users) consisted of 6 children (3 boys and 3 girls), ranging in age from 1;05 to 2;08 years at the first recording session. All the children had profound hearing loss in both ears prior to implantation. Their unaided thresholds prior to implantation were above 110 dB in both ears (this level represents the mean pure tone average of 500, 1000, and 2000 Hz). They were fitted with binaural personal conventional hearing aids for a short period early in their childhood. The hearing aids improved their auditory awareness to environmental and speech sounds. However, they received a cochlear implant because they derived negligible benefit from the conventional hearing aids and had no functional hearing. After implantation, their auditory thresholds for speech improved. Thus, more speech sounds became audible to them and they were able to detect, discriminate, identify and understand more speech stimuli. In fact, after implantation, the hearing of all the children became more functional. (Table 1)

Table 1: Background information for the CI group

Child	Gender	Onset age of profound HL	Age of HA fitting	Age of implantation
A1	Male	Congenital	0;05	1;02
A2	Female	Congenital	0;06	1;00
A3	Female	1;00	1;03	1;09
A4	Male	0;03	0;10	2;00
A5	Female	0;01	0;03	1;09
A6	Male	1;02	1;08	2;05

HL—hearing loss; HA—conventional hearing aid

The HA group (conventional Hearing Aid users) consisted of 4 children (2 boys and 2 girls), ranging in age from 1;05 to 3;05 years at the first recording session. All children had severe hearing loss. They were all fitted with hearing aids early in their childhood, which allowed them to detect, discriminate, identify and understand more speech stimuli. (Table 2)

Table 2: Background information for the HA group

Child	Gender	Onset age of profound HL	Mean unaided PTA (dB HL)	Mean aided PTA (dB HL)
B1	Male	0;04	80	34–40
B2	Female	0;03	90	50
B3	Male	2;05	80	30
B4	Female	0;10	75	35

HL—hearing loss; PTA—pure tone average; HA—conventional hearing aid

The findings from the hearing impaired children were compared with those reported in studies on typically developing Hebrew-acquiring children with normal hearing. The major part of the data was drawn from Ben-David (2001), a longitudinal study of the acquisition of Hebrew phonology (see also Ben-David this volume). The participants in this study were 10 monolingual typically developing Hebrew-acquiring children (6 boys and 4 girls), ranging in age from 0;10 to 1;05 years at their first recording session. The secondary data were drawn from Kaltum-Royzman (2008), a cross-sectional study of prosodic and segmental aspects of coda acquisition in Hebrew. The participants in this study were 21 typically developing children (10 boys and 11 girls), ranging in age from 1;08 to 2;05 years.

2.2. *Data Collection*

In all three studies mentioned above, the data were collected by speech and language pathologists (including the respective authors). Data collection for the longitudinal studies (hearing impaired in Adi-Bensaid 2006 and the typically developing in Ben-David 2001) was based on monthly recordings of spontaneous speech as well as picture and object naming (but only isolated words were analyzed). In the cross-sectional study of the typically developing children (Kaltum-Royzman 2008), only a naming task was used, which included 20 pictures representing different prosodic properties (word length and coda position in the word) and segmental properties (manner of articulation).

Data collection of the CI group started 2 to 4 months after implantation, from the beginning of the first words. During the initial recordings, each child produced less than ten words, most of them through imitation.

Due to difficulties in finding children using a conventional hearing aid device, who were also in the one word phase and who were not candidates for cochlear implant, the data collection of the HA group was less homogenous and started at different periods of the phonological development of each child. In order to determine the linguistic phase of each child, the Hebrew Communicative Development Inventory (HCDI) revised for hearing impairment was conducted for each child in the HA group.[1] The original HCDI (Maital et al. 2000) is an adaptation of the MacArthur Communicative Development Inventory (MCDI) developed for English (Fenson et al. 1993).

Table 3: Age of the children at the beginning and end of the study

	Child	**Age—beginning**	**Age—end**	
CI group:	A1	1;05	3;05	Completed phonological development
	A2	1;06	3;01	Completed phonological development
	A3	2;01	5;01	Completed phonological development
	A4	2;04	4;11	Completed phonological development
	A5	2:00	4;03	Completed phonological development
	A6	2:08	5;06	Dropped out after 3 months—stopped cooperating
HA group:	B1	1;06	2;11	Completed phonological development
	B2	3;02	4;09	Dropped out after 19 months—moved to another city
	B3	3;05	4;08	Completed phonological development
	B4	2;10	3;11	Dropped out after 13 month—due to implantation

[1] The parents of the HA group responded to the questionnaire of the HCDI version for hearing impaired children, which enabled determining the linguistic vocabulary size of each child: B1—130 words, B2—70 words, B3—200 words, and B4—50 words.

Data collection for the typically developing children in the longitudinal study (Ben-David 2001) started when each child had ten words in the first meeting (age average 1;02).

Data collection of the longitudinal studies (Adi-Bensaid 2006 for hearing impaired and Ben-David 2001 typically developing) continued till the end of the phonological development (for most children; see table 3), i.e. until the children have completed the acquisition of the prosodic aspects of the words (number of syllables, onsets, codas, and complex onsets).

The data for the hearing impaired children were collected during 30–45 minute recording sessions once a month. All sessions were recorded using a high quality audio recorder, a Panasonic microcassette recorder model No. RQ-L10. The recorder was placed close to the children, so that the signal-to-noise ratio obtained was highly efficient. Five audiotape-recording sessions of each child were selected at random, and a second examiner independently transcribed the sample records. The agreement between the examiners regarding the transcription reflected a high degree of inter-judged measurement reliability.

3. Phases of Coda Development

This section describes the phases of coda development of the hearing impaired children, both CI and HA groups. Throughout the discussion, a comparison with typically developing children acquiring Hebrew, as well as children acquiring other languages is provided. Since the findings for the children in the CI group were very similar to those in the HA group, data of the two groups are integrated.

3.1. *Codaless Words (Phase I)*

During the early phases of acquisition, the hearing-impaired children produced words without codas for target words of any length. Coda deletion occurred regardless of the position (final vs. non-final) and prominence (stressed vs. unstressed) of the target syllables with codas. (Table 4)

Table 4: Codaless words

Output	**Target**		**Child**	**Age**
ya	yad	'hand'	A1	1;09
e:	en	'none'	B1	1;05
má.i	má.im	'water'	A1	1;09
tí.ta	tík.tak	'clock sound'	A3	2;02
bá.ba	bám.ba	'snack'	A2	1;10
to	liʃ.tót	'to drink'	A2	1;11
pa.tí	pa.tíʃ	'hammer'	B1	1;05

Codaless words in early phases of acquisition were also reported for typically developing children acquiring Hebrew (Shaked 1990, Ben-David 2001, this volume) as well as other languages, such as English (Ingram 1976, Salidis and Johnson 1997), Dutch (Fikkert 1994, Levelt and Van de Vijver 1998), Portuguese (Fikkert and Freitas 1997, Freitas 1999), various dialects of Spanish (Macken 1978, Goldstein and Citron 2001), and Greek (Kappa 2002). These studies indicate that the segments, syllable structures, and word structures found in children's early speech tend to exhibit unmarked, simple structures (cf. Jacobson 1968).

Thus, the absence of codas during this phase is explained by prosodic markedness. Because language development proceeds from the unmarked (simple structure) to the marked (more complex structure), and as codaless syllables are less marked than syllables with codas, children are expected to first produce syllables without codas. This prosodic markedness is perceptually grounded: since a segment following the vowel of a syllable (i.e. coda) is acoustically less prominent than a segment preceding a vowel (i.e. onset) (Steriade 2000), codas are more likely to be deleted during the initial phases of acquisition.

Coda deletion occurred regardless of whether or not the segment had been acquired. For example, *má.im* → [*má.i*] 'water' shows that *m* has been acquired but nevertheless deleted in coda position. The same observation has been reported in Abraham (1989) with reference to English-acquiring hearing-impaired children using a hearing aid device. It should be noted, however, that although the first phase is characterized by coda deletion (i.e. codaless words), a few productions with codas in final position do appear.

3.2. *Preservation of Word Final Codas (Phase II)*

During the second phase, the hearing impaired children started producing word final codas, with an increase in final coda preservation from 20 % in phase I to 44 % in phase II. The examples in table 5 exhibit coda preservation in target words of different lengths and in different stress patterns, though during this phase, most productions were maximally disyllabic.

Table 5: Word final coda preservation

Output	Target		Child	Age
dad	dag	'fish'	A1	2;04
tuθ	sus	'horse'	B1	1;08
i.póy	t͡si.póʁ	'bird'	A5	2;07
a.ím, ta.ím	ta.ím	'delicious'	B4	2;11
us, ó.bus	ó.to.bus	'bus'	A1	2;06
má.im	má.im	'water'	B1	1;08

Shaked (1990) found that deletion of final codas was a frequent phonological processes in the speech of young typically developing Hebrew-acquiring children, in particular for the group of children between 1;07 and 2;02 years; the older group, between 2;02 and 2;07 years, produced the final codas quite well.

One of the questions addressed with regard to deletion in child's speech is whether syllables in prominent positions resist deletion to a greater extent than syllables in non-prominent positions. Accordingly, the following sub-sections examine coda preservation with reference to stressed vs. unstressed syllables (§ 3.2.1) and finals vs. non-final syllables (§ 3.2.2).

3.2.1. Stress

Table 6 provides quantitative data for the preservation of word final codas during phase I (codaless words) and phase II (preservation of final codas), with emphasis on the distinction between codas in stressed and unstressed syllables.

Table 6: Word final coda preservation with reference to stress

	Phase I: Codaless words			**Phase II: Preservation of final codas**		
Target's stress	**Target**	**Output**	**%**	**Target**	**Output**	**%**
Stressed	685	153	22%	1224	570	46.5%
Unstressed	478	81	17%	901	368	40.8%
Total	1163	234	20%	2125	938	44%

As shown in table 6, there is an increase in coda preservation from phase I (20%) to phase II (44%) in both stress patterns. The difference between the two phases was significant for each stress pattern. For stressed syllables, where 22% of the codas were preserved in phase I and 46.5% in phase II, the difference was statistically significant using a paired t-test analysis ($t_{(9)}=-7.08$, $p=.0001$). Similarly, for unstressed syllables, where 17% of the codas were preserved in phase I and 40.8% in phase II, the difference was statistically significant using a paired t-test analysis ($t_{(9)}=-5.27$, $p=.0003$).

However, within each phase, there was no significant difference between coda preservation in words with ultimate stress and words with non-ultimate stress ($p>.05$), though percentages show a stronger tendency of final coda preservation in stressed syllables. This tendency is also reported in Ben-David's (2001) study for typically developing children, although her study is qualitative and does not include a statistical analysis. Also, it can be seen that during the second phase of final coda development, there was still a considerable degree of coda deletion (above 50%), suggesting a gradual development.

With regard to the target words, the ratio within each stress group of words (i.e. final and non-final) did not change across the phases: words with final stress were about 58% of all target words; 58.9% (685/1163) in phase I and 57.6% (1224/2125) in phase II.[2] That is, no significant stress effect was found in the speech of the hearing impaired children.

These findings are similar to those in Gishri (2009), who reports on the absence of stress effect in the speech of a slow developing Hebrew-acquiring child. Similarly, Schwartz and Goffman (1995) report that coda deletion in English is affected mainly by its position in the word rather than by the stress pattern. That is, deletion occurred in word medial position more often than in word-final position and did not appear to be influenced by stress. The authors suggest that vowel lengthening in word final position may make the final codas more resistant to deletion.

In contrast with the findings in the present study, Ben-David (2001) reports on a brief stage during which final codas are produced only in stressed syllables. Similar findings are reported also for Spanish (Lleó 2003), Japanese (Ota 2003), Portuguese (Freitas et al. 2001) and English (Zamuner and Gerken 1998). The latter study, which used a novel word imitation task, found that English-speaking 2-year olds had a greater tendency to delete final codas in unstressed syllables than in stressed syllables.

The role of stress in children's productions is due to its acoustic prominence. Stressed syllables are of higher pitch, longer duration, and have stronger amplitude than unstressed syllables (Lehiste 1970, Ladefoged 2011). Therefore, they are better perceived than unstressed syllables and thus better produced by children.

In Hebrew, stress is predominantly final (Bat-El 1993, Graf and Ussishkin 2003), and since final syllables are also acoustically salient, the combination of two prominent acoustic properties in the same syllable contribute to it being better perceived and consequently produced more accurately than non-final and unstressed syllables. However, according to Ben-David (2001, this volume), the children start with preserving codas in final stressed syllables only, both in monosyllabic target words and disyllabic target words with final-stressed syllable, but not in disyllabic target words with non-final stress. Their productions with codas, however, consisted of monosyllabic words only. For example, Carmel (1;05) produced the final coda *xi.túl* → [*tul*] 'diaper', but deleted it in *ʁé.gel* → [*é.ge*] 'leg', and

---

2) These findings do not coincide with those in Adam and Bat-El (2009), which show the predominance of targets with non-final stress in early acquisition. The discrepancy might be due to the fact that the present study considers only targets with codas. In addition, the predominance of targets with non-final stress in Adam and Bat-El's study is limited to a very early period, which has probably been missed here because the children are older.

Eyal (1;06) produced the final coda in [*kax*] 'take! ms.sg.', but deleted in *xó.ʃex* → [*kó.ʃe*] 'darkness'. In both cases, the same segment is preserved in a stressed syllable (monosyllabic productions), but deleted in an unstressed syllable. It should be noted, however, that all disyllabic word productions during this stage ended with an unstressed syllable. Therefore, the effects of word length and stress cannot be isolated.

3.2.2. Position

The quantitative data in table 7 provides the relative rate of coda preservation during phase II, comparing between final and non-final codas. (Table 7)

Table 7: Coda preservation in final vs. non-final syllables (phase II)

Target syllable	Final coda preservation			Non-final coda preservation		
with coda	Target	Output	%	Target	Output	%
Stressed	1224	570	46.5%	222	41	18.5%
Unstressed	901	368	40.8%	321	46	14.3%
Total	2125	938	44.1%	543	87	16.0%

In both stressed and unstressed syllables, there was a higher rate of final coda preservation than non-final coda preservation. Using a paired t-test analysis, this difference was statistically significant for stressed syllables ($t_{(9)}$=4.21, p<.0011) as well as unstressed syllables ($t_{(9)}$=4.35, p<.0009).

Child A2 (2;06), for example, deleted the lateral coda in the unstressed medial syllable in *ʃul.xán* → [*u.xán*] 'table' and *yal.dá* → [*ya.dá*] 'girl', but preserved it in the final stressed syllable in [*ga.dól*] 'big ms.sg.'. Similarly, within the same word, child A4 (3;05) preserved the final glide coda but deleted the medial one in *bay.báy* → [*ba.báy*] 'bye'. These examples suggest that during this phase of acquisition, the production of final codas is affected by prosodic considerations, i.e. the position of the coda in the word, rather than by segmental considerations. Both children had the segment in their inventory, but they selected to produce it depending on its position in the prosodic word.

Similar findings are reported in Kaltum-Royzman's (2008) cross-sectional study of typically developing Hebrew-acquiring children. Final codas (208/252=82.5%) were produced more frequently than non-final codas (33/168=19.64%), with significant distinction ($\chi^2_{(1)}$=91.55, p<.0001).

Recall that there was no significant difference between coda preservation in words with ultimate stress and words with non-ultimate stress (p>.05) in the previous phase I (table 6). The same is true for phase II; there was no significant difference in coda preservation between words with ultimate stress and words with non-ultimate stress, both in final codas ($t_{(9)}$=1.52, p>.05), and in non-final codas ($t_{(9)}$=-0.32, p>.05).

The role of position in the preservation of final codas is acoustically supported. Acoustic cues are more salient in word final syllables than in non-final syllables due to the lengthening occurring in final position (Cooper 1983, Snow 1998, Echols and Newport 1992). Therefore, it is not surprising that codas in word final position are produced earlier than codas in non-final position, not only in Hebrew (Ben-David 2001, Kaltum-Royzman 2008), but also in Dutch (Fikkert 1994), French (Rose 2000), and Catalan (Prieto and Bosch-Baliarda 2006).

The interaction of stress and position is also studied. Kirk and Demuth's (2006) study of English-acquiring children found that the distinction between final and non-final codas is significant only in the unstressed syllables. Lleó's (2003) study of two Spanish-acquiring children reveals that, contrary to the above-mentioned studies, non-final codas are acquired before final codas. She attributes this apparent counter example to stress, as word final codas in Spanish typically occur in unstressed syllables (cf. Hebrew, where words final codas typically occur in stressed syllables).

3.3. *Preservation of Medial Codas*

As the data in table 7 indicate, medial codas in Hebrew are acquired after final codas. However, also within the development of medial codas we can detect two phases, as codas in penultimate syllables (§3.3.1) are acquired before codas in antepenultimate syllables (§3.3.2).

3.3.1. Medial Codas in Penultimate Syllables (Phase III)

During the subsequent phase III of coda development, there was a gradual progress in coda production in penultimate syllables. This phase enjoyed 70% (272/394) medial coda preservation in penultimate syllable, compared with 16% in the previous phase II (table 7).

Table 8: Preservation of medial codas in penultimate syllables

Output	Target		Child	Age
tiv.sá	kiv.sá	'sheep'	A5	3;07
zéb.ʁa	zéb.ʁa	'zebra'	A4	4;01
más.tik	más.tik	'chewing gum'	A1	2;08
táf.ta	sáf.ta	'grandma'	A5	3;07
pás.ta	pás.ta	'pasta'	B1	2;11
pan.téʁ	psan.téʁ	'piano'	B1	2;11
ox.yím	ox.lím	'eat ms.pl.'	B1	2;01

During this phase, codas in the antepenultimate syllables of trisyllabic target words were hardly produced (only 16.6%).

Table 9: Deletion of medial codas in antepenultimate syllables

Output	**Target**		**Child**	**Age**
a.bát.ya	am.bát.ya	'bath'	A4	4;02
á.bu.las	ám.bu.lans	'ambulance'	A2	2;11
ta.da.lám	san.da.lím	'sandals'	A5	3;07
ma.ʃi.vá	mak.ʃi.vá	'listens fm.sg'	A5	3;07
li.ya.tán	liv.ya.tán	'whale'	B1	2;01
ta.e.gól	taʁ.ne.gól	'rooster'	B1	2;03
ga.ga.yím	gal.ga.lím	'wheels'	B1	2;02

Given that Hebrew stress is predominantly final, it is not surprising that in 72.8 % (287/394) of the produced tokens the medial codas were in unstressed syllables. In addition, the role of stress was insignificant in the production of medial codas, as it is the case with final codas (§ 3.2.1); there was no significant difference in the deletion of non-final codas between codas in stressed (34/107=31.77 %) and unstressed (88/287=30.66 %) syllables. A paired t-test analysis revealed no significant difference between coda productions with different stress patterns ($t_{(5)}=-0.33$, $p>.05$).

Gishri (2009) reports on similar findings, whereby among the child's targets with medial codas, 75 % (457/612) were found in unstressed syllables. However, a detailed evaluation of stages of development revealed an early effect of stress. During stage I, the child produced more medial codas in stressed syllables (47 %) than in unstressed syllables (24 %). The effect of stress disappeared during stage II, where coda preservation was found in nearly equal proportions between the two syllable types—56 % in stressed syllables and 63 % in unstressed syllables.

Since the data in Gishri's study are drawn from a slow developing child, I assume that the effect of stress on medial coda preservation does exist. However, this effect is too small to detect in typical development (Ben-David 2001), as well as in the present study of hearing-impaired children, whose language development started at a later age due to input deficiency. Both in Ben-David's (2001) study and in the current study, percentages show a higher tendency of coda preservation in stressed syllables, however, a statistical analysis (in the present study) has shown no significant difference between coda productions with different stress patterns. Note also that data collection in Gishri's study was on a weekly basis, while data collection in the current study, as well as in Ben-David (2001), was on a monthly basis.

The examples in tables 8 and 9 reflect the preference for coda preservation in penultimate position (70 %) as opposed to coda preservation in antepenultimate position (16.6 %). During this phase of coda development, children either preserve codas in penultimate position, or replace them with other segments according to their segmental phases of coda acquisition. For example, child A2 produced *m* in the penultimate coda in [*kum.kúm*] 'kettle', but deleted it in the antepenultimate syllable in *ám.bu.lans* → [*á.bu.las*] 'ambulance'. Similarly, child A5 produced *f* in the penultimate syllable in [*bif.ním*] 'inside', but deleted it in the antepenultimate syllable in *af.ta.á* → [*a.ta.á*] 'surprise'. Once again, these examples suggest that during this phase of acquisition, the production of non-final codas is contingent upon prosodic rather than segmental considerations. Both children had the segment in their inventory, but they elected to produce it depending on its position in the prosodic word.

This phase of coda development was also reported for typically developing children acquiring Hebrew (Ben-David 2001, this volume) and English (Smith 1973). However, Ben-David reports on an additional earlier, though rather short stage during which the children either copied the final coda (e.g. *lid.fók* → [*lik.fók*] 'to knock', *san.dál* → [*sal.dál*] 'sandal'), or selected targets with two identical codas and preserved them both (e.g. [*míʃ.miʃ*] 'apricot', [*paʁ.páʁ*] 'butterfly', [*lix.lúx*] 'dirt'). There were few such forms in the present study (e.g. [*bay.báy*] 'bye', [*paʁ.páʁ*] 'butterfly', [*kum.kúm*] 'kettle', *baʁ.váz* → [*baw.báw*] 'duck'), but too few to support a separate phase.

3.3.2. Medial Codas in Antepenultimate Syllables

During the final phase, codas are preserved in all positions, regardless of the length of the target words. (Table 10)

Table 10: Faithful codas everywhere

Output	**Target**		**Child**	**Age**
iʃ.to.lél	iʃ.to.lél	'went wild ms.sg.'	A1	3;00
píl.pe.lim	píl.pe.lim	'peppers'	A1	3;00
max.bé.ʁet	max.bé.ʁet	'notebook'	A1	3;00
mag.ye.ʃá	mig.la.ʃá	'playground slide'	A1	3;01
ám.bu.lan	ám.bu.lans	'ambulance'	B1	2;11
max.ʃe.fá	max.ʃe.fá	'witch'	B3	4;08

Thus, as in the case of final codas, the production of medial codas by the hearing impaired children is affected by position rather than by stress.

4. Summary

The present study on the acquisition of Hebrew codas revealed that the developmental path of hearing-impaired children (using CI as well as a conventional HA device) is similar to that of typically developing (hearing) children. The initial phase I is characterized by the dominance of codaless words (80%). Codas were deleted regardless of the prominence of their hosting syllable (stressed vs.

unstressed) and its position in the word (final vs. non-final). During phase II there was a significant increase in the preservation of word final codas, while medial codas were still deleted in most cases. An increase in the preservation of medial codas is then encountered, during phase III, in penultimate codas, and only later, during phase IV, in antepenultimate codas. The four phases of coda development are summarized in table 11.

Table 11: Phases of coda development

Phase I:	Coda deletion in all prosodic positions and in all stress patterns
Phase II:	Preservation of word final codas
Phase III:	Preservation of medial codas in penultimate syllables
Phase IV:	Preservation of medial codas in antepenultimate syllables

Contrary to earlier studies, which showed the effect of position and stress on coda preservation, the present study provides evidence for the effect of position only; there was no significant effect of stress. However, the percentages show a greater tendency of coda preservation in stressed syllables than in unstressed syllables. For example, 22% vs. 17% of final coda preservation in stressed vs. unstressed syllables respectively during phase I, and 46.5% vs. 40.8% during phase II (table 6). The same tendency was shown with respect to medial codas. For example, 18.5% vs. 14.3% of medial coda preservation in stressed vs. unstressed syllables respectively during phase II (table 7). In other words, although no significant difference was found between coda productions in different stress patterns, there seems to be a numerical tendency towards coda productions in stressed syllables. It is possible that these differences were not statistically significant because the group of the hearing-impaired children was too small and heterogeneous (the wide range of standard deviation strengthens this proposal). Although Ben-David (2001, this volume) reports on stress effect in her study with typically developing Hebrew-acquiring children, no statistical analysis was done in her study, thus she also presents tendencies only, and as a result, no comparison to typically developing children could be made. A future study including a homogenous group with more children may enable us to understand stress effect in the production of codas in the speech of Hebrew-acquiring children.

References

Abraham, Suzanne. 1989. Using a phonological framework to describe speech errors of orally trained hearing impaired school-agers. *Journal of Speech and Hearing Disorders* 54:600–609.

Adam, Galit and Outi Bat-El. 2009. When do universal preferences emerge in language development? The acquisition of Hebrew stress. *Brill's Annual of Afroasiatic Languages and Linguistics* 1:1–28.

Adi-Bensaid, Limor. 2006. *The Prosodic Development of Hebrew-Speaking Hearing Impaired Children*. Ph.D. Dissertation, Tel-Aviv University.

Bat-El, Outi. 1993. Parasitic metrification in Modern Hebrew stress system. *The Linguistic Review* 10:189–210.

Bat-El, Outi. this volume. Phonological constraints on morphological development: The acquisition of Hebrew verb inflectional suffixes.

Ben-David, Avivit. 2001. *Language Acquisition and Phonological Theory: Universal and Variable Processes Across Children and Across Languages*. Ph.D. dissertation, Tel-Aviv University. [in Hebrew].

Ben-David, Avivit. this volume. The development of prosodic structure: Evidence from typical longitudinal data.

Bernhardt, Barbara, and Joseph Stemberger. 1998. *Handbook of Phonological Development from the Perspective of Constraint-Based Nonlinear Phonology*. San Diego: Academic Press.

Cooper, William. 1983. The perception of fluent speech. *Annals of the New York Academy of Science* 405:48–63.

Dodd, Barbara and Lydia So. 1994. The phonological abilities of Cantonese-speaking children with hearing loss. *Journal of Speech and Hearing Research* 37:671–679.

Echols, Catherine and Elissa Newport. 1992. The role of stress and position in determining first words. *Language Acquisition* 2:189–220.

Fenson, Larry, Philip Dale, Steven Reznick, Donna Thal, Elizabeth Bates, Jeff Hartung, Steve Pethick, and Judy Reilly. 1993. *MacArthur Communicative Development Inventories: User's guide and technical manual* (MCDI). San Diego, CA: Singular Publishing Group.

Fikkert, Paula. 1994. *On the Acquisition of Prosodic Structure*. The Hague: Holland Academic Graphics.

Fikkert, Paula and Maria Freitas. 1997. Acquisition of syllable structure constraints: Evidence from Dutch and Portuguese. In Antonella, Sorace, Caroline, Heycock, and Richard, Shillcock (eds), *Proceedings of the GALA '97 Conference on Language Acquisition* Edinburgh. 217–222.

Freitas, Maria. 1999. Syllabic constituency and segmental emergence: Evidence from the acquisition of European Portuguese. A paper presented as IASCL 99, San Sebastian.

Freitas, Maria, Matilde Miguel, and Isabel Faria. 2001. Interaction Between Prosody and Morphosyntax: Plurals within codas in the acquisition of European Portuguese. In J. Weissenborn and B. Höhle (eds), *Approaches to Bootstrapping: Phonological, Lexical, Syntactic and Neurophysiological Aspects of Early Language Acquisition* v2, 45–57. Amsterdam/Philadelphia: John Benjamins.

Gishri, Michal. 2009. *The Role of Prominence in the Acquisition of Medial Codas in Hebrew: Evidence from a Slow Developer*. M.A. thesis, Tel-Aviv University.

Goldstein, Brain and Patricia Cintron. 2001. An investigation of phonological skills in Puerto Rican Spanish speaking 2-year olds. *Clinical Linguistics and Phonetics*, 15: 343–361.

Graf, Dafna, and Adam Ussishkin. 2003. Emergent iambs: Stress in Modern Hebrew. *Lingua* 113:239–270.

Huttunen, Kerttu. 2001. Phonological development in 4–6 year old moderately hearing
Impaired children. *Scandinavian Audiology* 30 Supp. 53:79–82.

Ingram, David. 1976. *Phonological Disability in Children*. London: Edwards Arnold.

Ingram, David. 1981. *Procedures for the Phonological Analysis of Children's Language*. Baltimore: University Park press.

Jacobson, Roman. 1968. *Child Language, Aphasia and Phonological Universals*. The Hague: Mouton.

Kaltum-Royzman, Keren. 2008. *The Effect of Position in the Word, Word length and Manner of Articulation on Segment Productions in Coda Position of Hebrew-speaking Children*. M.A. thesis. Tel-Aviv University. [in Hebrew].

Kappa, Ioanna. 2002. On the acquisition of syllabic structure in Greek. *Journal of Greek Linguistics* 3:1–52.

Kirk, Cecilia, and Katherine Demuth. 2006. Accounting for variability in 2-year-olds' production of coda consonants. *Language Learning and Development* 2:97–118.

Ladefoged, Peter. 2011. *A Course in Phonetics*. Boston, MA: Wadsworth, Centage (6th edition).

Lehiste, Iise. 1970. *Suprasegmentals*. Cambridge, MA: MIT Press.

Levelt, Claartje, and Ruben Van de Vijver. 1998. Syllables types in cross-linguistic and development grammars. A paper presented at the 3rd Utrecht Biannual Phonology Workshop.

Lleó, Conxita. 2003. Prosodic licensing of codas in the acquisition of Spanish. *Probus* 15: 257–281.

Maital, Sharon, Esther Dromi, Sagi Abraham, and Marc Bronstein. 2000. The Hebrew communicative development inventory: Language specific properties and cross-linguistic generalizations. *Journal of Child Language* 27:43–67.

Macken, Marlys. 1978. Permitted complexity in phonological development: One child's acquisition of Spanish consonants. *Lingua* 44:219–253.

Meline. Timothy. 1997. Description of phonological patterns for nineteen elementary-age children with hearing losses. *Perceptual and Motor Skills* 85:643–653.

Oller, Kimbrough and Kelly Charleen. 1974. Phonological substitution processes of a hard of hearing child. *Journal of Speech and Hearing Disorders* 39:65–74.

Ota, Mitsuhiko. 2003. *The Development of Prosodic Structure in Early Words*. Amsterdam: John Benjamins.

Prieto, Pilar, and Marta Bosch-Baliarda. 2006. The development of coda in Catalan. *Catalan Journal of Linguistics* 5:237–272.

Rose, Yvan. 2000. *Headedness and Prosodic Licensing in the L1 Acquisition of Phonology*. Ph.D. dissertation. McGill University, Montréal.

Salidis, Joanna, and Jacqueline Johnson. 1997. The production of minimal words: A longitudinal case study of phonological development. *Language Acquisition: A Journal of Developmental Linguistics* 6:1–36.

Schwartz, Richard, and Lisa Goffman. 1995. Metrical patterns of word and production accuracy. *Journal of Speech and Hearing Research* 38:876–888.

Shaked, Galia. 1990. *Early Phonological Acquisition: Phonological Processes between Ages 1;7–2;7*. M.A. thesis, Tel-Aviv University. [in Hebrew].

Smith, Neilson.V. 1973. *The Acquisition of Phonology: A Case Study*. Cambridge: Cambridge University Press.

Snow, David. 1998. A prominence account of syllable reduction in early speech development: The child's prosodic phonology of Tiger and Giraffe. *Journal of Speech, Language, and Hearing Research* 41:1171–1184.

Steriade, Donca. 2000. Directional asymmetries in place assimilations: A perceptual account. In E. Hume and K. Johnson (eds), *Perception in Phonology*, 219–250. San Diego: Academic Press.

Tobin, Yishai. 1997. *Phonology as Human Behavior: Theoretical Implications and Clinical Applications*. Durham: Duke University Press.

Tubul-Lavy, Gila. 2005. *The Phonology of Hebrew-speaking Dyspraxic Children*. Ph.D. dissertation, Tel-Aviv University. [in Hebrew].

West, Jacqueline and Jack Weber. 1973. A phonological analysis of the spontaneous language of a four year old, hard of hearing child. *Journal of Speech and Hearing Disorders* 38:25–35.

Zamuner, Tania and LouAnn Gerken. 1998. Young children's production of coda consonants in different prosodic environments. In E. Clark (ed.), *Proceedings of the 29th Annual Child Language Research Forum*, 13–25. Center for the Study of Language and Information, Stanford, CA.

BAALL
BRILL Brill's Annual of Afroasiatic Languages and Linguistics 4 (2012) 120–139 brill.com/baall

Target Selection in Error Selective Learning*

Michael Becker
Department of Linguistics, Indiana University
michael.becker@phonologist.org

Abstract
SR shows a typical acquisition pattern of first *avoiding* marked structures, then *repairing* them, then producing them faithfully. I propose a method for diagnosing and quantifying avoidance, and then analyze the avoidance using the null parse approach. I offer a computationally implemented analysis of SR's acquisition path in terms of Error Selective Learning (Tessier 2007, 2008, 2009, Becker and Tessier 2012), modeling the avoidance of marked structure as selection of the null parse. The model predicts a realistic acquisition path using a persistent M > F > MParse bias and the relativization of MParse to markedness constraints.

Keywords
language acquisition; complex onsets; codas; paradigm gaps; phonotactic gaps; ineffability; null parse; Hebrew

1. Introduction

Child speech is phonologically different from adult speech in several different ways. One prominent and noticeable property of child speech is deletion, typically leading to entire syllables missing in the child's pronunciation. It is a longstanding observation that by using deletion so liberally, children eliminate structures that they are not ready to pronounce, such as codas, complex onsets, and unstressed syllables. As they approximate the adult pronunciation, children gradually phase deletion out of their speech. Another option children have, however, is to avoid words that have such structures altogether; they stay silent, or choose to say different words.

*) Thanks to Outi Bat-El for sharing her data and her insights, and to two anonymous reviewers for their helpful comments. Thanks also to Adam Albright, Hannes Fellner, Wendell Kimper, Joe Pater, John McCarthy, and Matt Wolf for feedback and valuable comments. Special thanks go to Anne-Michelle Tessier for thorough discussion of the proposal. I also thank the audience at the workshop on computational modeling of sound pattern acquisition (University of Alberta, Edmonton), and at the UC Berkeley linguistics department, in particular, Bruce Hayes, Sharon Inkelas, and John Sylak. There are no remaining errors.

 DOI: 10.1163/18776930-00400006

The idea that avoidance is a way to approximate adult speech is expressed in Kiparsky and Menn (1977:56–58), quoted by Kager et al. (2004:11), emphasis mine:

> Different children exclude **definable classes of output by different means** … When we observe such repeated 'exclusion', we conclude that these classes of outputs … represent difficulties to the child, and the various rules of child phonology (substitutions, deletions, etc.) as well as **selective avoidance of some adult words**, are devices the child finds for dealing with those difficulties.

The quote is particularly insightful given that it predates a theory with output constraints that can be satisfied in a variety of ways; the idea of excluding classes of output by different means was not expressible in the rule-based theory that was prevalent at the time (deletion or avoidance could be modeled separately in rule-based theory, but the conspiracy between them could not). In terms of Optimality Theory (Prince and Smolensky 1993/2004), a single markedness constraint, say against complex onsets, causes both simplification of these complex onsets by deletion, and avoidance of words that have complex onsets in their adult form. By avoiding words with complex onsets in their adult forms, children eliminate the faithfulness violations that would be caused by simplifying the adult form. Target avoidance, or target selection, is mentioned as a feature of language acquisition in, among others, Ferguson and Farwell (1975), Kiparsky and Menn (1977), Schwartz and Leonard (1982), Schwartz (1988), Schwartz et al. (1987), Stoel-Gammon and Cooper (1984), Fikkert (1994), Grijzenhout and Joppen-Hellwig (2002), Menn (2004), and Goad and Rose (2004), Bat-El this volume. In particular, Adam and Bat-El (2008a,b, 2009, 2010) discuss SR's target avoidance in the context of prosody (preferences for trochaic targets) and another child's selection of vowels (preference for [*a*]).

By selecting targets based on phonological criteria, the child carves out an increasingly representative subset of the adult language for their productions. In SR's case, he starts with a lexicon that has very few final sonorants in its adult forms, which is not at all representative of adult Hebrew. After a period of avoiding these words, he gradually adds final sonorants to his speech, until such words make more than a third of all the words he says, as in the adult language.

In this paper, I focus on two structures in SR's speech: initial complex onsets (see also Bloch 2011 and Karni 2012) and final sonorant codas (see also Bat-El 2012). I show that he avoids words that have these structures in § 2, and I offer an Optimality Theoretic analysis that derives the avoidance by selection of a null parse, or a failure to parse the input, in § 3. A generalized theory of avoidance, with a learning algorithm that produces the stages of acquisition, from avoidance to deletion to adult speech, is presented in § 4. A computational implementation of the learning algorithm, which formalizes the analysis, is presented in § 5, and § 6 concludes.

A particularly interesting aspect of SR's development is that complex onsets are avoided longer than sonorant codas. Theoretically, this will require avoidance to be sensitive to the marked structure that is being avoided. The model will accommodate this fact by relativizing a constraint against avoidance to particular markedness constraints that are active in the grammar.

2. Diagnosing Target Selection

By its very nature, target selection is not directly detectable. Rather, it needs to be deduced from the data by identifying the conspicuous underrepresentation of certain types of words. The phonological acquisition literature is mostly interested in unfaithful productions, and rightly so, since they are directly observable.

As the child transitions from avoiding a certain structure to a more advanced stage (either simplified production or adult-like production), the previously underrepresented structure will become increasingly prevalent, and gradually reach its ratio in the adult language. On the other hand, structures that are not avoided will be present in the data from the beginning, and their relative prevalence will not increase over time (in fact, it may decrease over time, as previously avoided forms become more prevalent).

SR's longitudinal corpus is ideally suited for testing the relative proportion of various structures along the acquisition path. SR was recorded by a trained phonetician about once a week, starting during his babbling period; he produced his first word at age 1;2. His productions were transcribed and paired with their intended meaning (as determined by the recorder). Most words were produced in the context of directed play, including naming tasks.

Figure 1 charts the development of SR's initial complex onsets. The diamonds trace the production of complex onsets as a percentage of SR's total productions. Each diamond represents one session, with its size proportional to the number of words recorded on that session. Up until the age of 1;7, SR does not produce complex onsets at all. Once he starts producing them faithfully, they gradually increase in frequency until they make about 2% of his productions. Statistically speaking, this development of SR's productions can be shown to be a positive correlation between SR's age and the probability that he would produce a complex onset. A logistic regression model using the *glm* function in R (R Development Core Team 2011) confirms that the correlation is significant (z=6.89, p<.0001).

The circles in Figure 1 trace SR's attempts to produce words with complex onsets. If SR were to choose words from the adult language based purely on their meaning, we would expect to see no progression; words with complex onsets would be attempted at a constant rate throughout the period of acquisition. This is not the case: SR starts by hardly attempting any complex onsets at all until about 1;5, then his attempts increase gradually until about 1;8. This gradual rise,

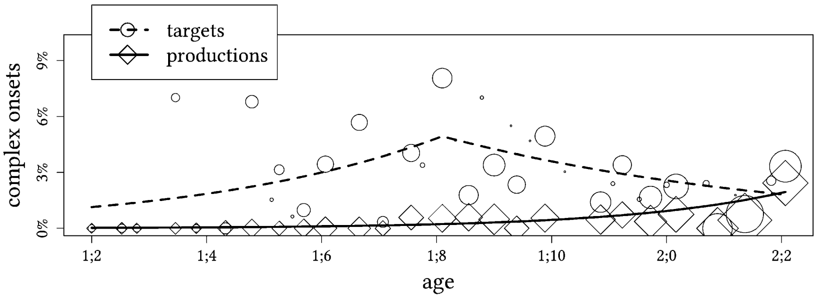


Figure 1: Increase in SR's initial cluster targets up until 1;8

or positive correlation between age and attempts of complex onsets, is statistically significant.

A logistic regression model with a change point[1] at 1;8 shows an initial positive slope from 1;2 up to 1;8 that is highly significant (z=3.84, p<.0005). Admittedly, the following decline in the prevalence of complex onsets is left unexplained here. I speculate that the decline from 1;8 to 2;2 is due to the acquisition of other marked structures, or perhaps other morpho-phonological categories (such as verbs), which make complex onsets relatively less common. I leave this puzzle for future work.

To summarize SR's treatment of complex onsets, we have seen that he starts without any complex onsets, neither in production nor in attempts. In other words, it is not simply the case that words with complex onsets are simplified—they are eliminated altogether, or avoided. The initial state gradually gives way to a stage where words with complex onsets are attempted, and produced unfaithfully. The increase in attempts of complex onsets, or the decrease in their avoidance, is statistically significant.

SR's treatment of final sonorant codas shows a similar pattern of avoidance. Figure 2 charts the development of his final sonorants, again showing productions with a solid line and attempts with a dashed line. Until the age of 1;4, SR hardly produces any sonorant codas at all, and then he quickly transitions to producing them mostly faithfully at 1;6. This acquisition is much quicker than

[1] Change points allow a regression analysis to model the rise and subsequent fall in the ratio of complex onsets in the data. In the case of SR's complex onsets, the introduction of the change point is justified by the significant improvement it makes over the model that lacks a change point ($\chi^2(1)$=30.2, p<.0001). For a similar use of a change point analysis in child data, see Becker and Tessier (2011). For general reference on regressions with a change point, see Baayen (2008) § 6.4, Jaynes (2003) § 15.8.1, and Mudelsee (2010) § 4.2.2.

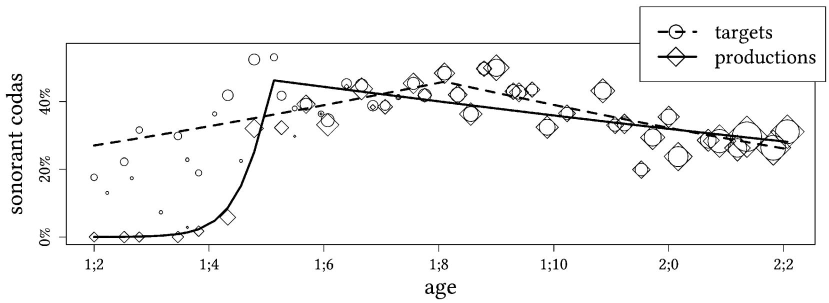


Figure 2: Increase in SR's final sonorant targets up until 1;8

SR's acquisition of complex onsets, which is to be expected given the higher frequency of these sonorant codas. The increase in final sonorants is also seen in his attempts: words with final sonorants in their adult form become increasingly prevalent in his speech, up until 1;8, and again this increase comes out statistically significant in a logistic regression model (z=6.68, p<.0001).

The evidence for avoidance of final sonorants is precisely the increase in SR's attempts from 1;2 to 1;8. If SR had not avoided sonorant codas, they would be targeted or attempted at a constant rate, but the regression analysis confirms that the change in the ratio of sonorant codas is significantly different from zero. Past the age of 1;8, the ratio of sonorant codas declines both in attempts and in production—mirroring the decline seen for the complex onsets.

The evidence for avoidance relies exclusively on the distribution of attempted targets, i.e. on the adult phonological forms, disregarding SR's surface productions. How SR pronounced these words is orthogonal to the question of avoidance; the fact that they are conspicuously missing from his early months of speech is enough evidence for target selection. Equivalently, the question can be framed in terms of overrepresentation of the complement forms: a vocabulary limited to final vowels and obstruents, with no initial clusters, is not a representative sample of the Hebrew lexicon. Now, it is possible that such a vocabulary is representative of a *child* lexicon, and that this is an accident about the Hebrew lexicon that concepts that children discuss at that age are phonologically simple. This does not seem to be the case: words like *ta'puaχ* 'apple' and *a'gas* 'pear' (which SR says) are hardly more relevant to a child's interests than *'maim* 'water' and *'glida* 'ice-cream' (which SR avoids). A cross-linguistic study of the acquisition of these concepts would clear this point, but this is beyond the scope of this paper.

SR does not attempt all words with equal probability. Rather, he carves out a non-representative portion of the lexicon for his early productions, limiting his attempts to words that he can produce with sufficient accuracy. To be sure, this is not a claim about SR's conscious efforts; as with most phonological behavior, it is entirely plausible that his avoidance is unconscious. The analysis provided below does not assume any conscious manipulation of linguistic elements.

While the evidence for avoidance comes from the distribution of SR's targets, it is also instructive to look at his productions. Once words with final sonorants or initial clusters appear, what form do they take? Here, we have to rely on the transcription of SR's words. While it is known that adults are imperfect transcribers of child productions, we have no better data for SR's speech, and therefore I will assume that the transcriptions are at least indicative of SR's actual speech.

Consonant deletion is SR's most common repair for word-final sonorants and word-initial clusters. For final sonorants, deletion accounts for about half of all unfaithful token, as in (2).[2] With initial onsets, deletion accounts for about three quarters of all unfaithful tokens, as exemplified in (3)

(2) SR's repairs of final sonorants by deletion

Target	**Output**		
ˈpil	ˈpi	'elephant'	1;04.10
na.ˈmeʁ̞	na.ˈme	'tiger'	1;05.08
ˈma.im	ˈma.i	'water'	1;05.15

(3) SR's repairs of initial clusters by deletion

Target	**Output**		
ˈpkak	ˈpak	'cap'	1;05.29
ˈgli.da	ˈgi.da	'ice-cream'	1;06.12
dvo.ˈʁ̞a	do.ˈʁ̞a	'bee'	1;06.26

If we accept that consonant deletion is used as a repair for both final sonorants and initial clusters, we must conclude that the same faithfulness constraint, namely MAX-C, is involved in both processes. The analytical implications of this shared reliance on MAX-C are explored in § 3.2. Going beyond the specifics of SR's particular acquisition path, however, it seems highly likely that a single repair, and in particular deletion, will be deployed by a child to deal with two separate sources of markedness; thus, the problem at hand is likely to be relevant to the analysis of acquisition paths in general. Even if the reader does not accept the accuracy of the transcriptions in this corpus, the form of the problem remains if one accepts that deletion can be used to repair more than one marked structure.

---

2) SR opts for metathesis in about one third of the tokens when it repairs an onsetless unstressed syllable, as in [ˈja.li] or [ˈla.li] for adult [ˈla.il] 'Lyle (name)'.

3. Analysis: SR's Avoidance as a Null Parse

I will analyze avoidance in OT (Prince and Smolensky 1993/2004), using the idea that avoidance results from inputs of certain kinds being mapped onto the null parse (Prince and Smolensky 1993/2004; McCarthy and Wolf 2010). The null parse is a candidate that fails to have any phonological or morphological structure, and thus vacuously satisfied all markedness and all faithfulness constraints. Noted ⊙, the null parse only violates the special constraint MPARSE.

Prince and Smolensky (1993/2004) proposed the null parse to model phonotactic gaps, and the approach has been used this way by Smith (2009) and Albright (2011). The null parse has also been used to model paradigm gaps, e.g. in Rice 2006, Bat-El 2010 (though see Albright 2010 for a different view). The null parse formalizes the idea that a phonological derivation may not succeed in generating an output; passing a phonological or morpho-phonological input form through the grammar produces no output, or equivalently, produces an output with no phonological or morphological form at all.

3.1. *Error-Selective Learning of Target Avoidance*

To generate realistic acquisition paths based on the null parse, I use Error Selective Learning (Tessier 2007, 2008, 2009, Becker and Tessier 2012), which is an elaboration of the error-based learning algorithms in Prince and Tesar (2004), Hayes (2004), et seq. In error-based learning, an error is defined as a mismatch between an adult form and the pronunciation is it assigned by the child. The child uses the error to learn by pairing it with the adult form, making a winner-loser pair, and finding out which constraints prefer the winner using comparative tableaux (Prince 2002). The winner-loser pairs are stored in the Support, which represents the evidence that the child has for their current constraint ranking. What Error Selective Learning adds to the basic algorithms in Prince and Tesar (2004) and Hayes (2004) is a method for choosing errors to learn from in a gradual way. In this paper, I will simply assume that the errors are selected correctly; the interested reader should consult the works cited above for further detail. One property of Error Selective Learning is that more frequent errors trigger learning earlier. In the case of SR, Error Selective Learning ensures that learning matches SR's path of mastering sonorant codas first and complex onsets later, simply because sonorant codas are more frequent in the target language.

To see how Error Selective Learning works, I start with a simplified grammar that has only three constraints: the markedness constraint M, the faithfulness constraint F, and MPARSE. There will only be one word in the language, 'adult form', which violates M. The learner is equipped with a M > F > MPARSE bias, meaning that in the absence of evidence to the contrary, all markedness constraints are at the top, all faithfulness constraints are ranked below, and MPARSE is at the bottom. With MPARSE so lowly ranked, the null parse is always the winner, and all words are avoided. This initial grammar, also known as the initial state, is noted as $\mathscr{H}_0$ in (4). With this grammar, the child is silent, as all words are mapped onto the null parse.

(4) $\mathscr{H}_0$: M ≫ F ≫ MPARSE
MPARSE is at the bottom, everything is avoided.

When the child attempts to pronounce 'adult form', the current grammar selects the null parse as the winner (5). The outside observer hears nothing being said, so the word 'adult form' is avoided. Since we assume 'adult form' as the input, the candidate 'adult form' is faithful, so it only violates M, but not F. By definition, the null parse only violates MPARSE.

(5)

/adult form/	M	F	MPARSE
a. adult form	*!		
b. ☞ ⊙			*

The adult form does not win in (5), i.e. the child makes an error. To learn from this error, the intended winner is compared to the actual winner, and this comparison creates the comparative tableau in (6), also known as the Support. The Support collects the errors that the child decides to learn from. The constraint M assigns a violation mark to the winner but not to the loser, so it prefers the loser. This preference is marked with an L in (6); similarly, MPARSE prefers the winner, so it marked with W. When the ranking algorithm is run on the Support, MPARSE is installed, meaning it is placed at the top of the hierarchy. The single winner-loser pair is accounted for and thus removed, leaving M and F without any evidence about their ranking. Due to the M > F bias, M is installed first below MPARSE, and F is installed below M, giving the new grammar in (7).

(6)

	M	F	MPARSE
adult form ≻ ⊙	L		W

(7) $\mathscr{H}_1$: MPARSE ≫ M ≫ F
Faithfulness at the bottom, everything is simplified

In this new grammar, faithfulness is lowly ranked, so running 'adult form' through the new grammar will give a new winner 'simplified form'. We will assume that 'simplified form' does not violate M and does violate F. Choosing 'simplified form' as the output is still an error, so learning needs to take place again. Now the learner pairs 'simplified form' with the adult form, and learns from the new error. The winner-loser pair from (6) is still part of the Support, so it also appears in (8).

(8)

	M	F	MParse
adult form ≻ ⊙	L		W
adult form ≻ simplified form	L	W	

When running the ranking algorithm on (8), we have two constraints that only prefer winners to choose from, F and MParse. Due to the F > MParse bias, we first install F, followed by MParse. When both are installed, M is free for installation below them, as in (9). At this point, the learner reached the adult grammar.

(9) $\mathcal{H}_2$: F ≫ MParse ≫ M
Adult forms surface faithfully

The learning path as illustrated moved the learner from avoidance through simplification to the adult form. The three stages appear without anything known about the specific markedness and faithfulness constraints involved; the trajectory of the learning path is only due to the general definition of markedness and faithfulness and to the M > F > MParse bias in the constraint ranking algorithm. The ranking algorithm as given by Prince and Tesar (2004) and Hayes (2004) only use an M > F bias, which I augmented with an F > MParse bias. The addition of further biases to constraint ranking algorithms has several precedents, such as the addition of the OO-F > M bias and the splitting of F into a specific-F > general-F bias; see Tessier (2006, 2007) for a review.[3]

The null parse approach has only been used to model avoided forms in adult language, to my knowledge. My use of it here is particularly close to its use in the modeling of phonotactic gaps, as in Prince and Smolensky (1993/2004), Smith (2009) and Albright (2011). This paper integrates the null parse approach with the learning algorithms used in constraint-based approaches.

The idea that gaps may shape language acquisition suggests that over time, some languages will get rid of words that have marked structures. An instructive case comes from the history of rhotic-initial roots in Proto-Indo-European: in most daughter languages, these rhotic-initial roots appear with prothesis, but the same roots are missing in Anatolian (Rasmussen 1999, Operstein to appear). Perhaps future attention from historical linguists will uncover more of these cases.

[3] The proposed F > MParse bias is motivated in this case by SR's acquisition path, and any other acquisition path that is similarly characterized by avoidance followed by simplification. It is hoped that this bias will receive additional support in the future from other sources, cross-linguistic and experimental.

3.2. *Application to Syllable Margins*

In the previous section, we have seen how a single markedness constraint can interact with faithfulness and MPARSE to produce the kind of learning trajectory that SR exhibits, with avoidance followed by repair and then mastery. This section assumes further that SR's initial clusters and final sonorants are both repaired with deletion, and thus both give rise to violations of the same faithfulness constraint, Max-C. Admittedly, it may not be possible to verify that deletion is involved in both cases beyond reasonable doubt, but the general case of two different markedness violations giving rise to violation of the same faithfulness constraint seems quite plausible. In particular, deletion is known to be highly prevalent in child language, and it is quite likely that at least some children deploy deletion as a repair for more than one marked structure.

With sonorants in word-final codas, SR's main choices are shown as candidates in (10). The grammar is in its initial state, as in (4), with M ≫ F ≫ MPARSE. Here, the markedness constraints are instantiated by *SONCODA, which penalizes final sonorants, and *COMPLEX, which penalizes initial clusters. The faithfulness constraint is MAX-C, which assigns one violation mark for every consonant of the input that lacks an output correspondent. The first candidate in (10) is fully faithful, violating the markedness constraint *SONCODA. The second candidate is a simplified form, with the final consonant deleted. The final candidate is the null parse, which only violates MPARSE.

(10)

/na.ˈmeʁ̥/	*SONCODA	*COMPLEX	MAX-C	MPARSE
a. na.ˈmeʁ̥	*!			
b. na.ˈme			*!	
c. ☞ ⊙				*

When SR moves to the next grammar, as in (7), MPARSE is installed above *SONCODA. *COMPLEX is not involved, and it stays at the top of the hierarchy. But since MPARSE is no longer at the bottom, complex onsets can no longer be avoided; this unintended consequence is shown in (11).

(11)

/ˈgli.da/	*COMPLEX	MPARSE	*SONCODA	MAX-C
a. ˈgli.da	*!			
b. ☞ ˈgi.da				*
c. ⊙		*!		

Once MAX-C is below MPARSE, avoidance is more costly than deletion, and all marked structures that can be repaired by deletion can no longer be avoided.

In other words, once sonorant codas are simplified, complex onsets should be simplified as well. Yes this is not the case: SR starts simplifying sonorant codas from the very first recording session at 1;2, while simplified complex codas do not appear until more than a month later.

The unintended interaction between the processes seen above is more severe when examined in a more generalized way. In § 4 below, I show the true depth of the problem, and offer a solution in the form of sub-categorization of MParse.

4. Generalizing the MParse(M) Approach

In this section, I show that the M > F > MParse bias is too coarse to derive a realistic acquisition path; the effect of MParse is too dramatic. Instead, I will propose that MParse is relativized to particular markedness constraints, thus limiting its effect.

4.1. *The Problem: Avoidance Lost Too Soon*

To see the problem in its general form, assume a more realistic grammar with several markedness constraints, noted M_1, M_2, M_3, etc., and several faithfulness constraints, noted F_1, F_2, F_3, etc. In the initial state, as in (12), all the markedness constraints are in one stratum at the top, followed by all of the faithfulness constraints, and MParse at the bottom.

(12) $\mathscr{H}_0$: $M_1, M_2, M_3, \ldots \gg F_1, F_2, F_3, \ldots \gg$ MParse
Initial state: everything avoided.

Now, the learner notices that one word, 'adult form', is being avoided, and it is paired with the current output, the null parse, to form the winner-loser pair in (13). We assume that 'adult form' violates M_1. The markedness constraints that do not have an L in their column are installed first, followed by MParse. Once the winner-loser pair is accounted for, M_1 is free to be installed, followed by all of the faithfulness constraints. The resulting grammar is in (14).

In this new grammar, MParse outranks all of the faithfulness constraints, so the null parse will never be a winner. Any possible repair for M_1 will be preferred to a violation of MParse. What happened was that learning triggered by a single markedness constraint caused avoidance to no longer be available as a response to any markedness violations.

(13)

	M_1	M_2	M_3	F_1	F_2	F_3	MParse
adult ≻ ⊙	L						W

(14) $\mathscr{H}_1$: $M_2, M_3, \ldots \gg$ MParse $\gg M_1 \gg F_1, F_2, F_3, \ldots$
Nothing avoided; everything simplified.

Continuing from here, the learner now produces 'adult form' simplified. Pairing 'simplified form' with 'adult form' adds another winner-loser pair to the Support, as in (15).

(15)

	M_1	M_2	M_3	F_1	F_2	F_3	MPARSE
adult ≻ ⊙	L						W
adult ≻ simplified	L			W			

When running the ranking algorithm on (15), M_2 and M_3 are free for installation first. Then F_1 and MPARSE need to be installed to free M_1, followed by the remaining faithfulness constraints F_2 and F_3. The resulting grammar is in (16).

(16) $\mathcal{H}_2$: $M_2, M_3, \ldots \gg F_1 \gg$ MPARSE $\gg M_1 \gg F_2, F_3, \ldots$
M_1-violating forms surface faithfully; everything else simplified if F_1 is not involved; avoided if F_1 involved.

In this grammar, the low ranking of M_1 allows forms that violate it to surface faithfully. Avoidance in general is not in use, because most faithfulness constraints are below MPARSE, but avoidance can happen in a situation where the only other option is violating F_1.

The learning path described in (12–14–16) seems rather implausible. While it correctly starts with avoidance, and leads particular forms through simplification to the adult forms, there is an unintended consequence for avoidance in general. The early promotion of MPARSE above all faithfulness constraints means that avoidance is no longer available as a strategy for dealing with any kind of phonotactic restriction. Since the null parse will no longer be a winner once the grammar in (14) is adopted, there will no longer be evidence for ranking it below any markedness constraint other than M_1.

4.2. *The solution: Markedness-Based Avoidance*

We have seen in §4.1 that MPARSE must not be promoted too early, or it will have an implausibly strong effect. The solution I propose relies on a better formalization of Kiparsky and Menn's insight quoted in (1), according to which avoidance is a response to a markedness constraint.

Instead of installing MPARSE above markedness as in §4.1, the revised algorithm installs a markedness-specific instances of MPARSE. This approach finds precedent in Rice (2006), who also proposes that MPARSE should be relativized to apply in fewer contexts.

The learner starts as before, with a grammar that has several markedness constraints, then several faithfulness constraints, and finally MPARSE at the bottom of the hierarchy.

(17) $\mathcal{H}_0$: M_1, M_2, M_3, … ≫ F_1, F_2, F_3, … ≫ MParse
Initial state: everything avoided.

Again the learner's grammar generates the null parse from the input 'adult form', and a winner-loser is formed, as in (18).

(18)

	M_1	M_2	M_3	F_1	F_2	F_3	MParse
adult ≻ ⊙	L						W

Now, applying the ranking algorithm would normally lead us to install MParse. But instead, we create a new constraint, MParse(M_1), and install it. This new constraint only penalizes the null parse if the fully faithful candidate violates M_1 (see 23 below for a formal definition). This frees up M_1, and following it, faithfulness can be installed, followed by the general MParse. With this new grammar, faithfulness still outranks general MParse, and avoidance is still largely in place. Only forms whose fully faithful candidate violates M_1 are simplified.

(19) $\mathcal{H}_1$: M_2, M_3, … ≫ MParse(M_1) ≫ M_1 ≫ F_1, F_2, F_3, … ≫ MParse
M_1-violating adult forms simplified; everything else avoided.

Now, the learner's output for 'adult form' is 'simplified form', which is still an error. An additional winner-loser pair is added to the Support, as in (20).

(20)

	M_1	M_2	M_3	F_1	F_2	F_3	MP(M_1)	MParse
adult ≻ ⊙	L						W	W
adult ≻ simplified	L			W				

The Support in (20) has three constraints that could be installed: F_1, MParse (M_1), and MParse. We install F_1 first due to the F > MParse bias. Next, MParse(M_1) is chosen for installation, presumably because it is more specific than MParse. The resulting grammar, in (21), allows forms that violate M_1 to surface faithfully, but forms that do not violate M_1 are still avoided.

(21) $\mathcal{H}_2$: M_2, M_3, … ≫ F_1 ≫ MParse(M_1) ≫ M_1 ≫ F_2, F_3, … ≫ MParse
M_1-violating forms faithful; everything else avoided.

The learner achieved an adult-like grammar as far as M_1 is concerned. The acquisition path goes through avoidance and then simplification on its way to the adult form, all the while allowing forms that do not violate M_1 to remain avoided. Regarding the formal definition of the markedness-specific versions of MParse, it should be noted that MParse(M_1) is defined relative to the fully faithful candidate (McCarthy 2003, 2007). In this stage of phonotactic acquisition, the fully faithful candidate (FFC) is conveniently identical to the adult form (as in, e.g. Hayes 2004).

(22) MPARSE(M_1): Assign a violation mark to ⊙ if the FFC violates M_1

The definition of the markedness-specific MPARSE can be made more general, applying to a set of markedness constraints.

(23) MPARSE(M_m ... M_n): Assign a violation mark to ⊙ if the FFC violates all of the Markedness constraints in M_m ... M_n

To summarize, I showed that the general MPARSE is too blunt as a tool for modeling avoidance in acquisition, as it creates unintended and implausible effects on the learner's behavior. Relativizing MPARSE to the markedness constraints that cause avoidance creates a well-behaved and realistic acquisition path, and offers a first formalization for Kiparsky and Menn's insight.

An anonymous reviewer asks whether it would be possible to relativize faithfulness constraints instead of MPARSE. While it is technically possible, it would lead to a much more complicated theory: to prevent avoidance in response to M_1, F_1 will need to be demoted below MPARSE, but only for those cases where M_1 is involved. So F_1 will have to be split into one version that is sensitive to M_1 (to be demoted below MPARSE), and one version that is sensitive to all candidates that do not violate M_1 (to be kept above MPARSE). The general F_1 is removed from the grammar. Worse still, all other faithfulness constraints will also have to be specified as not applying to forms that violate M_1. These negative definitions of faithfulness constraints will have to be repeated for each markedness constraint that causes simplification rather than avoidance. Relativizing MPARSE, then, is the preferred solution.

5. Implementation

The issue of learning Optimality Theoretic grammars has received much attention over the years, with much of the theory highly formalized and rigorously proven to work, as in e.g. Tesar and Smolensky (1998, 2000). The current model adds a new component to the theory, and thus should be checked carefully to work as advertised. I implemented the learner computationally as a Perl script. The script and accompanying files are available at http://becker.phonologist.org/shaxar/. The learner is overall similar to the one in Becker and Tessier (2012), but with constraints defined as bona fide functions, as in Becker (2005).

First, I will show the learner in its basic form, and show how it generates the problem discussed in § 4.1. Then, a mechanism for installing markedness-specific versions of MPARSE will be added, and a more realistic acquisition path will emerge.

The implementation I offer is categorical in two senses: it moves from one grammar to the next categorically (i.e. there is only one grammar operative at each point in time), and each grammar is categorical (all constraints are categorically ranked). This results in a simplified acquisition path relative to SR's actual productions. See Becker and Tessier (2012) for a noisier implementation of Error Selective Learning.

5.1. *Installing the General MParse*

The learner starts with a set of four universal constraints (con): *SonCoda, *ComplexOnset, Max, MParse. When given an input, eval creates up to five candidates: the fully faithful candidate and ⊙ are always created. If the input has an initial cluster or a final sonorant, simplified forms that repair either or both are created. Given a candidate set, eval simply chooses the winner given the current ranking.

Whenever the learner produces a non-adult form, or an error (i.e. the fully faithful candidate is not the winner), it is stored in the Cache (Tessier 2007, 2008, 2009, Becker and Tessier 2012). When errors accumulate in the Cache, they are selectively moved to the Support. Then, the ranking algorithm (à la Prince and Tesar 2004, Hayes 2004) creates a new grammar, persistently favoring M > F > MParse.

As its input, the learner runs a list of SR's targets through its current grammar, one by one, in random order. Randomizing the list assures that the learner attempts words with marked structures throughout the learning process. When enough errors accumulate, the Support is updated and a new grammar is learned. The learner starts with the initial state ($\mathcal{H}_0$) and passes through three intermediate grammars on its way to the adult grammar ($\mathcal{H}_4$).

As seen in Figure 3, the learner starts by being completely silent in $\mathcal{H}_0$, as everything is avoided. Then, final sonorants are simplified in $\mathcal{H}_1$, and at the same time, initial clusters are simplified as well. Avoidance is switched off at $\mathcal{H}_1$ for both marked structures. When *SonCoda is ranked below faithfulness in $\mathcal{H}_2$, final sonorants are pronounced faithfully, and initial clusters are avoided again. Initial clusters are again simplified in $\mathcal{H}_3$, and produced faithfully in $\mathcal{H}_4$.

The appearance of simplified initial clusters in $\mathcal{H}_1$ is due to the installation of MParse above faithfulness, and their disappearance in $\mathcal{H}_2$ is due to the renewed installation of MParse below faithfulness. The learner adopts both of these grammars in an attempt to master final sonorants; the effect on initial clusters is unintended.

It should be noted that the learner chooses what to learn from based on the accumulation of errors in the Cache, which is a buffer that determines which errors are sent to the Support. In Hebrew, final sonorants are much more com-

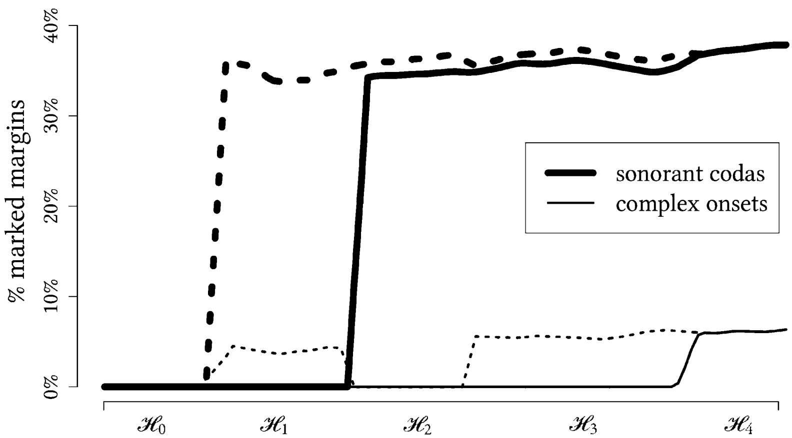


Figure 3: Model predictions: Productions and attempts of marked syllable margins. Solid lines represent faithful productions, dashed lines simplified productions.

mon than initial clusters, which is why the learner masters them earlier. It would seem, however, that the frequency effect here is rather large: initial clusters are about five times rarer than sonorant codas, yet SR acquires them in fairly rapid succession. To mimic SR's pace, I allowed learning thresholds to differ by markedness constraint; in essence, making the model more sensitive to violations of *ComplexOnset than frequency would require. While this improves the fit of the model to the data, further research will be needed to assess the appropriateness of this solution more generally.

5.2. *Installing Markedness-specific MParse*

To fix the problem with the model in § 5.1, a new model was built that installs markedness-specific versions of MParse, as defined in (23). The original MParse stays at the bottom of the hierarchy. Markedness constraints and MParse are functions from a linguistic form (a candidate) to a number of violations. Similarly, faithfulness constraints are functions from a pair of linguistic forms (the input and a candidate) to a number of violations. The new markedness-specific MParse proposed here is a little more involved, though perfectly well-defined: it is a function from a linguistic form (the candidate), a markedness constraint, and the fully faithful candidate, to a number of violations. The simulation creates these new constraints/functions on the fly, and they are added to CON.

Running the simulation with this new mechanism in place makes the acquisition path more plausible, as show in Figure 4. In $\mathcal{H}_1$, the general MParse is still

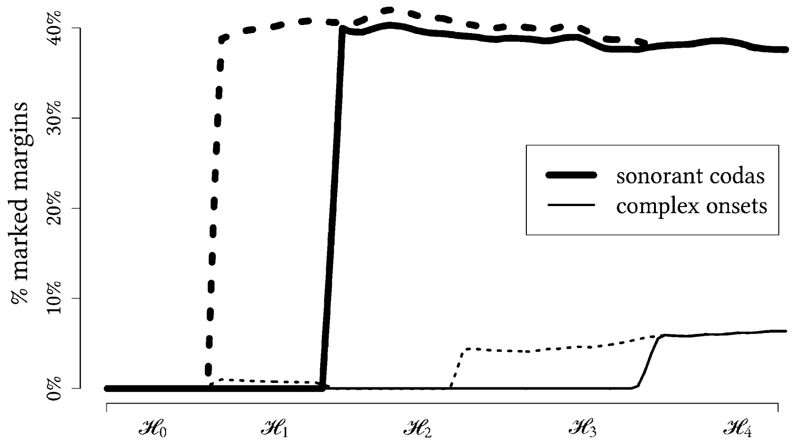


Figure 4: Model predictions: Productions and attempts of marked syllable margins. Solid lines represent faithful productions, dashed lines simplified productions.

at the bottom of the hierarchy, but MParse(*SonC) is installed above *SonCoda. Forms with initial clusters are still avoided, since the general MParse is below faithfulness. And yet, Figure 4 shows a few forms with initial clusters sneaking in during $\mathscr{H}_1$. Why is that? The reason is that some words contain both an initial cluster and a final sonorant, and these words are not avoided when $\mathscr{H}_1$ is in place. Recall that simplifying an initial cluster or a final sonorant is done by deletion, so the same Max-C is violated in both cases. When a form such as [pʁ̞a.ˈχim] 'flowers', which has both marked structures, is run through $\mathscr{H}_1$, the null parse is not the winner (24).

(24)

/pʁ̞a.ˈχim/	*Complex Onset	MParse (*SonC)	*SonCoda	Max-C	MParse
a. pʁ̞a.ˈχim	*!		*		
b. pa.ˈχim			*!	*	
c. ☞ pa.χi				**	
d. ⊙		*!			*

The emerging result is that two marked configurations that involve the same faithfulness constraint are predicted to interact, but *only in the words that have both configurations*. I find the prediction to be intriguing, yet SR's data is not sufficiently rich to prove or disprove it. Hopefully, more generous avoidance patterns will be identified and examined in this light in the future.

6. Conclusions

I analyzed SR's acquisition of marked syllable margins, showing that he first *avoids* words that have them, then he *deletes* the offending consonants, then produces them faithfully. I offered an analysis of SR's acquisition path in terms of Error Selective Learning, modeling the avoidance of marked structure as selection of the null parse. The model includes a persistent M > F > MParse bias and relativization of MParse to markedness constraints.

A result that emerges from the null parse approach to target selection is the dual utility of target selection: Firstly, selection removes non-adult-like productions, leaving the forms that the child does produce more adult-like than they would otherwise be. This makes the child's speech more likely to be interpreted correctly by hearers. Secondly, selecting the null parse is informative: it identified the markedness constraints that are involved, and it causes the learner to transition into simplification and then into adult-like speech.

The analysis is implemented computationally, which serves as a check on its accuracy and its ability to generate realistic acquisition paths. The selection of constraints to install is a rather complex procedure, as it goes through markedness, faithfulness, and MParse, treating each one differently. It would seem that the mechanism can be improved and streamlined, perhaps with an optimization technique on the selection process; this is left for future work.

Questions remain about the general applicability of the approach taken in this paper. I diagnosed target avoidance in SR's corpus by looking at his intended productions only. The assumption that two different kinds of marked structures are repaired in the same way relies additionally on the transcriptions of his productions, which requires a greater reliance on the accuracy of the corpus. It is hoped that future research will shed more light on the repairs that children make, and improve our confidence in analyses that rely on repair identification.

Going beyond SR's case, questions remain about the kinds of structures that children avoid, and differences between children in their tendencies to avoid certain structures and not others. Assuming that such differences do exist, the learning mechanism would need to accommodate these differences, hopefully by nothing more than minor adjustments to the model's parameters.

References

Adam, Galit and Outi Bat-El. 2008a. Segmental effects on syllable selection: Evidence from Hebrew. In A. Gavarró and M.J. Freitas (eds), *Language Acquisition and Development: Proceedings of GALA 2007*, 1–11. Newcastle: Cambridge Scholars Publishing.

Adam, Galit and Outi Bat-El. 2008b. The trochaic bias is universal: Evidence from Hebrew.

In A. Gavarró and M.J. Freitas (eds), *Language Acquisition and Development: Proceedings of GALA 2007*, 12–24. Newcastle: Cambridge Scholars Publishing.

Adam, Galit and Outi Bat-El. 2009. When do universal preferences emerge in language development? The acquisition of Hebrew stress. *Brill's Annual of Afroasiatic Languages and Linguistics* 1:255–282.

Albright, Adam. 2010. Lexical and morphological conditioning of paradigm gaps. In C. Rice (ed.), *Modeling Ungrammaticality in Optimality Theory*, London: Equinox.

Albright, Adam. 2011. Gradient complexity thresholds in phonology. A talk given at Stanford University.

Baayen, Harald. 2008. *Analyzing Linguistic Data: A practical introduction to statistics*. Cambridge University Press.

Bat-El, Outi 2010. A gap in the feminine paradigm of Hebrew: A consequence of identity avoidance in the suffix domain. In C. Rice (ed.), *When Nothing Wins: Modeling Ungrammaticality in OT*, 165–194. London: Equinox.

Bat-El, Outi. 2012. The role of sonority in the acquisition of hebrew word final codas. In S. Parker (ed.), *The Sonority Controversy*, Mouton de Gruyter.

Becker, Michael. 2005. CCamelOT—an implementation of OT-CC's gen and eval in Perl. Software, UMass Amherst, http://people.umass.edu/mbe/CCamelOT/.

Becker, Michael and Anne-Michelle Tessier. 2012. Trajectories of faithfulness in child-specific phonology. *Phonology* 28:163–196.

Bloch, Tamar. 2011. *Simplification Patterns in the Acquisition of Word Initial Consonant Clusters in Hebrew*. M.A. thesis, Tel Aviv University.

Ferguson, Charles A. and Carol Farwell. 1975. Words and sounds in early language acquisition. *Language* 51:419–439.

Fikkert, Paula. 1994. *On the Acquisition of Prosodic Structure*. Ph.D. dissertation, Leiden University.

Goad, Heather and Yvan Rose. 2004. Acquisition of left-edge clusters in West Germanic. In R. Kager, J. Pater and W. Zonneveld (eds), *Constraints in Phonological Acquisition*, 109–157. Cambridge University Press.

Grijzenhout, Janet and Sandra Joppen-Hellwig. 2002. The lack of onsets in German child phonology. In I. Lasser (ed.), *The Process of Language Acquisition*, 319–339. Frankfurt/Berlin: Peter Lang Verlag.

Hayes, Bruce 2004. Phonological acquisition in optimality theory: the early stages. In R. Kager, J. Pater and Wim Zonneveld (eds), *Constraints in Phonological Acquisition*, 319–339. Cambridge: Cambridge University Press.

Jaynes, E.T. 2003. *Probability Theory: The Logic of Science*. Cambridge University Press.

Kager, René, Joe Pater and Wim Zonneveld. 2004. *Constraints in Phonological Acquisition*. Cambridge University Press.

Kiparsky, Paul and Lise Menn. 1977. On the acquisition of phonology. In *Language Learning and Thought*, 47–78. New York: Academic Press.

McCarthy, John. 2003. Comparative markedness. *Theoretical Linguistics* 29:1–51.

McCarthy, John. 2007. *Hidden Generalizations: Phonological Opacity in Optimality Theory*. London: Equinox.

McCarthy, John and Matthew Wolf. 2010. Less than zero: Correspondence and the null output. In C. Rice (ed.), *Modeling Ungrammaticality in Optimality* Theory. London: Equinox.

Menn, Lise. 2004. Saving the baby: making sure that old data survive new theories. In René Kager, Joe Pater and Wim Zonneveld (eds), *Constraints in Phonological Acquisition*, 54–72. Cambridge University Press.

Mudelsee, Manfred. 2010. *Climate Time Series Analysis*. Springer.

Operstein, Natalie. to appear. Mapping the linguistic sub-areas of Eurasia: Word-initial /r-/. In V. Shevoroshkin and H. Sverdrup (eds) *Festschrift in Honor of Aharon Dolgopolsky*.

Prince, Alan. 2002. Arguing optimality. ROA 562–1102.

Prince, Alan and Paul Smolensky. 1993/2004. *Optimality Theory: Constraint Interaction in Generative Grammar*. Oxford: Blackwell. [ROA-537].

Prince, Alan and Bruce Tesar. 2004. Learning phonotactic distributions. In R. Kager, W. Zonneveld and J. Pater (eds), *Fixing Priorities: Constraints in Phonological Acquisition*, 245–291. Cambridge University Press.

R Development Core Team. 2011. R: A language and environment for statistical computing. Vienna, Austria. (http://www.R-project.org).

Rasmussen, Jens Elmegård. 1999. New evidence for infixal -o- in Indo-European: Ablaut re-/or-. In *Selected Papers on Indo-European Linguistics* v1, 327–335. Copenhagen: Museum Tusculanum Press, University of Copenhagen.

Rice, Curt. 2006. Nothing is a phonological fact: Gaps and repairs at the phonology-morphology interface. A talk given at NELS 36.

Schwartz, Richard. 1988. Phonological factors in early lexical acquisition. In M. Smith and J. Locke (eds) *The Emergent Lexicon: The Child's Development of a Linguistic Vocabulary*, 185–222. New York: Academic Press.

Schwartz, Richard and Laurence Leonard. 1982. Do children pick and choose? An examination of phonological selection and avoidance in early lexical acquisition. *Journal of Child Language* 9:319–336.

Schwartz, Richard, Laurence Leonard, Diane Frome Loeb and Lori Swanson. 1987. Attempted sounds are sometimes not: An expanded view of phonological selection and avoidance. *Journal of Child Language* 14:411–418.

Smith, Brian. 2009. Cumulative constraint interaction and the null parse. Talk given at HUMDRUM '09 and MUMM '09.

Stoel-Gammon, Carol and Judith Cooper. 1984. Patterns of early lexical and phonological development. *Journal of Child Language* 11:247–271.

Tesar, Bruce and Paul Smolensky. 1998. Learnability in Optimality Theory. *Linguistic Inquiry* 29:229–268.

Tesar, Bruce and Paul Smolensky. 2000. *Learnability in Optimality Theory*. Cambridge, MA: MIT Press.

Tessier, Anne-Michelle. 2006. Testing for OO-Faithfulness in artificial phonological acquisition. In D. Bamman, T. Magnitskaia and C. Zaller (eds), *Proceedings of BUCLD30*, 619–630. Cascadilla Press.

Tessier, Anne-Michelle. 2007. *Biases and stages in phonological acquisition*. Ph.D. dissertation, University of Massachusetts Amherst, Amherst, MA.

Tessier, Anne-Michelle. 2008. Children's exceptional words: Lexical challenges from the timecourse of L1 phonological acquisition. Talk given at the University of Western Ontario.

Tessier, Anne-Michelle. 2009. Frequency of violation and constraint-based phonological learning. *Lingua* 119:6–38.

BAALL

BRILL *Brill's Annual of Afroasiatic Languages and Linguistics 4 (2012) 140–161* brill.com/baall

The Correlation between Phonological Spelling Errors and Language Development in Hebrew-Speaking children

Gila Tubul-Lavy
Department of Communication Sciences and Disorders, Ono Academic College & Department of Special education, Achva Academic College
gilatu@ono.ac.il

Abstract
Written language is based on linguistic knowledge, and thus children with language impairment, primarily phonological impairment, may have difficulties in learning literacy. In this study, the spelling of phonologically impaired Hebrew-speaking children is compared with that of typically developing children. Twenty-five children participated in the study and were divided into four groups: children with typical development (n = 7, 2nd grade), language impaired (n = 7, 3rd to 5th grade), phonologically impaired (n = 7, 3rd to 5th grade), and children who have a history of phonological impairment (n = 4, 3rd to 5th grade). The results are compatible with previous studies that found that spelling correlates with phonological abilities.

Keywords
phonological impairment; spelling; phonological processes; complexity; Hebrew

1. Introduction

Recent research has revealed a close connection between children's development of spoken language and written language, and the importance of language acquisition to basic reading and writing skills (Kamhi and Catts 1999, Bourassa and Treiman 2001). Moreover, writing is regarded to be the forth language skill to develop within a child, after three prime developmental prerequisites: understanding, speaking and reading (Ezer 1991).

This paper examins the spelling errors of Hebrew-speaking children, comparing among four groups of children: children with typical development, language impaired, phonologically impaired, and children with a history of phonological impairment. The discussion concentrates on phonological spelling errors, which correlate with phonological processes in the course of language acquisition (e.g. coda deletion, consonant harmony). The results suggest that

 DOI: 10.1163/18776930-00400007

children with phonological impairment (in the past or the present) have more spelling errors than younger typically developing children as well as children with language impairment, though the children with current phonological impairment have more errors than children with a history of phonological impairment.

2. Phonology and Spelling

This section provides a brief review of the phonological processes (§2.1) and types of spelling errors (§2.2) found in typical and atypcial populations. It then discusses the relation between phonological impairment and spelling skills (§2.3).

2.1. *Phonological Process in Acquisition*

2.1.1. Typical Development

Children's productions of Hebrew words, compared to those of adults, reveal various phonological processes occurring at all levels of representation. Processes at the segmental level include substitution of segments (e.g. *vilón* → [*bilón*] 'curtain', *kof* → [*tof*] 'monkey'), assimilation/harmony (e.g. *dégel* → [*dédel*] 'flag', *dúbi* → [*búbi*] 'bear'), and metathesis (e.g. *patíʃ* → [*tapíʃ*] 'hammer', *kise* → [*sike*] 'chair'). Processes at the syllabic level include consonant omission (e.g. *glída* → [*gída*] 'ice cream', *bakbúk* → [*babú*] 'bottle'), vowel insertion (e.g. *dli* → [*delí*] 'bucket'), and coalescence (e.g. *trufá* → [*kufá*] 'medicine'). At the prosodic word level, there is syllable omission (e.g. *kadúr* → [*dur*] 'ball'). These processes gradually disappear in the course of language development. In terms of age, Grunwell (1981) reports (for English) that they disappear by the age of 3:6–4:0. In terms of the children's developmental stage, Ben-David (2001) reports (for Hebrew) that they diminish as children produce longer words; most of the processes decrease at the minimal word stage (a disyllabic word in Hebrew), and the rest fade away when trisyllabic words are produced.

2.1.2. Atypical Development

Phonological impairment is "a communication disorder characterized by difficulty to use developmentally expected speech sounds, matched for age and dialect" (DSM-IV 1994). Speech intelligibility in children with phonological impairment is low due to the presence of a relatively large number of phonological processes that fail to fade at the expected rate. These processes are often comparable to typical phonological development (e.g. the omission of a word's unstressed non-final syllable), though they linger to a relatively advanced age. In such cases, the difference between the typically developing and the phonologically impaired children is only quantitative. For phonological phenomena that are rarely evident in typical development, such as the production of consonant free words (e.g. *ótobus* → [*ó.o.u*] 'bus'; Adi-Bensaid and Tubul-Lavy 2009), the difference may be qualitative.

2.2. *Spelling*

2.2.1. The Acquisition of Spelling

Spelling is the encryption of linguistic forms into written form or, in other words, the usage of conventional written language to encode spoken language (Treiman 2004). It follows that spelling is not merely a technical skill, but also, and perhaps primarily, the representation of the language's phonology, morphology, and syntax. Therefore, spelling is based on linguistic knowledge; i.e. the writing process depends on verbal thinking, learned after the acquisition of speech (Veltman 1992). Another important component in reading and writing is the acquisition of morphological skills (Ravid 2011), but this issue is beyond the scope of this study. Some researchers claim that reading and spelling share orthographic and phonological representations (Romani, Olson and Di Betta 2005, Friend and Olson 2008). Others argue that they require different skills (Landerl, Wimmer, and Frith 1997); while reading is a process of identification that can be carried out with cues, writing is an output process that requires complete and accurate knowledge. Henceforth, we focus on writing.

According to Moats (1995), difficulty in spelling stems from a deficiency in the linguistic ability to analyze sounds and syllables in spoken words and in written language. Therefore, when children begin writing at kindergarten age or in first grade, they spell according to sounds, i.e. with phoneme-grapheme correspondence. However, this phase, known as the alphabetic stage, is short lived. Children later spell according to spelling rules, while relying on language knowledge. Levin, Share and Shatil (1996) identified five writing levels in Hebrew-speaking children's orthographic acquisition in the age range of 4 to 7 years. The last two are *phonetic writing*, i.e. breaking the grapho-phonemic code which associates graphemes with phonemes, evidenced by letters representing phonological units in the spoken word, and *orthographic writing*, which involves incorporating orthography-specific and morphological components into the spelling. In the orthographic level, children learn to use words and syllable units as exemplars of possible spelling patterns (Seymour 2005). These levels are compatible with those found in other languages (Ellis 1994, Goswami 1999, Treiman, Zukowski and Richmond-Welty 1995). Development of the alphabetic stage is highly influenced by the relationship between individual letters and sounds in a given language. Children who have spelling difficulties because of specific language impairment may be stuck at the beginning of the alphabetic stage. They fail to link letter to sound and sound to letter, skills that are required in the alphabetic phase (Dodd and Carr 2003).

2.2.2. Hebrew Spelling Characteristics

Hebrew script is an alphabetical writing system with two types of orthographies: (a) "transparent orthography", with one-to-one correspondence between sound and letter (e.g. the letter <ל> is always and only *l*, and the letter <מ> is always and only *m*), and (b) "deep orthography", where one sound corresponds to more than one letter (e.g. *k* corresponds to <כ> and <ק>), and one letter corresponds to more than one sound (e.g. <כ> corresponds to *k* and *x*). The deepness of the Hebrew orthography is also due to the scarce vowel representation. Most letters represent consonants, and only a couple (<ו> and <י>) represent vowels) e.g. <דובי> *dúbi* 'teddy bear', where <ו> corresponds to *u* and <י> to *i*, <שומר> *ʃomér*, where <ו> corresponds to *o*). Otherwise, vowels are represented by diacritics below or above the consonant letters. The presence of vowel diacritics, the so-called "pointed Hebrew", greatly enhances the orthographic transparency. However, this system is used primarily in children's books and poetry. In all other literary texts, the Hebrew orthographic system is characterized as deep orthography. For example, the word spelled <ספר> represents *sapár* 'hairdresser', *safár* 'he counted', *séfer* 'book', and *sfar* 'periphery', where only the semantic and/or syntactic context allows disambiguation.

Consequently, knowledge of the Hebrew writing system requires more than sound-to-letter encoding. It requires phonological, morphological, and syntactic knowledge of the language (Bourassa and Treiman 2001, Ravid 2001, Bar-On 2010, Vaknin-Nusbaum and Miller 2011).

Preschoolers initially write phonetically and exhibit much variation in their writing. They may omit letters corresponding to vowels, as in <LŠN> instead of <LŠWN> *laʃón* 'tongue', or exchange letters that correspond to the same sound, as <MRK> instead of <MRQ> *marák* 'soup' (Ravid 2005). In the first and second grades, there is a transition from the alphabetic phase to orthographic writing, but spelling errors of the following types remain:

a. Distorted representation of vowels, including the omission of vowel letters (e.g. <ŠFR> instead of <ŠWFR> *ʃofár* 'horn'), and the addition of vowel letters (e.g. <DאG> instead of <DG> *dag* 'fish').
b. Homophonous exchanges between characters representing the same linguistic sound (e.g. <QWV9> instead of <KWV9> *kóva* 'hat').

c. Phonetic substitutions between letters representing similar phonetic sounds (<RTF> instead of <RDF> *radáf* 'chased').

By the third grade, as orthographic spelling and writing skills become dominant, children acquire phonological, morphological, and morpho-phonological knowledge, knowledge of spelling patterns, and of the proper spelling of words, and they acquire the ability to write fluently (Shany, Zeiger, and Ravid, 2001, Ravid 2005).

2.2.3. Spelling Errors (dysgraphia)

DSM-IV defines dysgraphia as a "disturbance in written expression". The disturbance is identified when "writing accomplishments are below those expected … relating to age, intelligence and learning appropriate for his age" (Stott, Henderson, and Moyes, 1987). According to O'Hare and Brown (1989), there are three types of dysgraphia: Type A includes technical difficulties such as motor learning and execution of the script; type B relates to difficulties in the linguistic aspects of written language, such as spelling, punctuation, structure, and language rules; and type C includes semantic problems such as written expression, text organization, formulation, planning, and feedback. In this study, we focus on type B of dysgraphia, that is, on the linguistic aspect in general, and spelling in particular.

2.3. *The Relationship between Phonological Impairment and Spelling*

Previous research found a link between phonological disorders and different language capabilities, such as word retrieval (Ellis and Young 1988), auditory memory (Webster, Plante, and Couvillion 1997, Stackhouse et al. 2002), phonological awareness (Bird, Bishop, and Freeman 1995), and reading and writing (Lewis, Freebairn, and Taylor 2000).

Studies on the relation between the spoken and written English (Menyuk 1983, Kahmi and Catts 1989, Carlisle 1995) and on Hebrew (Ravid 2011) have concluded that the spoken language is the basis for typical reading and writing. Therefore, difficulty in the spoken language causes difficulty in the written language (Rapin and Allen 1983, Kahmi and Catts 1999, Leonard 1998). Several studies (Lewis, Freebairn, and Taylor 2000, Friend and Olson 2008, among others) found a high correlation in preschool and school children between impaired phonological development and difficulties in spelling. Dodd, Sprainger, and Oerlemans (1989) compared children with spelling errors to children with typical development, and concluded that children with spelling errors have difficulty in processing phonological information in reading, writing, and in speaking.

Researchers are still debating whether children with spelling errors differ from typical children only quantitatively (i.e. their errors resemble those of typical younger children), or whether the gap is also qualitative (spelling errors that are incompatible with a developmental writing process). Swanson and Ramalgia (1992), for example, found that 13 year-old children with learning disabilities exhibited misspellings that matched those of typical 9 year olds. In contrast, Lewis, Freebairn, and Taylor (2000) found that children with spelling errors have poor phonological representation, i.e. their spelling errors are not according to the language's rules and are, therefore, qualitatively different. Since most of the studies are for English-speaking children, and no research has been made on Hebrew with its peculiar writing system, I attempt to answer this question with reference to Hebrew-speaking children. Specifically, I address the following questions:

a. What is the prevalence of orthographic and phonological misspelling in children with atypicial development compared to the typically developing children?
b. What are the common phonological processes that result in phonological spelling errors?
c. Are errors corresponding to phonological processes affected by complexity, such as word length or syllable structure?

Following the studies linking between impaired phonological development and misspelling (Lewis and Freebairn 1993, Friend and Olson 2008, Lewis, Freebairn, and Taylor 2000, Arndt and Foorman 2010), our hypotheses are as follows:

a. The prevalence of orthographic and phonological misspelling will be higher in children with phonological impairment (current and past) than in children with (non-phonological) language impairment or with no impairment.
b. The common phonological processes exhibited in the spelling errors of the phonologically impaired children (current and past) will correspond to the latest phonological processes to be acquired in spoken language (e.g. medial coda deletion and cluster reduction).
c. These phonological processes may be affected by structural complexity, especially in children with current or past phonological impairments.

3. The Experiment

3.1. *Research Method*

3.1.1. Participants

Twenty five children (10 girls and 15 boys) ages 7:6–11:0 years participated in the study. They were divided into four groups:

Group A – Phonological Impairment (PI): 7 children (3 girls and 4 boys), 3rd to 5th graders, ages 8:6–11:0, with a current phonological impairment with no known etiology (diagnosed by speech therapists, still receiving treatment). They had difficulties also in reading and received tutoring for improving their reading.

Group B – Phonological Impairment in the Past (PIP): 4 children (1 girl and 3 boys), 3rd to 5th graders, ages 8:6–11:0, with a history of phonological impairment with no known etiology, whose speech is currently error free (diagnosed by speech therapists as having moderate phonological impairment including reduced speech intelligibility with at least four phonological processes and had been treated in the past once a week for more than two years). They did not have any reading difficulties.

Group C – Language Impairment (LI): 7 children (2 girls and 5 boys), 3rd to 5th graders, ages 8:6–11:0, with language impairment without phonological disorders (diagnosed by speech therapists as having semantic, morphological or syntactic disabilities and still receiving treatment). They did not have difficulties in encoding, but had a relatively low level of reading comprehension for their age.

Group D – Typical Control Group (TCG): 7 children (4 girls and 3 boys), 2nd graders, ages 7:6–8:0, without any impairment. They all had good reading skills as expected of their age.

Since spoken language is the basis of written language, we wanted to see if there were traces of phonological impairment in the spelling of PIP group, despite the accuracy of their speech production.

Although most researchers found that language impairment relates to difficulties in reading comprehension, we wanted to check if this is also the case with the Hebrew LI group, given Hebrew's peculiar writing system (§ 1.4).

The children in group D (TCG) are one or two years younger than the children in groups A–C. If the spelling errors of the other groups match those of the younger children, then this is merely a prolonged phase, and the difference is thus quantitative; if they do not match, then the difference must be qualitative.

3.1.2. Instrument

The test consisted of 49 pictures, each representing an individual word. All the words were common and concrete nouns. The pictures were divided into 5 groups, based on the words' syllabic templates:

a. 4 'warm-up words' with CV syllables only (e.g. *kisé* 'chair')
b. 15 words with final codas only, with no medial codas (e.g. *xatúl* 'cat')
c. 8 words with medial codas only, with no final codas (e.g. *malká* 'queen')
d. 10 words with both medial and final codas (e.g. *sargél* 'ruler')
e. 12 words with initial consonant clusters with codas (e.g. *kluv* 'cage') and without codas (e.g. *dvorá* 'bee').

Each template was divided into groups of words according to the number of syllables, from one to three syllables, with the exception of words with medial codas, which were disyllabic and trisyllabic words only.

3.1.3. Process

Each child was given two tasks during a personal meeting in a quiet room. The first task consisted of naming the pictures and the second of writing the words. All 49 pictures were presented in a fixed order. If the child made a mistake when naming the picture, a hint was provided, and s/he was asked to name the picture again. For example, if a picture of a tooth paste was named a toothbrush, the clue was "you spread it on the toothbrush". After giving the correct answer, the child was asked to write the word. If the child had a phonological error in the spoken response, the experimenter did not correct him/her, but asked the child to write the word. The children used a script without points (vowels).

Diacritics were not included in the error analysis. The results refer to the written words only. The errors were categorized at first, to orthographic errors and phonological errors. Then the phonological errors were divided according to their phonological process: consonant harmony, coda deletion, voicing, substitution, syllable deletion, metathesis and cluster reduction.

3.2. *Results*

The aim of the test was to compare spelling skills of the four groups of children and to evaluate the phonological characteristics of the errors. Groups A, C, and D provided 343 words each (49 words × 7 children), and group B (PIP) provided 196 words (49 words × 4 children). The spelling errors were compared among the groups.

3.2.1. Comparison among Groups

The first hypothesis was that the PI group would have more spelling errors than the other three groups. In order to test this hypothesis, a one way ANOVA test was conducted. The hypothesis was confirmed ((F 3, 21)=23.56, p < 0.001). Table 1 presents the means and standard deviations of the misspelled words among the four groups.

Table 1: Spelling errors by type

	PI		**PIP**		**LI**		**TCG**	
	%	**SD**	%	**SD**	%	**SD**	%	**SD**
Phonological errors	33.12	17.55	10.20	1.66	2.04	1.66	1.71	1.79
Orthographic errors	37.76	16.97	24.48	13.63	24.77	13.6	8.18	6.95
Total errors	70.88	18.16	34.68	13.01	26.81	14.4	9.91	8.08

In order to test whether the groups were significantly different from one another, a post hoc test was performed. A Scheffé post-hoc multiple comparison revealed that that the PI group differed significantly from all the other groups. There was no significant difference among these three groups.

The results in Table 1 distinguish between orthographic and phonological errors. Orthographic errors included errors that occurred due to the impaired orthographic knowledge, such as homophones usage (e.g. <ק> instead of <כ> for *k*, or <ו> instead of <ב> for *v*). Phonological errors (see § 2.2.2) correspond to phonological processes that occur in children's speech, such as devoicing (e.g. *f* instead of *v*) or deletion of codas (e.g. <מכה> instead of <מלכה>, deleting <ל> for the medial coda *l*).

A one way ANOVA test was conducted among the four groups. The results of both the orthographic erros (F 3, 21 = 5.684, p < 0.05) and the phonological errors ((F 3, 21) = 15.82, p < 0.01) were significant. A Scheffé post-hoc multiple comparison revealed that the PI group made significantly more phonological errors than each of the other groups. No significant difference was found among the three other groups, though the PIP group (phonological impairment in the past) had a higher rate of phonological spelling errors than both the LI group (language impairment) and the TCG group (typical control). For orthographic errors, the PI group made significantly more errors than the typical group only. Hereafter, we focus on the phonological errors and their nature.

3.2.2. Phonological Processes

The second hypothesis was that that the common phonological processes in misspelling in the PI group would correspond to the phonological process that are the last to disappear in children's speech, i.e. medial coda deletion and cluster reduction. A one way ANOVA test was conducted for each of the seven dependent variables: consonant harmony, coda deletion, voicing, substitution, syllable deletion, metathesis and cluster reduction. Significant results were found for consonant harmony ($F(3,24)=6.02$, $p < 0.01$), coda deletion ($F(3,24)=3.09$, $p < 0.05$), voicing ($F(3,24)=6.28$ $p < 0.01$), and syllable deletion ($F(3,24)=5.9$, $p < 0.01$). Substitution, cluster reduction, and metathesis were not significantly different statistically. That is, our hypothesis was weakly confirmed: the PI group made significantly more errors with medial codas (see § 3.2.4), as predicted, but not with clusters. In addition, the PI group made significantly more errors with consonant harmony, although this process disappears rather early in children's speech.

Table 2: Errors by phonological processes

	PI		PIP		LI		TCG	
	%	SD	%	SD	%	SD	%	SD
Consonant harmony	3.29	2.43	1.75	1.7	0.29	0.48	0.43	0.53
Coda deletion	5.00	6.40	1.25	0.95	0.29	0.48	0	0
Voicing	2.29	1.79	1.00	0.80	0	0	0.43	0.53
Substitution	2.29	3.20	0.25	0.50	0.14	0.37	0	0
Syllable deletion	1.14	0.90	0.25	0.50	0.14	0.37	0	0
Metathesis	1.00	1.41	0.75	0.50	0	0	0	0
Cluster reduction	1.71	2.81	0	0	0	0	0	0

A Scheffé post-hoc multiple comparison revealed that the PI group made significantly more errors than the LI and TCG groups, but not the PIP group, in voicing and consonant harmony. As for syllable deletion and coda deletion, the PI group made significantly more errors than the typical group only. There were no significant differences among the groups with regard to cluster reduction, substitution, and metathesis. The PIP group made more errors than the LI and TCG groups, but the difference was not statistically significant for all the phonological processes.

3.2.3. Word Length

The third question addressed the impact of word length on spelling errors. Table 3 presents the percentage and standard deviation of errors in monosyllabic, disyllabic, and trisyllabic words.

Table 3: Errors by word length

	PI		PIP		LI		TCG	
Length of word	%	**SD**	%	**SD**	%	**SD**	%	**SD**
Monosyllabic	10.29	7.67	6.50	4.50	0	0	1.29	3.40
Disyllabic	31.86	23.58	11.00	2.30	1.93	2.40	1.93	2.40
Trisyllabic	49.43	26.31	15.25	3.17	3.50	4.87	2.57	4.80

A one way ANOVA test confirmed that each of the four groups differs in the percentage of spelling errors in words with increasing length: monosyllabic words ($F(3,21) = 6.77$ $p < 0.05$), disyllabic words ($F(3,21) = 8.55$ $p < 0.01$), trisyllabic words ($F(3,21) = 15.30$ $p < 0.001$). That is, as predicted, the longer the words (in terms of number of syllables) the more spelling errors.

To test whether the percentage of errors differed significantly between the PI group and the other three groups, a Scheffé post-hoc multiple comparison was conducted. The comparison revealed that in monosyllabic and disyllabic words, the PI group made significantly more errors than the LI and TCG groups. The PI group made more errors than the PIP groups, but this was not significant. In trisyllabic words, the PI group made significantly more errors than any of the other three groups.

3.2.4. Position of Codas

Our last hypothesis was that the phonological processes may be affected by the position of the coda in the word, especially in children with current or past phonological impairments. In order to test the effect of the position of the coda on spelling errors in each of the four groups, a one-way ANOVA was conducted. The results were significant for final coda ($F(3, 21) = 6.889$, $p < 0.005$), medial coda ($F(3, 21) = 15.64$, $p < 0.001$) and both final and medial codas ($F(3, 21) = 33.24$, $p < 0.001$). Table 4 shows the effect of coda position (final vs. medial) and the number of codas in the word (final and medial) on misspelling.

Table 4: Errors by codas

	PI		PIP		LI		TCG	
Coda position	%	**SD**	%	**SD**	%	**SD**	%	**SD**
Final only	10.12	7.55	5.20	2.08	0	0	0.14	0.37
Medial only	40.21	22.11	21.88	6.25	5.93	4.09	1.78	1.27
Medial and final	44.42	15.42	22.73	5.24	2.60	4.43	2.60	4.43

To test which group differed from the others in misspelled words with codas, a post hoc test was performed. A Scheffé post-hoc multiple comparison revealed that the PI group differed significantly only from the LI and TCG groups on words with final codas and on words with medial codas. On words with both medial and final codas, the PI and PIP groups differed significantly from all the other groups.

4. Discussion

The study examined phonological spelling errors of 25 Israeli Hebrew-speaking children aged between 7:6 and 11:0 years: children with phonological impairment (PI; n = 7, 3rd to 5th grade), children with phonological impairment in the past (PIP; n = 4, 3rd to 5th grade), children with language impairment (LI; n = 7, 3rd to 5th grade), and typically developed children (TCG; n = 7, 2nd grade). The children's errors were analyzed according to phonological processes, word length, and coda position.

The results show that there is no significant difference between the typically developed (TCG) and the language impaired (LI) children. The phonologically impaired children (PI), however, made significantly more errors than the other three groups in general (1), though in three phonological processes (substitution, cluster reduction, and metathesis) the difference was not significant. These findings rank the spelling skills of the PI group below that of the other groups. As for the group with past phonological impairment (PIP), although their speech was intelligible, they had numerically more errors than the other two groups but fewer than the PI group. In some cases (consonant harmony, deletion of final codas, voicing, syllable deletion), their error rate did not differ significantly from the PI group. These results rank the PIP group above the PI group but below the two other groups. This suggests that the phonological system underlying written language of the PIP group is still incomplete, and since the spelling skills rely on phonological knowledge (see §2.3), we can conclude that the phonological system of the PIP group is also incomplete.

All in all, the ranking of the four groups is, as expected, PI < PIP < LI and TCG. These findings support studies on Italian (Brizzolara et al. 2011) and English (Bradley and Bryant 1985, Bruck 1993, Rvachew 2007), which found a correlation between phonological impairment and spelling errors.

4.1. *The Dual Spelling Route*

To write a word in free writing, two routes are available: the lexical route and the sub-lexical route (Gvion, Friedmann and Yachini 2008). The more efficient route, the lexical route, uses the orthographic output lexicon in which orthographic representations of words are stored and activated. The orthographic output lexicon can be accessed from the semantic system in free writing. Only items that exist in the orthographic output lexicon can be written via the lexical route; non-words and new words cannot.

The sub-lexical route uses phoneme-to-grapheme conversion. This route is used mainly for writing new words and non-words, i.e. letter sequences that do not exist in the orthographic lexicon. It is also used when the lexical route is impaired, as in surface dysgraphia (where a good visual memory is coupled with a poor ability to encode serial order). Words that have more than a single option for conversion from phonemes to graphemes (i.e. words with homophonic letters) and also words that do not obey standard phoneme-to-grapheme conversion rules (i.e. irregular words), may be written incorrectly via the sub-lexical route. This route is heavily used by first graders in the early stages of writing, enabling the writing of new words (Berninger 1994, Gvion and Friedmann 2010). It is also the route that was predominantly used by the PI group, although they would have been expected to use the lexical route more often.

Spelling mistakes can help us learn about the routes that were taken. The results of a spelling dictation given to English speaking second-graders revealed that morphological spelling errors occurred more frequently than orthographic and phonological errors and that the children relied on multiple sources of linguistic knowledge for spelling (Arndt and Foorman 2010). In contrast, Dodd, Sprainger, and Oerlemans (1989) argue that children who have a phonological speech disorder have difficulties in spelling due to a particular difficulty in generating phoneme-to-grapheme correspondence. They base this on the fact that these children are much worse than normal children at spelling words that have a 1:1 sound-letter correspondence, but are equally bad at spelling words that do not have a 1:1 correspondence.

Most research on spelling errors was conducted on Latin orthographies (e.g. Gillam and Johnston 1992, Mackie and Dockrel 2004 for English, Pennala et al. 2010 for Finnish), rarely on Semitic orthographies like Arabic and Hebrew. Two studies were carried out for Arabic: one included students in grades 1–9 who were presented with lists of words to test their spelling skills. Their spelling errors were analyzed according to error categories and the most frequent errors were found to be phonological. No significant differences in the percentages of phonological errors were found across grades one to nine (Abu-Rabia and Taha 2006). An earlier study included second-graders: dyslexic Arabic readers, a young readers group (matched with the dyslexics for reading level) and an age-matched group (Abu-Rabia and Taha 2004). A dictated spelling test of texts, isolated words and pseudo-words was administered. Results revealed that the profile of spelling errors was similar in percentages and quality among the dyslexics and the reading-level-matched group but different from the age-matched group on the spelling measures. The dominant type of error was phonological due to the limited orthographic lexicon. In addition, Arabic orthography also contributed to these types of errors because many spelling mistakes were made due to poor knowledge of the spelling rules. Therefore, the authors concluded that phonology probably presents the greatest challenge to students developing spelling skills in Arabic (Abu-Rabia and Taha 2004, 2006).

Our research, which deals with phonological and orthographic misspelling, supports these findings. The errors of Hebrew-speaking children were similar; the phonologically impaired groups (PI and PIP) had more spelling mistakes than the typical and LI groups. This suggests that Hebrew phonology plays an important role in spelling, probably due to deep orthography enriched with homophones, where in several cases one letter corresponds to two sounds and two sounds correspond to one letter. Homophones can only be learned via the lexical route. Typical first and second graders can have spelling mistakes in homophones, but such errors may also indicate a problem in developing a lexicon. Thus, we assume that PI and PIP children have difficulty in both routes: lexical and sub-lexical. Our claim is supported by a study on a transparent language such as Italian (Brizzolara et al. 2011), which shows that children have difficulties in spelling, although the correspondence between letter and sound is rather clear. Therefore, in addition to phonology, knowledge of vocabulary is important to spelling. Stackhouse and Snowling (1992) even suggest that both impaired speech production and spelling difficulties can be attributed to difficulties in the mental representation of words in the lexicon.

Bird et al. (1995) found that students with a history of phonological impairment whose speech is currently error free are at risk of experiencing reading and spelling difficulties. Moreover, children with a history of phonological impairment in preschool are likely to have literacy difficulties even as adolescents (Leitao and Fletcher 2004). Lewis and Freebairn (1993) examined four groups with a history of preschool phonological disorders on measures of phonology, reading, and spelling (preschool age, grade school age, adolescence, and adulthood). The results showed that in each age group, subjects with a history of phonological disorders performed more poorly than the control subjects matched for age, sex, and socioeconomic status in all domains. Greater improvement on these measures was seen from preschoolers to grade school age.

Our findings support this claim. Both the PI and PIP groups had more errors than the LI and the TCG group, though the difference was significant only for the PI group. While children with language disorders may have difficulties in comprehension, a phonological difficulty may be associated with decoding impairment that leads to writing/spelling difficulties because it affects the word segmentation skills necessary for reading and spelling.

4.2. *Children with Phonological Spelling Deficits vs. Younger Typical Children*

Friend and Olson (2008) compared pairs of children, one older child with spelling disability (SD) and one spelling-level-matched younger child with normal spelling ability. In phonological accuracy, the SD group scored significantly lower than the spelling-level-matched younger child with normal spelling ability.

Similar results were obtained in the current study. The younger typical children (2nd grade) made much fewer spelling errors than the PI group (3rd to 5th grade). In orthographic errors, the ratio was 1:4.6 and in phonological errors it was 1:20. This difference cannot be explained by maturity or quantitative variables. Even though second graders may still confuse homophones (orthographic errors), they spell better than phonologically impaired children. In addition, attention should be drawn to the ratio between orthographic and phonological misspelling. While the typical children had 4.8 times more orthographic mistakes than phonological errors, and the LI group had 1, the PI group showed almost the same percentage of errors for both kinds of misspelling. In contrast, the LI group's ratio was 1:14, but they had very few phonological errors. This suggests that the PI group failed in spelling tasks due to deficiencies in both the sub-lexical and the lexical routes. Having one functioning route, helps in spelling more words correctly. When both routes are impaired, many more words are misspelled.

4.3. *Phonological Processes*

The second question in our research concerned the phonological processes that result in misspelling. To determine whether differences between PI and typical spellers exist, we analyzed the phonological processes underlying the spelling tasks (2). The most common phonological processes found in the spelling errors were voicing, consonant harmony, and coda deletion (medial codas more than final codas).

Klein-Sade (2005) classified children's spelling errors in Hebrew according to their source: (a) Orthographic errors due to homophones, similar sounds with different graphic expression and (b) Phonological errors, where phonological processes due to speech impairment are transferred to the writing system (e.g. medial coda omission—***kumkum*** → [***kukum***] 'kettle' and metathesis—[***kalabat***] for ***kabalat*** 'receipt').

Orthographic misspellings are considered a mild impairment and were found in all four groups while impaired phonological processes were found especially in the PI and PIP groups.

Voicing substitution was frequent, via both consonant harmony and non-assimilatory voicing/devoicing. Gvion and Friedmann (2010) report on a new type of dysgraphia (which they termed "dyscravia"), where the main error type is substitution of the target letter with a letter that differs only with respect to the value of voicing, (e.g. writing *coat* for *goat*). These sub-lexical errors were made by two elderly Hebrew-speaking patients, who suffered from acquired dysgraphia, and by two children who had developmental dyscravia. The authors claim that a separate function of voicing feature conversion (without a parallel deficit in reading) exists in the phoneme-to-grapheme conversion route, and may be more prone to conversion errors than more stable and consistent phonological features, such as place and manner of articulation.

Another phonological process evident only in the PI group was cluster reduction but the difference was not significant. Harmony, on the other hand, was significant, although it disappears in speech rather early and often does not constitute more than 5% of the children's productions. Nevertheless it was significant. Since Hebrew clusters within a syllable are mostly found in word initial position and consist of two consonants, our task referred to these characteristics. Such errors were found only in the PI group. Consonant clusters, which are more marked (complex) than singletons, are one of the last prosodic structures to be acquired by children in the course of their phonological development (Grunwell 1981, Ingram 1989). Cluster reduction is a common process in language acquisition (Grunwell 1981, Fikkert 1994, Kehoe et al. 2008).

Ingram (1989) suggests four main stages of cluster acquisition: deletion of the entire cluster, cluster reduction (one member of the cluster is deleted), cluster simplification (a cluster is produced, but one or both members are substituted) and finally, correct articulation. There is no agreement regarding deletion patterns and not all children go through all the stages. Our results indicate that some of the PI children write only one of the two consonants. One possible explanation is that in PI, the encoding of clusters in the oral language was not qualitatively completed. It is used in everyday speech, but when the situation becomes more complex, as in encoding language, there is a withdrawal and errors emerge. It seems that although typical children acquire clusters pretty early, between 3;6–4;0 years old (Grunewll, 1981), PI children still have spelling errors of cluster reduction.

The question of the deleted consonant is controversial to this day. Ingram (1989) presents a model of deletion based on the markedness value of the individual consonants in the cluster. According to this model, the more marked consonant in the cluster is deleted. A second model, which refers to sonority-based onset selection, suggests that the more sonorous consonant in the onset is deleted (Fikkert 1994, Barlow 2005). Yet another model, based on the contiguity principle, claims that children prefer producing the second member in the cluster, since a consonant adjacent to a vowel is perceptually more salient (Steriade 2001). Adi-Bensaid and Ben-David (2010) and Bloch (2011) suggest an interaction between the contiguity principle, which accounts for almost all the deletion patterns of target clusters (deletion of C1) and the markedness model, which accounts for the deletion pattern of obstruent-liquid clusters (deletion of a liquid C2).

The written words misspelled by the PI group did not reveal a preferred pattern. Following are two examples with a plosive in C_1 and *v* in C_2: while <DBWRH> *dvorá* 'bee' was written as <DWRH> *dorá* (deletion of C_2), <KBYŠ> *kviʃ* 'road' was written as <PYŠ> *fiʃ* (deletion of C_1). In the first example, the more sonorous consonant C_2 *v* is deleted whereas in the second, C_1 *k* is deleted, following the contiguity principle. Such heterogeneity was found in other deleted consonants and no model was found to be consistent. Because only a few examples of cluster reduction were exhibited in PI, this issue remains unclear. Both the PI and the PIP groups made more errors in coda deletion than in cluster reduction (the PIP group had no errors in cluster reduction), though most errors of coda deletion were in medial position. This could indicate that medial codas are acquired before word initial clusters. However, this conclusion requires further investigation with a larger population in a number of other languages.

4.4. *Increasing Complexity*

Our third research question related to structural complexity, which in turn often correlates with markedness. As the complexity of the word increases, so is the number of production errors expected to increase in children who have not fully mastered the process. This was verified for coda position (§ 2.2.4) and word length (§ 2.2.3). For the coda, the spelling test consisted of words, in increasing complexity, with a final coda only, a medial coda only, and both medial and final codas. The typical and LI children exhibited no difference among the three types. The PI and PIP children showed an increasing number of errors as the words' complexity increased (although the PIP group had fewer errors than the PI group at all levels of complexity). For PI and PIP groups, the percentage of errors in words with medial codas only was four times the percentage of errors in words with final codas only. The percentage of errors in words with both final and medial codas was almost the same as words with medial codas only. The PI group differed significantly only from the LI and TCG groups on words with final codas and on words with medial codas. In words with both medial and final codas, the PI and PIP groups differed significantly from all the other groups, meaning that this is the hardest situation for the phonological impaired groups.

These results suggest that the spelling skills of the children with (past or present) phonological impairment (PI and PIP) are sensitive to phonological complexity; the typical children and children with language disorders (LI) showed not effect of phonological complexity. The scale of complexity correlates with the order of coda acquisition in Hebrew, where final codas are acquired before medial codas. This order is maintained by typically developing children

(Ben-David 2001, this volume) as well as by atypically developing children (Gishri 2009, Adi-Bensaid and Tubul-Lavy 2009, Adi-Bensaid this volume).

An observation of codas that were deleted in spelling revealed another phonological effect: obstruents are deleted more than sonorants, indicating a preference to sonorants in coda position. This is in line with the Sonority Dispersion Principle (Goldsmith 1990), according to which the more sonorous consonants are preferred as codas and the less sonorous consonants as onsets (see Bat-El 2012 for the Sonority Dispersion Principle in the acquisition of Hebrew).

A correlation between complexity and the rate of spelling errors was exhibited also in relation to word length—the longer the word (in terms of number of syllables) the higher the relative rate of spelling errors. The LI (language impaired) and the typical groups had a slight increase in misspelling from monosyllabic to disyllabic words, and another increase from disyllabic to trisyllabic words, reaching only 5 % errors. The PIP group had 6.5 % errors in monosyllabic words; their errors doubled in disyllabic words and almost tripled in trisyllabic words, reaching more than 15 %. The largest increase was shown in the PI group: they had 10 % errors in monosyllabic words, 31 % in disyllabic words and almost 50 % in trisyllabic words.

The effect of word length is also found in the acquisition of speech. Children with phonological impairment, such as developmental apraxia of speech (DAS), make more mistakes when pronouncing longer words (Crary 1993).

5. Summary and Conclusion

The aim of this research was to compare the misspelling of four groups: children with language impairment (LI), children with phonological impairment in the present (PI), children who had phonological impairment in their past (PIP), and a typical control group (TCG). Two of the three hypotheses have been supported:

a. The phonologically impaired children (PI) had more phonological spelling errors than the children with a history of phonological impairment (PIP). The two other groups (LI and TCG) hardly made any phonological errors.
b. The phonological spelling errors have been affected by structural complexity (word length and coda position), mainly in children with current phonological impairments (PI), but also with past phonological impairment (PIP).
c. The hypothesis that the common phonological processes exhibited in the spelling errors of the phonological impaired children (current and past) will correspond to the latest phonological processes in spoken language was only partially supported. Medial coda deletion and consonant harmony were common phonological processes for the PI and PIP groups; in both pro-

> cesses, the PI group differed from the LI and TCG groups significantly, but not from PIP group. However, while consonant harmony disappears from the children's speech relatively early (see Gafni this volume), cluster reduction survives much longer (see Bloch 2011).

The results of this study support earlier findings, which correlate past and present phonological impairment (but not language impairment) with spelling deficiencies. Further study is required, with a larger number of children, to illuminate the qualitative nature of the spelling errors among phonologically impaired children.

Further study is required, with a larger number of children, to illuminate the qualitative nature of the spelling errors among phonologically impaired children.

References

Abu-Rabia, Salim and Haitham Taha. 2004. Reading and spelling error analysis of native Arabic dyslexic readers. *Reading and Writing* 17:651–690.

Abu-Rabia, Salim and Haitham Taha. 2006. Phonological errors predominate in Arabic spelling across grades 1–9. *Journal of Psycholinguistic Research* 35:167–188.

Adi-Bensaid, Limor and Avivit Ben-David. 2010. Typical acquisition by atypical children: Initial consonant cluster acquisition by Israeli Hebrew-acquiring children with cochlear implants. *Clinical Linguistics and Phonetics* 24:771–794.

Adi-Bensaid, Limor and Gila Tubul-Lavy. 2009. Consonant-free words: Evidence from Hebrew speaking children with cochlear implants. *Clinical Linguistics and Phonetics* 23:122–132.

Arndt, Elissa and Barbara Foorman. 2010. Second graders as spellers: What types of errors are they making? *Assessment for Effective Intervention* 36:57–67.

Bar-On, Amalia. 2010. *The role of linguistic knowledge in learning to read non-voweled Hebrew*. Ph.D. dissertation, Tel-Aviv University [in Hebrew].

Barlow, Jessica. 2005. Phonological change and the representation of consonant clusters in Spanish: A case study. *Clinical Linguistics and Phonetics* 19:659–679.

Bat-El, Outi. 2012. The Sonority Dispersion Principle in the acquisition of Hebrew word final codas. In S. Parker (ed.), *The Sonority Controversy*, Berlin: De Gruyter.

Ben-David, Avivit. 2001. *Language acquisition and phonological theory: Universal and variable processes across children and across languages*. Ph.D. dissertation, Tel-Aviv University. [in Hebrew].

Berninger, Virginia. 1994. *Reading and Writing Acquisition: A Developmental Neuropsychological Perspective*. Madison, WI, England: Brown and Benchmark.

Bird, Judith, Dorothy Bishop, and Norman Freeman. 1995. Phonological awareness and literacy development in children with expressive phonological impairments. *Journal of Speech and Hearing Research* 38:446–462.

Bloch, Tamar. 2011. *Simplification Patterns in the Acquisition of Word Initial Consonant Clusters in Hebrew*. M.A. thesis, Tel-Aviv University.

Bourassa, Derrick and Rebecca Treiman. 2001. Spelling development and disability: The importance of linguistic factors. *Language, Speech, and Hearing Services in Schools* 32: 172–181.

Bradley, Lynette and Peter Bryant. 1985. *Rhyme and reason in reading and spelling*. Ann Arbor: University of Michigan Press.

Brizzolara, Daniela, Filippo Gasperini, Lucia Pfanner, Paola Cristofani, Claudia Casalini, and Anna Chilosi. 2011. Long-term reading and spelling outcome in Italian adolescents with a history of specific language impairment. *Cortex* 77:955–973.

Bruck, Maggie. 1993. Component spelling skills of college students with childhood diagnoses of dyslexia. *Learning Disability Quarterly* 16:171–184.

Carlisle, Joanne. 1995. Morphological awareness and early reading achievement. In *Morphological aspects of language processing*, Laurie Beth Feldman (ed.), 189–209. Hillsdale, NJ: Erlbaum.

Clements, Nick. 1990. The role of sonority cycle in core syllabification. In John Kingston and Mary E. Beckman (eds) *Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech*. Cambridge: Cambridge University Press. 283–333.

Crary, Michael A. 1993. *Developmental motor speech disorders*. San Diego: Singular Publishing Group.

Dodd, Barbara, Nichole Sprainger, and Michael Oerlemans. 1989. The phonological skills of spelling disordered children. *Reading and Writing* 1:333–355.

Dodd, Barbara and Alex Carr. 2003. Young children's letter-sound knowledge, *Language, Speech and Hearing Services in Schools* 34:128–137.

DSM-IV. 1994. *Diagnostic and statistical manual of mental disorders*. Arlington, VA: American Psychiatric Association (4th edition).

Ellis, Andrew and Andrew Young. 1988. *Human cognitive neuropsychology: A textbook with readings*. Hove, UK: Erlbaum.

Ellis, Nick 1994. Longitudinal studies of spelling development. In *Handbook of spelling: theory, process and intervention*, G.D.A. Brown and N.C. Ellis (eds.), 155–177. Chichester: John Wiley and Sons.

Ezer, Hanna. 1991. Writing to learn. *Helkat Lashon* 3–4:54–59 [in Hebrew].

Fikkert, Paula. 1994. *On the acquisition of prosodic structure*. The Hague: Holland Academic Graphics.

Friend, Angela, and Richard Olson. 2008. Phonological spelling and reading deficits in children with spelling disabilities. *Scientific Studies of Reading* 12:90–105.

Gafni, Chen. this volume. Consonant harmony in the scope of language development: Evidence from Hebrew.

Gillam, Ronald and Judith Johnston. 1992. Spoken and written language relationships in language learning impaired and normally achieving school-age children. *Journal of Speech and Hearing Research* 35:1303–1315.

Gishri, Michal. 2009. *The role of prominence in the acquisition of medial codas in Hebrew*. M.A. thesis, Tel Aviv University.

Goldsmith, John, ed. 1999. *Phonological theory: The essential readings*. Oxford, UK: Blackwell.

Goswami, Usha. 1999. The relationship between phonological awareness and orthographic representation in different orthographies. In *Learning to read and write: A crosslinguistic perspective*, M. Harris and G. Hatano (eds.), 134–156. Cambridge: Cambridge University Press.

Grunwell, Pamela. 1981. The development of phonology: descriptive profile, *First Language*, 3:161–191.

Gvion, Aviah and Naama Friedmann. 2010. Dyscravia: Voicing substitution dysgraphia. *Neuropsychologia* 48:1935–1947.

Gvion, Aviah, Naama Friedmann, and Maya Yachini, 2008. Writing and dysgraphia: On the writing process, writing impairments, and the relation between dysgraphia and dyslexia. In the Israeli Association of Physical and Rehabilitation Medicine (PMR) bulletin *Shikumada* 26:32–35. [in Hebrew].

Ingram, David. 1989. *Phonological disability in children: Studies in disorders of communication*. London: Whurr.

Kamhi, Alan and Hugh Catts. 1999. Language and reading: Convergence and divergence. In *Language and reading disabilities*, Hugh W. Catts and Alan G. Kamhi (eds), 1–24. Needham Heights, MA: Allyn and Bacon.

Kehoe, Margaret, Geraldine Hilaire-Debove, Katherine Demuth, and Conxita Lleo. 2008. The structure of branching onsets and rising diphthongs: Evidence from the acquisition of French and Spanish. *Language Acquisition* 15:5–57.

Klein-Sade, Riki. 2005. Categorization of spelling mistakes in children in 3rd–5th grades in Israel. Ph.D. dissertation. Budapest University [in Hebrew].

Landerl, Karin, Heinz Wimmer, and Uta Frith. 1997. The impact of orthographic consistency on dyslexia: A German-English comparison. *Cognition* 63:315–334.

Leitao, Suze and Janet Fletcher. 2004. Literacy outcomes for students with speech impairment: Long-term follow-up. *International Journal of Language and Communication Disorders* 39:245–256.

Leonard, Laurence 1998. *Children with specific language impairment*. Cambridge, MA: The MIT Press.

Levin, Iris, David Share, and Evelyn Shatil. 1996. A qualitative-quantitative study of preschool writing: Its development and contribution to school literacy. In *The science of writing*, M. Levy and S. Ransdell (eds), 271–293. Hillsdale, NJ: Erlbaum.

Lewis, Barbara and Lisa Freebairn. 1993. A clinical tool for evaluating the familial basis of speech and language disorders. *American Journal of Speech-Language Pathology* 2:38–43.

Lewis, Barbara, Lisa Freebairn, and Gerry Taylor. 2000. Follow-up of children with early expressive phonology disorders. *Journal of Learning Disabilities* 33:433–444.

Mackie, Clare and Julie Dockrell. 2004. The nature of written language deficits in children with SLI. *Journal of Speech, Language and Hearing Research* 47:469–483.

Menyuk, Paula. 1983. Language development and reading. In *Pragmatic assessment and intervention issues in language*, Tanya M. Gallagher and Carol A. Prutting (eds), 151–170. San Diego, CA: College-Hill Press.

Moats, Luisa Cook. 1995. The missing foundation in teacher preparation. *American Educator* 19:43–51.

O'Hare, Anne and Judith Brown. 1989. Childhood dysgraphia: Part 1. An illustrated clinical classification. *Child Care, Health and Development* 15:79–104.

Pennala, Riitta, Kenneth Eklund, Jarmo Hämäläinen, Ulla Richardson, Maisa Martin, Matti Leiwo, Paavo H.T. Leppänen, and Heikki Lyytinen. 2010. Percept phonemic length and its relation to reading and spelling skills in children with family risk for dyslexia in the first three grades of school, *Journal of Speech, Language and Hearing Research* 53:710–724.

Rapin, Isabelle and Doris Allen. 1983. Developmental language disorders: Nosologic considerations. In *Neuropsychology of language, reading and spelling*, Ursula Kirk (ed.), 155–184. New York: Academic Press.

Ravid, Dorit. 2005. Hebrew orthography and literacy. In *Handbook of orthography and literacy*, R.M. Joshi and P.G. Aaron (eds), 339–363. Mahwah, NJ: Erlbaum,

Ravid, Dorit. 2001. Learning to spell in Hebrew: Phonological and morphological factors. *Reading and Writing* 14:459–485.

Ravid, Dorit. 2011. Writing morphophonology: Psycholinguistics of Hebrew writing. In *Literacy and Language*, Ofra Korat and Dorit Aram (eds), 190–210. Jerusalem: Maganes Betta.

Rvachew, Susan. 2007. Phonological processing and reading in children with speech sound disorders. *American Journal of Speech-Language Pathology* 16:260–270.

Romani, Cristina, Andrew Olson and Anna Maria Di Betta. 2005. Spelling disorders. In *The science of reading: A handbook*, M.J. Snowling and C. Hulme (eds), 431–447. Malden, MA: Blackwell.

Seymour, Philip. 2005. Early reading development in European orthographies. In *The science of reading: A handbook*, M.J. Snowling and C. Hulme (eds), 296–315. Malden, MA: Blackwell.

Shany, Michal, Tali Zeiger and Dorit Ravid. 2001. Development and validation of diagnostic tools for assessing basic processes in reading and spelling. *Script* 2:167–203 [in Hebrew].

Stackhouse, Joy and Maggie Snowling. 1992. Barriers to literacy development in two cases of developmental verbal dyspraxia. *Cognitive Neuropsychology* 9:273–299.

Stackhouse, Joy, Bill Wells, Michelle Pascoe, and Rachel Rees. 2002. From phonological therapy to phonological awareness. *Seminars in Speech and Language* 23:27–42.

Steriade, Donca. 2001. Directional asymmetries in place assimilation: A perceptual account. In *The role of speech perception in phonology*, Elizabeth Hume and Keith Johnson (Eds), 219–250. New York: Academic Press.

Stott, Denis, Sheila Henderson, and Fred Moyes. 1987. Diagnosis and remediation of handwriting problems. *Adapted Physical Activity Quarterly* 4:137–147.

Swanson, Lee, and Janet Ramalgia. 1992. The relationship between phonological codes on memory and spelling tasks for students with and without learning disabilities. *Journal of Learning Disabilities* 25:396–407.

Treiman, Rebecca, Zukowski, Andrea and Daylene Richmond-Welty. 1995. What happened to the "n" of sink? Children's spelling of final consonant clusters. *Cognition* 55:1–38.

Treiman, Rebecca. 2004. Phonology and Spelling In Handbook of Children's Literacy, Terezinha Numes and Peter Bryant (Eds), 31–42. Netherlands, Kluwer Academic Publishers.

Vaknin-Nusbaum, Vered and Paul Miller. 2011. The importance of vowel diacritics for the temporary retention of high and low frequency Hebrew words of varying syllabic length. *Memory and Cognition* 39:516–526.

Veltman, Robert. 1992. An Orthography as a theory of a Language, *In Psychology, spelling and education*, Sterling, Chris and Cliff Robson (eds). 30–42. Clevedon, UK: Multilingual Matters

Webster, Penelope, Solomon Plante, Amy and Michael Couvillion. 1997. Phonologic impairment and prereading: Update on a longitudinal study. Journal of Learning Disabilities 30:365–375.

BAALL
BRILL Brill's Annual of Afroasiatic Languages and Linguistics 4 (2012) 162–188 brill.com/baall

Filler Syllables in the Acquisition of Hebrew: A Prosodic Account

Aviad Albert and Hadass Zaidenberg
Department of Linguistics, Tel-Aviv University
aviadalb@post.tau.ac.il, hadaszai@post.tau.ac.il

Abstract
In this paper we review the phenomenon of filler syllables in the early speech of RM, a monolingual Hebrew-acquiring girl. Our findings support former claims, in particular those made in Demuth (2001a), which tie the emergence of filler syllables with the process of prosodic structure acquisition. We present longitudinal corpus-based data that are analyzed against pre-defined stages in RM's acquisition of prosodic units to corroborate our predictions. We show that the distributional patterns of filler syllables can be attributed to prosodic requirements such as minimal word and foot type preferences during early stages of acquisition, and the emergence of concatenative morpho-syntax at later stages, where prosodic units above the phonological word begin to appear. In our view, a proper analysis of filler syllables is possible with "pure" phonological devices that rely on the prosodic hierarchy (Selkirk 1978, 1986, Nespor and Vogel 1986), since this hierarchy already encapsulates an underlying interaction with morpho-syntactic domains.
Our criteria for defining filler syllables do not presuppose that fillers are limited to any specific position, yet we take measures to ensure that actual fillers are not overlooked while general epenthesis processes are not confused with augmentation processes (only the latter are considered as fillers). We do so by detection of vowel insertions that stem from vocalization of approximant coda targets, cluster simplification processes and coda resyllabification. We believe that our strategy in considering subsets of fillers enables to verify attested trends and consider their complexities in full.

Keywords
language acquisition; filler syllables; prosodic hierarchy; foot; minimal word; minor phonological phrase

1. Introduction

During the course of language acquisition, children often produce an output syllable that has no corresponding syllable in the target word, as in Hebrew *ken* → [*ə'ken]* 'yes' (RM 1;05.22). These additional syllables, generally termed *filler syllables*, are attested in the early speech of children acquiring various languages, in ways that appear to be systematic to some extent (Veneziano and Sinclair 2000, Peters 2001, Demuth 2001a to name a few). The unique patterns of filler

 DOI: 10.1163/18776930-00400008

syllables' dispersion indicate their role as potential tools for prosodic adjustments in developing grammars, during acquisition phases of prosodic constituents.

In this paper we review the phenomenon of filler syllables in the speech of RM, a monolingual Hebrew acquiring girl. Our findings support former claims, in particular those made in Demuth (2001a), which tie the emergence of filler syllables with the process of acquiring prosodic structures. The underlying assumption, which has some evidence to rely on, is that prosodic structure may be acquired separately from segmental information, and often before most segmental distinctions have been acquired (Peters 1983, Pepinsky et al. 2001). This assumption gains further support from atypical language development (Tubul-Lavy 2005, Jacks et al. 2006, Bat-El 2009).

Some researchers refer only to prefixed filler syllables as actual fillers that reflect augmentation processes (Veneziano and Sinclair 2000), while others assume that fillers can emerge in suffixed or infixed positions, depending on language-specific properties (Peters et al. 1993, Peters 2001). In our analysis, we did not assume that fillers are limited to a certain position, yet we took many measures to carefully observe additional syllables in all positions. Our results indicate that, to some extent, filler syllables may appear in any position, although the prefix position clearly remains prominent throughout the data.

Our analysis of the corpus ties together observations on distributional behavior of filler syllables with distinct phases of the child's phonological development. The distributional patterns that we detect interact with the gradual acquisition of prosodic constituents within the Prosodic Hierarchy (Selkirk 1978, 1986, Nespor and Vogel 1986)—from small units such as syllables, feet and minimal prosodic words in the earliest phases of language acquisition, to minor phonological phrases in later stages.[1]

In § 2 we motivate our definition of filler syllables, present some preliminary hypotheses and assumptions, and our first division of the data into categorized periods reflecting the prosodic development of feet in RM's speech. In § 3 we analyze the data and account for the distribution of early fillers. We show that factors such as the minimal word, the preferred foot type and resyllabification of final codas, play a fundamental role in the use of additional syllables and in determining their position within the uttered word (note that the latter factor, resyllabification of final codas, might serve several different phonological requirements, which we address later in our analysis). In § 4 we analyze the distribution of fillers in later stages of RM's speech, when bound function morphemes begin to appear, requiring prosodic units of higher levels. We present our final conclusion in § 5.

---

[1] Our data covers an age range that does not present larger phonological units in the child's speech.

2. The Scope of RM's Filler Syllables

In this section we present the preliminary methods, assumptions and motivations that lie behind our analysis in § 3 and § 4. We describe the data used in this research (§ 2.1), explain our criteria for defining filler syllables (§ 2.2), and then provide our initial predictions on the distribution of filler syllables in Hebrew (§ 2.3). Finally, we outline our first division of the data in accordance with measurable cues of early prosodic development (§ 2.4).

2.1. *Data*

Our data (available in http://www.outibatel.com/wp-content/uploads/2010/12/Albert-and-Zaidenberg-Appendix.pdf) are drawn from corpora from the longitudinal *Child Language Project* headed by Outi Bat-El and Galit Adam (ISF grant #554/04). The recording sessions in this project began during the prelingual ("babbling") period, in order to detect the emergence of the child's very first words. All recordings were collected during one-hour weekly sessions in the child's natural environment, and they primarily include spontaneous speech and picture/object naming. For this research, we focus on speech recordings of one typically developed monolingual Hebrew acquiring girl, RM.

The obtained data were phonetically transcribed using IPA conventions in CHAT format for use with CLAN software (CHILDES project: http://childes.psy.cmu.edu/). All utterances were analyzed such that each word was individually encoded to reflect segmental and structural differences in comparison to its corresponding target. The encoded information included syllable structure (omissions and additions), stress pattern, and detailed segmental information. Recordings, transcriptions, and encodings were done by trained students of linguistics.

We base our analysis of RM's productions on 33 weekly sessions recorded over 10 months, from age 1;03.13 to 2;00.09. The total number of additional syllables (tokens) found in the data comprises 6.3 % (313/4,979) of the total number of productions during that period. Table 1 shows that the majority of additional syllables produced by RM were prefixed to the target word, as in *po* → [*əˈpo*] 'here' (1;05.10). This was the case in 57.2 % of the productions that included additional syllables. In 35.8 % of the cases, the additional syllables were suffixed to the target word, as in *po* → [*ˈpoʔo*] 'here' (1;08.14). The remaining 7.0 % were infixed additional syllables as in *aˈni* → [*ˈaleni*] 'I' (1;08.27).

Table 1: Positional distribution of additional syllables

	Prefixed	**Infixed**	**Suffixed**
Additional syllables (1;03.27–2;00.09)	57.2 % (179/313)	7.0 % (22/313)	35.8 % (112/313)

2.2. *Criteria for Definition of Filler Syllables*

Filler syllables have a variety of definitions, each of which is critical for the set-up of the relevant data for further analysis. In this paper, we define filler syllables rather narrowly. We only consider as fillers those syllables that have no correspondent (identical or substituted) in the target word (Table 2a). To this extent, we regard segmental alterations such as consonant vocalizations (Table 2b-i) as cases with substituted correspondent, and thus non-fillers. Consonant vocalizations are cases in which a final approximant consonant (liquid or glide) in the target word is substituted with a (usually high) vowel. Furthermore, since our study of fillers distinguishes between general epenthesis processes and prosodic augmentation processes, we screened out cases of vowel insertion within a consonantal sequence in the target word (Table 2b-ii). Such cases of cluster/sequence simplification seem to be readily motivated by universally unmarked tendencies against consonant sequences in early stages of acquisition (i.e. they represent general epenthesis processes which are not likely the result of prosodic augmentation). Another contributing factor to our decision to overlook this type of insertions is the fact that they were quite rare in comparison with other types of vowel insertions (only 20 cases throughout the data).

Table 2: Filler syllables vs. non-filler additional syllables

a. Filler syllables

Target	**Output**		
po	**ə**'po	'here'	(1;05.10)
'safta	**e**'navta	'grandma'	(1;09.18)
ze	'ze**i**	'this'	(2;00.02)
lo	'lo**ʔo**	'no'	(2;00.02)
igu'lim	**e**nixu'lim	'circles'	(2;00.09)

b. Non-filler syllables

i. Consonant vocalization: Liquid → Vowel

Target	**Output**		
kaʁ	'ka**u**	'cold'	(1;08.27)
parpa'rim	pa**u**pa'wi:m	'butterflies'	(1;08.27)
na'fal	af'a**i**	'fell'	(1;10.13)
pil	'pi**a**	'elephant'	(1;10.28)
niʃbaʁ	iʃpa**u**	'broke'	(2;00.02)

ii. Cluster/sequence simplification: CC → CVC

Target	**Output**		
ˈʃtaim	ʃ**ə**ˈtaim	'two fm.'	(1;07.10)
zvuv	ʃ**i**ˈbuux	'a fly'	(1;10.28)
t͡svi	ˈt͡s**i**pi	'a deer'	(1;10.28)
nigˈmaʁ	tek**i**ˈmar	'finished ms.sg.'	(1;11.18)
miʃkaˈfaim	ev**a**keˈʃaim	'glasses'	(2;00.09)
lifˈtoax	tiʃ**i**ˈtoax	'to open'	(2;00.09)

Our definition of filler syllables with the above criteria is intended to narrow our focus on the systematic appearance of output syllables that represent prosodic augmentation processes and cannot be seen as substitution cases of some other segment in the target word. It allows us to focus our analysis on the distributional patterns of prefixed and suffixed fillers that seem to be motivated by prosodic augmentation and comprise the large body of additional syllables in RM's speech.

We observed another subset of additional syllables that were unique in the sense that they could be readily motivated by universal tendencies against marked syllabic structures. Such were cases where a vowel in the output production was inserted right after a final coda in the target word, thus shifting the final consonant from a coda position to a less-marked onset position (i.e. avoiding the production of coda consonants while retaining the lexical information that would have been lost in cases of consonant deletion). Since these occurrences could also be motivated by augmentation factors, as well as other general factors (such as coda resyllabification) and since there was a substantial number of occurrences of this kind, these cases of post-coda insertion (1a) were not screened out from our set of filler syllables, but rather marked for further observation, which we applied throughout our analysis.

(1) Post-coda insertion

a. Post-coda insertion

Target	**Output**		
od	[ˈod**ə**]	'more'	(1;04.02)
ken	[ˈkeh**e**]	'yes'	(1;05.14)

b. No post-coda insertion

Target	**Output**		
od	[ˈo**i**]	'more'	(1;05.14)
ken	[ˈte**a**]	'yes'	(1;07.24)

Post-coda insertions were only considered as such if the consonant (or its substitute) in the original coda position was present in the output and syllabified accordingly in an onset position.

2.3. *The Coda Factor*

It is crucial to establish a stance regarding the status of additional syllables in post-coda positions. In order to do so, we need to verify to what extent fillers appear in suffixed positions due to coda resyllabification.

For this test, we divided our corpus into periods, in line with cues for gradual coda development in RM's speech (see also Bat-El 2012, this volume). The criterion we used is faithfulness to coda position, i.e. whether a consonant is preserved in coda position (faithful) or deleted (unfaithful). The data were divided in two, to reflect that change in faithfulness. As shown in Table 3, RM's unfaithful coda productions drop from 58.7% during the first period to 17.9% during the second.

Table 3: The two periods of coda faithfulness (% out of all coda-final targets)

Period	**Age**	**Unfaithful coda production**
Unfaithful codas	1;03.27–1;06.05	58.7% (321/547)
Faithful codas	1;06.12–2;00.09	17.9% (410/2288)

An analysis of the distribution of post-coda insertions across the two periods reveals the expected correlation: During the *Unfaithful coda* period, 34.6% of RM's additional syllables were post-coda insertions. These were 66.7% of all suffixed fillers during that period. During the *Faithful coda* period, only 9.1% of RM's fillers were post-coda insertions. These were less than a third of all the suffixed fillers during that period.

Table 4: Distribution of post-coda insertions

		Post-coda insertion	
Period	**Age**	**% of all additions**	**% of suffixed additions**
Unfaithful codas	1;03.27–1;06.05	34.6% (28/81)	66.7% (28/42)
Faithful codas	1;06.12–2;00.09	9.1% (21/232)	30.0% (21/70)

The above figures seem to strengthen the contribution of final codas in the target word, to the post-position of the additional syllable.

(2) Post coda fillers

Target	**Output**		
ˈken	ˈk'ət**ʃe**	'yes'	(1;05.10)
ˈsus	ˈtut**u**	'horse'	(1;05.22)
ˈejn	ˈen**ə**	'none'	(1;06.05)
eˈxad	jeˈxað**i**	'one'	(1;11.25)

Another observation that corroborates the interaction between target codas and suffixed additional syllables is demonstrated in the data about filler distribution in monosyllabic target words. RM produced 2,414 tokens of monosyllabic target words throughout the corpus. This figure makes up 51.5 % of all the recorded productions in our data. 1,458 (60.4 %) of those monosyllabic target words ended with a final coda consonant (mostly VC and CVC words). The other 956 (39.6 %) tokens were CV words. As expected, during both coda-related periods, CV target words had substantially more prefixed fillers than suffixed ones (11.5 % vs. 0.6 % of all CV targets, respectively).

The interesting picture emerges when we observe the position of additional syllables in (C)VC target words vis-à-vis the coda-related periods, under two types of analysis—with and without the inclusion of the subset of post-coda insertions (abbreviated in the following tables to PCI) in the set of fillers. While the relative amount of prefixed fillers in (C)VC targets remains low and relatively steady during the two periods (2.7–2.1 %), the behavior of suffixed additions seems to vary: when fillers are analyzed with the inclusion of post-coda insertions, the values of suffixed fillers during the *Unfaithful codas* period are substantially higher (6.5 %) than during any other period and it remains slightly above the values of prefixed fillers in the following *Faithful codas* period (2.9 % vs. 2.1 % respectively). However, when fillers are analyzed with the exclusion of post-coda insertions, the values remain low and relatively steady during the two periods (1.6–1.3 %), and always less than the values of prefixed fillers. The differences between those two analyses correlate the emergence of many of the suffixed additions with epenthesis processes due to coda resyllabification.

Table 5: Distribution and position of filler syllables in monosyllabic targets

		CV targets		**(C)VC targets**		
		Prefixed	**Suffixed**	**Prefixed**	**Suffixed fillers**	
Period	**Age**	**fillers**	**fillers**	**fillers**	**incl. PCIs**	**excl. PCIs**
Unfaithful codas	1;03.27–1;06.05	11.5 % (20/174)	0.6 % (1/174)	2.7 % (13/489)	6.5 % (32/489)	1.6 % (8/489)
Faithful codas	1;06.12–2;00.09	8.1 % (63/782)	2.0 % (16/782)	2.1 % (20/969)	2.9 % (28/969)	1.3 % (13/969)

Our findings lend support to the conclusion that post-coda insertions are tightly connected to general epenthesis processes, yet their possible contribution to augmentation process should not be overlooked. In our view, a suffixed filler on a CV target must not necessarily differ in motivation from a suffixed filler on a (C)VC target simply because the former lacks any motivation other than augmentation, while the latter may also be motivated by general epenthesis processes such as coda resyllabification. We believe that our strategy in considering post-coda insertions as a subset of fillers enables to better observe the data from several angles (with or without the subset) in order to verify attested trends and consider their complexities in full.

2.4. *Predictions*

We assume that the phonological structure of utterances complies with the prosodic hierarchy—a nested organization of prosodic categories. The categories relevant to the present study are (Minor) Phonological Phrase > Prosodic Word > Foot > Syllable > Mora. Following Demuth (2001a), we hypothesize that filler syllables are motivated by requirements that stem from the gradual acquisition of the prosodic structure. We therefore assume that fillers' distribution during acquisition should be adequately explained vis-à-vis the gradual acquisition of prosodic units. During early stages of speech, we expect filler syllables to appear in environments that will adjust small prosodic constituents such as *feet* and *prosodic words*. That is, fillers' distribution during early stages of acquisition is expected to promote certain foot types (*trochee* vs. *iamb*) and word forms (*minimal word*, consisting of a binary foot).[2]

In later stages of speech, the child acquires larger prosodic units by concatenation of function words and content words together under one *minor phonological phrase* (or, alternatively, under one larger *prosodic word*). In these cases, we expect filler syllables to appear as "placeholders" for functional units (Bottari et al. 1993/1994), extending the prosodic word and moving up in the prosodic hierarchy. By this, children demonstrate common cases where prosody is acquired before segmental and other structural aspects of phonology (Peters 1983).

Veneziano and Sinclair (2000) show that filler syllables in French are prefixed, due to language-specific as well as universal constraints. "The child first constructs an iambic metrical structure—an important prosodic pattern of French lexical units—that she realizes preferentially as a VCV(C) pattern" (pp. 486–487). Since epenthetic vowels are universally unstressed (Alderete 1999, Kager 1999), the filler syllables, being epenthetic, hold the weak position in the iambic foot, i.e. the first syllable, and are therefore prefixed.

The metrical structure in Hebrew is not as uniform as in French. Although there is a clear majority of iambic words in the Hebrew lexicon, the number of trochaic words is not insignificant, constituting approximately 25 % of the nouns in Hebrew (Adam and Bat-El 2009). Furthermore, Adam and Bat-El (2008, 2009) argue that data from Hebrew-acquiring children support the hypothesis

---

2) The universally unmarked foot is binary (two syllables or two moras), and this is also the minimal word size (McCarthy and Prince 1990, 1993).

of universal bias towards the trochaic foot in early stages of language acquisition. Their quantitative data of early productions show an inclination towards the trochaic foot despite the fact that Hebrew stress system and the frequency of the stress patterns, do not promote trochees over iambs.

2.5. *Developmental Periods*

In order to forward claims based on distinct prosodic acquisition periods, it was essential for our initial observation of the data to detect tendencies towards preferred foot types—from very early trochaic bias (universally unmarked), to an iambic tendency period (more frequent in the language). We first had to make sure that RM also exhibited the universal bias towards trochaic feet in her early speech. We used the method proposed in Adam and Bat-El (2009) in order to determine the foot tendency. We compared attempted disyllabic target words, disyllabic output words and truncation of disyllabic targets to monosyllabic outputs.[3]

We found that, exactly like the Hebrew acquiring child studied in Adam and Bat-El (2008, 2009), RM exhibits a clear tendency towards a trochaic foot during her early stages of speech (1;03.27–1;05.14). During that period, RM attempted more trochaic target words (79.3%) than iambic target words (20.7%) and produced more trochaic words (64.8%) than iambic words (35.2%). Lastly, she truncated more iambic polysyllabic words to monosyllabic outputs (75% of all attempted iambs) than trochaic polysyllabic words (10.9% of all attempted trochees).

(3) Attempted targets

a. Trochaic targets

Target	Output		
ˈefo	ˈaːpo	'where'	(1;04.23)
ˈaʁba	ˈhabaː	'four'	(1;05.00)

b. Iambic targets

Target	Output		
buˈba	baː	'a doll'	(1;04.09)
kaˈduʁ	duː	'a ball'	(1;05.14)

(4) Productions (with fillers)

a. Trochaic productions

Target	Output		
lo	ˈo**a**	'no'	(1;05.00)
eyn	ˈeːyn**ə**	'none'	(1;05.10)

b. Iambic productions

Target	Output		
lo	**pə**ˈlo	'no'	(1;04.18)
ken	**ə**ˈkẽ	'yes'	(1;03.27)

[3] We only compared disyllabic forms to clearly determine foot types, as they are unambiguous in this respect. Also, the disyllabic targets and output productions outnumbered all other polysyllabic targets and output productions in the data combined, by more than twice.

(5) Truncated productions

a. Trochaic polysyllabic targets

Target	Output		
ˈkelev	keː	'dog'	(1;05.14)
ˈzehu	ˈze	'that's it'	(1;06.05)

b. Iambic polysyllabic targets

Target	Output		
xaˈtul	tuː	'cat'	(1;05.14)
t͡saˈhov	ˈhav	'yellow'	(1;06.05)

The gradual shift in values of the above-mentioned criteria was evidenced in all of the three criteria we checked: RM's attempted target words and actual productions, as well as her ratio of polysyllabic truncations, slowly shifted towards an iambic preference. The two former criteria (attempted targets and actual outputs) exhibited substantial shifts in trends, which fully reversed throughout the periods. The trend observed for polysyllabic truncation criterion did not reverse (more iambic targets were truncated throughout the periods), yet it exhibited a substantial decline. This is rather expected given that more than any other syllable in the word, the final syllable in an iambic target carries two properties promoting prominence—stress and final position (Kehoe and Stoel-Gammon 1997, Kehoe 2001). Compared against iambs, disyllabic trochees split the prominence factors between the first (stressed) syllable and the second (final) syllable. Under this view, iambs are better candidates for truncation.

RM's early speech development was thus divided into three stages, as shown in Table 6 below, representing different metrical tendencies that were revealed in the data, in accordance with shifts in two criteria—attempted targets and actual outputs. The first period was defined as the *Trochaic bias*. The second period was defined as the *Transitional phase* towards iambs, in which values for trochees and iambs were close to equal (46 % vs. 54 % for output productions, and 45.9 % vs. 54.1 % for attempted targets). The last *Iambic tendency* period exhibits a clear tendency for iambic feet. During this period, RM attempted more iambic target words (64.6 %) than trochaic target words (35.4 %), and she produced more iambs (63.9 %) than trochees (36.1 %).

Table 6: The three periods of foot preference

		Disyllabic targets		**Disyllabic productions**	
Period	**Age**	**Trochee**	**Iamb**	**Trochee**	**Iamb**
Trochaic bias	1;03.27–1;05.14	79.3 % (46/58)	20.7 % (12/58)	64.8 % (57/88)	35.2 % (31/88)
Transitional phase	1;05.22–1;08.07	45.9 % (164/357)	54.1 % (193/357)	46 % (179/389)	54 % (210/389)
Iambic tendency	1;08.14–2;00.09	35.4 % (525/1482)	64.6 % (957/1482)	36.1 % (524/1451)	63.9 % (927/1451)

3. Early Filler Syllables

In the early stages of RM's speech, the vast majority of productions consisted of monosyllabic and disyllabic target words (both content and function words). During the *Trochaic bias* period, 78.5% of RM's productions were monosyllabic, while 20.1% of her productions were disyllabic; only 1.3% trisyllabic productions were recorded. Many of those polysyllabic productions were, in fact, extended productions, as they were produced with a filler syllable. This was the case with 40.7% of the disyllabic productions recorded, which also make up 90.5% of all the productions uttered with a filler syllable in that period (37/41). The observed trend was stronger with trisyllabic production, as 4 out of 6 were produced with fillers, yet their small overall amount makes them less than 10% of the filler cases.

Table 7: Production tokens during the trochaic bias period (including post-coda insertions)

	All			With fillers (incl. PCIs)		
Period	**Monosyllabic**	**Disyllabic**	**Trisyllabic**	**Disyllabic**	**Trisyllabic**	**Total**
Trochaic bias (1;03.27–1;05.14)	78.5% (355/452)	20.1% (91/452)	1.3% (6/452)	40.7% (37/91)	66.7% (4/6)	9.1% (41/452)

Note that if we calculate fillers without the subset of post-coda insertions, the relative amount of fillers in disyllabic productions during the first period drops, as expected (from 40.7% to 27.5%). However, it is important to notice that the amount of disyllabic outputs containing a filler still makes up 86.2% of all the productions uttered with a filler syllable during that period (25/29).

Table 8: Production tokens during the trochaic bias period (excluding post-coda insertions)

	All			With fillers (excl. PCIs)		
Period	**Monosyllabic**	**Disyllabic**	**Trisyllabic**	**Disyllabic**	**Trisyllabic**	**Total**
Trochaic bias (1;03.27–1;05.14)	78.5% (355/452)	20.1% (91/452)	1.3% (6/452)	27.5% (25/91)	66.7% (4/6)	6.4% (29/452)

The picture that emerges from both tables above indicates that at the very early stages of acquisition, filler syllables serve to extend the existing pool of monosyllabic productions and forward the production of more disyllabic outputs.

3.1. *The Minimal Word Effects*

Hebrew phonology does not reflect sensitivity to moraic structure, given that the stress system does not distinguish between CV and CVC syllables (Bat-El

2005). Therefore, CVC words are usually considered sub-minimal (Adam 2002). However, studies of hearing impaired children acquiring Hebrew reveal compensatory lengthening in cases of final coda deletion, in particular when the coda is a sonorant (Adi-Bensaid and Bat-El 2004, Adi-Bensaid 2006, Adi-Bensaid and Tobin 2010). This may suggest that children assume that (at least sonorant) codas are moraic, before they encounter sufficient evidence to the contrary (see Ben-David this volume). Also Fainleib's (2008) experimental study with novel words may suggest that final codas are moraic, since speakers showed a tendency towards final stress in words ending with a CVC syllable, but preferred penultimate stress in words ending with a CV syllable.

In line with our initial assumptions, according to which we expect to find filler syllables reflecting prosodic acquisition phases, we hypothesize that CV words would be more prone to the addition of a filler syllable than other monosyllabic target words with a coda consonant. The motivation for filler syllables in this case would be to augment the prosodic words to meet the minimal word restriction (McCarthy and Prince 1990, 1993, among others).

However, there is another motivation to extend CV words more than CVC words, regardless of whether codas are moraic; this motivation relies on language-specific frequency. There are very few CV content words in the Hebrew lexicon, far fewer than CVC. Most CV words in the data are, indeed, function words, which usually prosodify with the following prosodic word. That is, the scarcity of CV words in Hebrew may also have lead RM to extend her CV inputs with fillers. To that extent, it is important to consider the fact that RM's early productions of CV function words (which were often uttered in isolation) were prosodified as independent prosodic words. As shown in Table 9, the data confirm these assumptions.

Table 9: Distribution of filler syllables in (C)VC and CV target words (tokens)

		Filler syllables		
Period	**Age**	**CV targets**	**(C)VC targets (incl. PCIs)**	**(C)VC targets (excl. PCIs)**
Trochaic bias	1;03.27–1;05.14	15.8% (12/76)	7.3% (22/302)	3.3% (10/302)
Transitional phase	1;05.22–1;08.07	10.0% (40/402)	9.4% (45/481)	4.4% (21/481)
Iambic tendency	1;08.14–2;00.09	10.0% (48/478)	3.9% (26/675)	3.4% (23/675)
All periods	1;03.27–2;00.09	10.5% (100/956)	6.4% (93/1458)	3.7% (54/1458)

Throughout the periods, RM attempted ~1.5 times more (C)VC targets than CV targets (1,458 vs. 956 respectively). This is not entirely surprising given the low frequency of CV content words in Hebrew, yet RM inserted filler syllables in a larger relative amount of CV targets, which represent a steady preference to augment more CV words (above 10%, all in all). The very early *Trochaic bias* period sees the peak of RM's use of fillers in order to extend sub-minimal CV words, with close to 16% fillers.

Again, the data on insertions in (C)VC targets in Table 9 presents two alternative analyses—with and without consideration of the post-coda insertions subset among the set of fillers. The obtained results show some differences. When analyzed with post-coda insertions as fillers, the percentages of fillers among (C)VC targets remains low (always under 10%) but exhibits inconsistent trends as values rise from 7.3% to 9.4%, and then drop to 3.9%. However, when post-coda insertions are excluded from the analysis, the overall relative amount of fillers in (C)VC targets decreases and remains relatively stable throughout the periods (around 3.7%).

(6) Filler syllables in (C)VC and CV target words

a. (C)VC targets

Target	**Output**		
od	**i**ˈde	'more'	(1;05.10)
zuz	**u**ˈʃoʃ	'move'	(1;06.12)
daf	**ə**ˈdaf	'sheet'	(1;08.27)
kos	**e**ˈkoʃ	'glass'	(1;09.10)

b. CV targets

Target	**Output**		
lo	ˈo**a**	'no'	(1;04.18)
ze	ˈde**a**	'this'	(1;06.12)
ze	**ə**ˈze	'this'	(1;09.07)
ma	**a**ˈpa	'what'	(1;11.25)

3.2. *Prefixed vs. Suffixed Fillers*

Given the division into periods and the common assumption that filler syllables, being epenthetic, are less marked when unstressed (§2.4), our preliminary hypothesis led us to expect more filler syllables to appear suffixed to monosyllabic target words, as long as the preferred foot is trochaic (7a). When the foot bias changes to iamb, we expect more filler syllables to move into prefixed positions (7b).

(7) a. Trochee: lo → [ˈo.**a**] 'no' (1;05.00)
b. Iamb: lo → [əˈnoo] 'no' (1;07.10)

Another factor that we considered for a possible interaction with early filler syllable distribution is the presence (or absence) of final codas in the attempted target word, since post-coda insertions create an environment that enables production of final coda consonants as onsets of the inserted vowel. As discussed earlier in

§ 2.3, we assume that post-coda insertions may be related to coda resyllabification, as well as word augmentation.

The effects of post-coda insertions, together with the effects of the preferred foot type, predict that during the *Trochaic bias* period there would be a stronger tendency to suffix filler syllables. This trend is expected to change vis-à-vis the transition to the preferred iambic foot, and the gradual increase in faithfulness to coda positions.

Our comparison of prefixed and suffixed fillers during the three periods reveals the predicted trends under both types of analysis. When post-coda insertions are included (Table 10), the obtained results indicate that there are more suffixed than prefixed fillers during the *Trochaic bias* period (and only then). During the *Transitional phase*, the prefixed fillers outnumber the suffixed fillers, reversing the ratio in the previous period, and in the final, *Iambic tendency* period, the number of prefixed fillers is more than double the amount of suffixed fillers.

Table 10: Distribution of prefixed and suffixed filler syllables (including post-coda insertions)[4]

Period	Age	Prefixed fillers	Suffixed fillers (incl. PCIs)
Trochaic bias	1;03.27–1;05.14	43.9 % (18/41)	56.1 % (23/41)
Transitional phase	1;05.22–1;08.07	55.0 % (61/111)	38.7 % (43/111)
Iambic tendency	1;08.14–2;00.09	62.1 % (100/161)	28.6 % (46/161)
Total		179	112

When we exclude the post-coda insertions from our analysis (Table 11) the picture that emerges is less coherent, yet it still exhibits a tendency to use more suffixed fillers during the *Trochaic bias* period, in comparison with other periods (37.9 % vs. 13.9–26.3 %, respectively). This means that even when all post-coda insertions are discarded from the set of fillers, there appear to be factors that promote more suffixed fillers during the *Trochaic bias* period.

Note also that an analysis that excludes post-coda insertions changes the relative amounts of prefixed filler syllables. In the case of the discussed comparison, the obtained results exhibit a more consistent overall relative amount of prefixed fillers (above 62 %), yet the trends are somewhat inconsistent. One possible explanation for the relatively extreme values of both prefixed and suffixed fillers during the *Transitional phase* period may suggest that extreme values are expected as they often characterize erratic transitional periods in acquisition (in this sense, these results may indirectly support our initial division into periods by foot tendency).

[4] Infixed fillers are ignored.

Table 11: Distribution of prefixed and suffixed filler syllables (excluding post-coda insertions)

Period	Age	Prefixed fillers	Suffixed fillers (excl. PCIs)
Trochaic bias	1;03.27–1;05.14	62.1 % (18/29)	37.9 % (11/29)
Transitional phase	1;05.22–1;08.07	77.2 % (61/79)	13.9 % (11/79)
Iambic tendency	1;08.14–2;00.09	64.1 % (100/156)	26.3 % (41/156)
Total		179	63

Apparently, the tendency towards the trochaic foot was strong during the *Trochaic bias* period, as revealed by the fact that almost half (8/18) of the prefixed fillers in this period were produced bearing stress, promoting a trochaic production even when prefixed. During the *Trochaic bias* period, stressed filler syllables consisted of 24.4 % (10/41) of all fillers at this period, when calculated with post-coda insertions, or 34.5 % (10/29) when calculated without post-coda insertions (none of the post-coda inserted syllables were stressed). In the following periods, the percentage of stressed prefixed fillers drops down to ~3.3 % during the *Transitional phase* and to ~5.7 % during the *Iambic tendency* period.[5]

(8) Stressed filler syllables

Target	**Output**		
od	ˈ**ha**id	'more'	(1;04.23)
od	ˈiod	'more'	(1;05.14)
lo	ˈ**ʔe**o	'no'	(1;05.00)
lo	ˈ**ha**o	'no'	(1;05.10)

These productions do not conform to the universal tendency noted above, by which epenthetic elements, being minimally intrusive (Kenstowicz 2007), are unstressed. Moreover, they involve stress shift, a rather rare process in the acquisition of Hebrew stress (Ben-David 2001), as it violates faithfulness to the head syllable. However, they maintain a trochaic foot even with a prefixed filler. Within the framework of Optimality Theory (Prince and Smolensky 1993/2004), these facts about stressed filler syllables may be due to the interaction between the following two constraints:

(9) a. *IAMB: Iambic feet are banned in phonetic representation.
b. HEADDEP: Non-lexical vowels are not allowed in prosodic heads (=stressed syllables).

[5] The values for stressed filler syllables were very close when analyzed with and without post-coda insertions during the *Transitional phase* period (2.7 % (3/111)–3.8 % (3/79)) and the *Iambic tendency* period (5.6 % (9/161)–5.8 % (9/156)).

The constraint *IAMB is drawn from the universal ranking *IAMB >> *TROCHEE, which reflects the unmarked status of the trochaic foot. The constraint HEADDEP expresses the universal tendency for stressed vowels to have input correspondence (Alderete 1999), or alternatively, for epenthetic elements to be unstressed. The ranking of these two constraints in the first two periods is as follows:

(10) a. Trochaic bias period (1;03.27–1;05.14): *IAMB>>HEADDEP
b. Transitional phase (1;05.22–1;08.07): HEADDEP >>*IAMB

During the *Trochaic bias* period, the trochaic preference prevails and *IAMB is thus dominant, at the cost of violating HEADDEP and thus stressing filler syllables. This ranking is expected to change during the *Transitional phase*, where the iambic productions start taking over (see the division into periods in Table 7 above).

4. Filler Syllables and Phonological Phrases

According to Demuth's (2001a) prosodic approach, the change in the distribution of filler syllables over time should be accounted for as a change in the phonological constituent acquired by the child. We follow this line in our assumptions that RM's filler syllables are a reflection of her developing prosody.

In the former sections we suggested a prosodic analysis for the longitudinal distribution of filler syllables in RM's productions. We argued that the observable changes in the position and quantity of filler syllables in RM's speech can be readily motivated if we assume their role as prosodic tools, which function on different levels of the prosodic hierarchy to extend prosodic structures and/or advance the production of preferred, unmarked, forms.

In the following sections we present additional data supporting these arguments, by demonstrating the possible role of filler syllables in the formation of early phonological phrases above the single prosodic word.

4.1. *The Prosody of Proclitics*

Proclitics are bound morphemes that are prefixed to content words. They are highly common function words in Hebrew and they are universally among the first functional elements to be used in systematic concatenative syntax, towards productions of phrases larger than a single prosodic word (Chierchia et al. 1999, Lleó and Demuth 1999, Demuth 2001b).

The proclitic function words are not independent phonological words, but rather prosodify with the following content word, and thus extend the phonological unit. The two components, proclitic and content word, are mapped together through concatenation to constitute a polymorphemic phonological phrase, often termed *Minor Phonological Phrase* (Selkirk 1986, 1995). Below are selected examples of functional proclitics observed in RM's productions.

(11) Hebrew proclitics

a.	Conjunct:	ve-	'and'	ve-'ze	'and this'	(1;11.18)
b.	Subordinator:	ʃe-	'that'	ʃe-'bait	'that a house'	(1;10.28)
c.	Determiner:	ha-	'the'	ha-'gan	'the kindergarten'	(1;11.25)
d.	Prepositions:	le-	'to'	le-'po	'to here'	(1;08.27)
		la-	'to the'	la-'yam	'to the sea'	(1;10.28)
		be-	'in'	be-'oto	'in a car'	(2;00.02)
		ba-	'in the'	ba-'oto	'in the car'	(1;10.28)

Lleó and Demuth (1999), Demuth (2001b), and Roark and Demuth (2000) address the cross-linguistic variation in the emergence of function words in early stages of language acquisition. The data presented in these studies reveal an intra-linguistic variance in the timing of the appearance of function morphemes. It appears that while children acquiring Romance languages (such as Spanish or Italian) tend to produce a high percentage of articles and proto-articles as early as 1;10, children acquiring Germanic languages (such as English or German) begin to produce these proto-articles relatively late and initially in restricted contexts. In addition, Selkirk (1995) establishes that the emergence of well-formed prosodic structures containing a function word will vary not only cross-linguistically but within a certain language as well, depending on the nature of the prosodic features of a given function element.

The study of cross-linguistic and intra-linguistic variations facilitates our understanding of the acquisition course of function elements in different languages. One prediction, which is supported by such studies, contends that a function element that can be prosodified within a restricted prosodic structure, as in the case of proclitic elements, will emerge earlier in acquisition. We thus hypothesize that Hebrew proclitics that prosodify together with the following word to constitute a merged prosodic unit will appear early in children's speech and precede the appearance of other yet higher prosodic units.

Any attempt to claim that filler syllables may serve as prosodic extenders to constitute early phonological phrases, will need to correlate some data regarding filler syllables with data regarding the emergence of such proclitics. Therefore, we expect the distribution of filler syllables to correlate in position and in quantity with the emergence of these early phonological phrases. Two main hypotheses are derived from this assumption:

a. Positional correlation: Filler syllables are expected to move towards prefixed positions, exhibiting the emergence of phonological phrases of this sort. The positional correlation assumption is based on our view in this paper that filler syllables may appear in various positions.

b. Quantitative correlation: Prefixed filler syllables are expected to reduce in quantity as proper proclitics gradually fill their prefixed position and replace the temporary fillers with concrete content. This assumption stems from the common view about filler syllables, which ties their emergence and disappearance in language acquisition processes.

4.2. *Signs of Early Concatenative Morpho-Syntax*

Up until the age 1;06.26, RM attempted production of very few phonological phrases (0.4 % of her total targets during that period). A more substantial appearance of phonological phrases that include proclitics can be observed from the age of 1;07.03 to 1;10.13 (1.6 % of her total targets during this period), but their distribution is still low in quantity and irregular, as some sessions include no such productions. It is only from age 1;10.28 that the presence of phonological phrases with proclitics begins to show stability with higher numbers among RM's productions (3.8 % of her total targets during this period).

For the following analysis of RM's construction of *minor phonological phrases*, our corpus is divided once again, this time in accordance with evidence on the emergence and development of proclitics. Our division schema was devised around one criterion—the appearance of proclitics in RM's speech.

(12) The two periods of proclitic attempted words (% of total productions)

Period	**Age**	**Proclitic targets**
Pre-phrasing	1;03.27–1;10.13	1.1 % (32/2923)
Early-phrasing	1;10.28–2;00.09	3.8 % (79/2053)

The *Pre-phrasing* period covers a range that was previously divided into the three periods of foot tendencies (see Table 6), while the *Early-phrasing* period covers a smaller range, coinciding with the latter two months of the *Iambic foot tendency* period. In line with our hypotheses, we expect the quantity and distribution of filler syllables in RM's speech to correlate with the above-mentioned division into two periods, which are assumed to be analogous to the acquisition stages of higher-level prosodic units. If filler syllables have a role, such as *monosyllabic placeholders* (Bottari et al. 1993/1994) or *prosodic extenders* (Demuth 2001a) that correlates with the developing notion of positions in child's early speech, we should expect them to slowly disappear as this position becomes filled with actual words. The data from RM's speech may advance such claims.

4.2.1. The Positional Factor

As demonstrated in the previous sections, a set of competing constraints modifies the distribution of filler syllables throughout the development, and advances their dispersion towards suffixed position at the early stage of RM's acquisition. Assuming that filler syllables in RM's speech serve as prosodic placeholders for the emerging proclitics, we would expect to find an alteration of their distribution within the utterances, towards the initial prefixed position, throughout the overall development and in particular during the *Early-phrasing* period.

From our data, it is evident that such a tendency plays a role in RM's productions. Analyses that include post-coda insertions among the fillers obtained coherent results. During the *Trochaic bias* period an inclination towards suffixed fillers was observed. That tendency is reversed as early as the next *Transitional phase* kicks in; the percentage of prefixed filler syllables increases up to 65.9% in the final *Early-phrasing* period, which is also the second part of the *Iambic tendency* period.

Table 12: The positional distribution of fillers throughout acquisition (% of total fillers) (including post-coda insertions)

Period (by proclitics)	**Period (by foot)**	**Age**	**Prefixed fillers***	**Suffixed fillers***	**Total**
Pre-phrasing	Trochaic bias	1;03.27–1;05.14	43.9% (18/41)	56.1% (23/41)	9.1% (41/452)
	Transitional phase	1;05.22–1;08.07	55.0% (61/111)	38.7% (43/111)	8.3% (111/1341)
	Iambic tendency (a)	1;08.14–1;10.13	58.2% (46/79)	27.8% (22/79)	7.0% (79/1130)
Early-phrasing	Iambic tendency (b)	1;10.28–2;00.09	65.9% (54/82)	29.3% (24/82)	4.0% (82/2053)

* incl. PCIs

Analyses that exclude post-coda insertions from the set of fillers obtained less coherent results. However, in comparison with all other periods, suffixed fillers were most prevalent in the *Trochaic bias* period (37.9%, compared with values under 27%), while prefixed fillers were present in large relative amounts during all periods, and especially during the *Early-phrasing* period (68.4%) and the *Transitional phase* within the *Pre-phrasing* period (77.2%). Again, it is interesting to point out that the slightly erratic values occur during the *Transitional phase*, which may explain some incoherencies in the attested trends.

Table 13: The positional distribution of fillers throughout acquisition (% of total fillers) (excluding post-coda insertions)

Period (by proclitics)	Period (by foot)	Age	Prefixed fillers*	Suffixed fillers*	Total
Pre-phrasing	Trochaic bias	1;03.27–1;05.14	62.1% (18/29)	37.9% (11/29)	6.4% (29/452)
	Transitional phase	1;05.22–1;08.07	77.2% (61/79)	13.9% (11/79)	5.9% (79/1341)
	Iambic tendency (a)	1;08.14–1;10.13	59.7% (46/77)	26.0% (20/77)	6.8% (77/1130)
Early-phrasing	Iambic tendency (b)	1;10.28–2;00.09	68.4% (54/79)	26.6% (21/79)	3.8% (79/2053)

* excl. PCIs

In earlier sections, we claimed that some of the changes in the ratio between prefixed and suffixed additional syllables could be attributed to their assumed prosodic role in advancing a preferable foot (augmentation) and avoiding coda consonants without deletion (epenthesis). This explanation, in particular the impact of the preferred foot, is not sufficient to account for the increase in relative amount of prefixed filler syllables. As shown in Table 14, the ratios of iambic vs. trochaic targets and productions remain stable during the two *Iambic tendency* periods, and yet we can observe in Table 13 a noticeable growth in prefixed filler syllables.

Table 14: Ratio of trochee to iamb within the Iambic tendency period

			Productions		Targets	
Period (by proclitics)	Period (by foot)	Age	Disyllabic trochees	Disyllabic iambs	Disyllabic trochees	Disyllabic iambs
Pre-phrasing	Iambic (a)	1;08.14–1;10.13	16.8% (190/1130)	29.3% (331/1130)	17.0% (192/1130)	31.8% (359/1130)
Early-phrasing	Iambic (b)	1;10.28–2;00.09	16.3% (334/2053)	29.0% (596/2053)	16.2% (333/2053)	29.1% (598/2053)

These data contribute to the claim that filler syllables promote the generation of early minor phonological phrases during this phase, and thus play a significant role in generating higher-level prosodic units.

4.2.2. Segmental Support

Another important correlation emphasizing the distinction between *Pre-phrasing* period and *Early-phrasing* period in RM's development was found in the analysis of the segmental features of vowels in RM's filler syllables.

As shown in Tables 15 and 16, the schwa ([ə]) constitutes over 45% of the vowels found in RM's filler syllables during the *Pre-phrasing* period (1;03.13–1;10.13), way more than any other vowel. The schwa is a common epenthetic vowel, serving also as a placeholder in children's early combinations (Bloom 1970, 1973). Note that Modern Hebrew does not include schwa in its phonemic vowel inventory, yet it is one of the most widely used vowels in RM's filler syllables.

Table 15: Vowels across filler syllables (% of all fillers including post-coda insertions)

Period	**Age**	[ə]	[e]	[a]	[o]	[i]	[u]
Pre-phrasing	1;03.27–1;10.13	48.1% (111/231)	13.0% (30/231)	16.5% (38/231)	5.6% (13/231)	10.4% (24/231)	4.8% (11/231)
Early-phrasing	1;10.28–2;00.09	8.5% (7/82)	35.4% (29/82)	25.6% (21/82)	12.2% (10/82)	12.2% (10/82)	6.1% (5/82)

Table 16: Vowels across filler syllables (% of all fillers excluding post-coda insertions)

Period	**Age**	[ə]	[e]	[a]	[o]	[i]	[u]
Pre-phrasing	1;03.27–1;10.13	45.4% (84/185)	13.5% (25/185)	18.9% (35/185)	5.9% (11/185)	10.8% (20/185)	4.3% (8/185)
Early-phrasing	1;10.28–2;00.09	7.6% (6/79)	36.7% (29/79)	26.6% (21/79)	12.7% (10/79)	10.1% (8/79)	6.3% (5/79)

No less important, the use of schwa is dramatically reduced during the *Early-phrasing* period (1;10.28–2;00.09) to 8.5% (including post-coda insertions) or 7.6% (excluding post-coda insertions). This significant drop in the schwa's prevalence correlates both with the increase in use of other vowels within filler syllables and with the increase in the number of proclitics during the same period. These proclitics are assumed to fill their prefixed position and replace the fillers with concrete content.

All of RM's 111 attempted productions with proclitics featured one of two vowels in the target word; 54.9% (61/111) had an [a] and 45.1% (50/111) had an [e]. The rate of these two vowels, specifically among the prefixed filler syllables, increased as the rate of the number of schwas in this position dropped. As shown in Table 17, the vowel [e] increased in presence from a combined average of 6.4% during the *Pre-phrasing* period to an average of 42.6% during the *Early-phrasing* period. The presence of the vowel [a] increased from a combined average of 18.2% during the *Pre-phrasing* period to an average of 22.2% during the *Early-phrasing* period.

Table 17: Vowel distribution in prefixed filler syllables (% of all prefixed fillers)

Period (by proclitics)	**Period (by foot)**	**Age**	[ə]	[e]	[a]
Pre-phrasing	Trochaic bias	1;03.27–1;05.14	44.4% (8/18)	5.6% (1/18)	27.8% (5/18)
	Transitional phase	1;05.22–1;08.07	77.0% (47/61)	4.9% (3/61)	11.5% (7/61)
	Iambic tendency (a)	1;08.14–1;10.13	50.0% (23/46)	8.7% (4/46)	15.2% (7/46)
Early-phrasing	Iambic tendency (b)	1;10.28–2;00.09	11.1% (6/54)	42.6% (23/54)	22.2% (12/54)

(13) Vowels in prefixed filler syllables

a. Pre-phrasing period

Target	**Output**		
ˈdevek	əˈbebe	'glue'	(1;08.07)
ˈt͡seva	ət͡siˈa	'color'	(1;08.07)
daf	əˈdaf	'sheet'	(1;08.27)
kos	eˈkoʃ	'glass'	(1;09.10)
ʁoʃ	aˈʁoʃ	'head'	(1;09.18)

b. Early phrasing period

Target	**Output**		
ˈmaim	eˈbaim	'water'	(1;10.28)
miʃˈxa	eʃeʃˈxa	'cream'	(1;10.28)
gaˈdol	agaˈdoy	'big'	(1;11.18)
kaˈtan	akaˈtan	'small'	(1;11.18)
miˈxal	emiˈxay	'Michal'	(2;00.09)

Another interesting fact about the distribution of schwa arises from its presence in suffixed fillers. Apparently, the schwa vowel distribution resembles trends of filler syllables, which we predicted and found in our analysis, as they almost disappear from fillers in suffixed positions during the *Iambic tendency* period.

Table 18: Vowel distribution in suffixed filler syllables (including post-coda insertions)

Period (by proclitics)	**Period (by foot)**	**Age**	[ə]	[e]	[a]
Pre-phrasing	Trochaic bias	1;03.27–1;05.14	47.8% (11/23)	21.7% (5/23)	8.7% (2/23)
	Transitional phase	1;05.22–1;08.07	44.2% (19/43)	9.3% (4/43)	20.9% (9/43)
	Iambic tendency (a)	1;08.14–1;10.13	0% (0/22)	45.5% (10/22)	22.7% (5/22)
Early-phrasing	Iambic tendency (b)	1;10.28–2;00.09	4.2% (1/24)	16.7% (4/24)	29.2% (7/24)

Table 19: Vowel distribution in suffixed filler syllables (excluding post-coda insertions)

Period (by proclitics)	**Period (by foot)**	**Age**	[ə]	[e]	[a]
Pre-phrasing	Trochaic bias	1;03.27– 1;05.14	9.1% (1/11)	9.1% (1/11)	54.5% (6/11)
	Transitional phase	1;05.22– 1;08.07	9.1% (1/11)	9.1% (1/11)	54.5% (6/11)
	Iambic tendency (a)	1;08.14– 1;10.13	0% (0/20)	50.0% (10/20)	25.0% (5/20)
Early-phrasing	Iambic tendency (b)	1;10.28– 2;00.09	0% (0/21)	19.0% (4/21)	33.3% (7/21)

(14) Vowels in suffixed filler syllables

a. Trochaic bias

Target	**Output**		
ˈoto	ˈotʰoh**ə**	'car'	(1;04.18)
od	ˈoːd**ə**	'more'	(1;05.00)

b. Transitional Phase

Target	**Output**		
eyn	ˈen**ə**	'none'	(1;06.05)
ze	ˈde**a**	'this'	(1;06.12)

c. Iambic tendency

Target	**Output**		
ken	ˈke**ʔe**	'yes'	(1;09.18)
lo	ˈlo**ʔo**	'no'	(2;00.09)

This distributional behavior of vowels by quality within filler syllables adds segmental evidence to support the structural analysis we have presented, regarding the role and function of filler syllables in language acquisition.

5. Conclusions

Our analysis of the phenomenon of filler syllables began with criteria for defining fillers, since it is not the case that every epenthetic vowel in children's emerging phonologies counts as a filler syllable. Our narrow definition of filler syllables and our marking strategy for cases of post-coda insertion were extremely important for our goal—to investigate the major forces that drive filler syllables in language acquisition.

Some views on filler syllables (cf. Peters 2001) refer to difficulties in analysis that arise from the fact that filler syllables interact with various domains of grammar (such as morphology and syntax). In our view, a proper analysis of filler syllables is possible with "pure" phonological devices that rely on the prosodic hierarchy, since this hierarchy encapsulates an underlying interaction with morpho-syntactic domains. In other words, since higher-level units within the prosodic hierarchy are assumed to interface with morpho-syntactic domains, the phenomenon of filler syllables should be understood within the phonological domain and its advanced theoretic devices.

Our findings show that the preference between prefixed and suffixed fillers is the result of different forces that constantly shift during early stages of language acquisition, although, all things being equal, the general preference towards prefixed position was attested in the data. In light of studies such as Veneziano and Sinclair (2000), who referred to filler syllables as *Prefixed Additional Elements*, it may very well be that the universally less marked filler is prefixed. Yet, language-specific and other universal competing forces may sometimes promote suffixed positions, as well as infixed ones.

The main forces observed in RM's speech exhibited interactions between filler syllables' distribution, minimal word, word-final codas, and foot bias/tendency during the very early stages of acquisition. The prosodic role that fillers seem to have in these stages concerns various adjustments in these constituents. Later on, as higher-level prosodic units emerge, and words with more syllables are gradually acquired, filler syllables can be employed to serve as prosodic extenders that precede segmentally faithful productions of phonological phrases.

Our findings also support previous claims that segmental qualities of the schwa vowel are among the strongest characteristics of filler syllables. The schwa is often considered as a featureless vowel (Borowsky 1986, Van Oostendorp 2000), and thus serves as the optimal placeholder. Our observation of the schwa distribution across filler syllables in RM's speech exhibited clearer patterns of the same general observed trends, and some valuable comparative conclusions to support the interaction between proclitics, higher-level phonological constituents and filler syllables.

These data from a Hebrew-acquiring child corroborate many of the hypotheses in Demuth (2001a): "Learning the phonology of a language involves not only learning the phonemic status of segments and their acoustic/articulatory correlates, but also how to combine these to form higher-level prosodic/articulatory units such as syllables, phonological words, and phonological utterances. Although many children initially focus on the phonological word as their early prosodic unit of choice, other children appear to focus on higher-level prosodic units such as the phonological phrase, the phonological utterance, or the intonational phrase." (246). We should add that it seems probable that one child would focus on different prosodic units (as they gradually emerge) and would make use of filler syllables to adjust different types of such prosodic units during various stages of acquisition. Our observation and analysis of RM's filler syllables seem to support this direction.

References

Adam, Galit and Outi Bat-El. 2008. The trochaic bias is universal: Evidence from Hebrew. In *Language Acquisition and Development: Proceedings of GALA 2007*, Anna Gavarró and Maria João Freitas (eds), 12–24. Newcastle: Cambridge Scholars Publishing.

Adam, Galit and Outi Bat-El. 2009. When do universal preferences emerge in language development? The acquisition of Hebrew stress. *Brill's Annual of Afroasiatic Languages and Linguistics* 1:1–28.

Adi-Bensaid, Limor. 2006. *The Prosodic Development of Hebrew-Speaking Hearing Impaired Children*. Ph.D. dissertation, Tel-Aviv University.

Adi-Bensaid, Limor and Outi Bat-El. 2004. The development of the prosodic word in the speech of a hearing-impaired child with a cochlear implant device. *Journal of Multilingual Communication Disorders* 2:187–206.

Adi-Bensaid, Limor and Yishai Tobin. 2010. Is there compensatory vowel lengthening in the language acquisition of a cochlear implanted child? *Poznan Studies in Contemporary Linguistics* 46:255–274.

Alderete, John. 1999. Head dependence in stress-epenthesis interaction. In *The derivational residue in phonological Optimality Theory*, Ben Hermans and Marc van Oostendorp (eds), 29–50. Amsterdam: John Benjamins.

Bat-El, Outi. 2005. The emergence of the trochaic foot in Hebrew hypocoristics. *Phonology* 22:1–29.

Bat-El, Outi. 2009. Harmonic domains and synchronization in typically and atypically developing Hebrew-speaking children. *Language Sciences* 31:117–135.

Bat-El, Outi. 2012. The role of sonority in the acquisition of Hebrew word final codas. In S. Parker (ed.), *The Sonority Controversy*. Berlin: Mouton de Gruyter.

Bat-El, Outi. this volume. Phonological constraints on morphological development: The acquisition of Hebrew verb inflectional suffixes.

Ben-David, Avivit. 2001. *Language Acquisition and Phonological Theory: Universal and Variable Processes Across Children and Across Languages*. Ph.D. dissertation, Tel-Aviv University (in Hebrew).

Bloom, Lois Masket. 1970. *Language Development: Form and Function in Emerging Grammar*. Cambridge: MIT Press.

Bloom, Lois Masket. 1973. *One Word at a Time*. The Hague: Mouton and Co.

Borowsky, Toni. 1986. *Topics in the Lexical Phonology of English*, Ph.D. dissertation, University of Massachusetts, Amherst.

Bottari, Piero, Paula Cipriani, and Anna Maria Chilosi. 1993/1994. Protosyntactic device in the acquisition of Italian free morphology. *Language Acquisition: a Journal of Developmental Linguistics* 3:327–369.

Chierchia, Gennaro, Maria Teresa Guasti, and Andrea Gualmini. 1999. Nouns and articles in child grammar and the syntax/semantics map. Paper presented at Generative Approaches to Language Acquisition, Potsdam.

Demuth, Katherine. 1996. The Prosodic Structure of Early Words. In *Signal to Syntax: Bootstrapping from Speech to Grammar in Early Acquisition*, James Morgan and Katherine Demuth (eds), 171–184. Mahwah, N.J.: Lawrence Erlbaum Associates.

Demuth, Katherine. 2001a. A prosodic approach to filler syllables. *Journal of Child Language* 28:246–249.

Demuth, Katherine. 2001b. Prosodic constraints on morphological development. In *Approaches to bootstrapping: Phonological, lexical, syntactic and neuro- physiological aspects of early language acquisition*, Jürgen Weissenborn and Barbara Höhle (eds), *Language Acquisition and Language Disorders Series*. 24:3–21. Amsterdam: John Benjamins.

Fainleib, Lena. 2008. *Default Stress in Unpredictable Stress Languages. Evidence from Russian and Hebrew*. M.A. thesis, Tel-Aviv Uniersity.

Jacks, Adam, Barbara Davis, and Thomas Marquardt. 2006. Consonant and syllable structure patterns in childhood apraxia of speech: developmental change in three children. *Journal of Communication Disorders* 39:424–441.

Kager, René. 1999. Surface opacity of metrical structure in Optimality Theory. In *The derivational residue in phonology*, Ben Hermans and Marc van Oostendorp (eds), 207–245. Amsterdam: John Benjamins.

Kehoe, Margaret and Carol Stoel-Gammon. 1997. The acquisition of prosodic structure: An investigation of current accounts of children's prosodic development. *Language* 73:113–144.

Kehoe, Margaret. 2001. Prosodic patterns in children's multisyllabic word productions. *Language, Speech & Hearing Services in Schools* 32:284–294

Kenstowicz, Michael. 2007. Salience and similarity in loanword adaptation: a case study from Fijian. *Language Sciences* 29, 2/3: 316–340.

Lleó, Conxita, and Katherine Demuth. 1999. Prosodic constraints on the emergence of grammatical morphemes: Crosslinguistic evidence from Germanic and Romance languages. In *Proceedings of the 23rd Annual Boston University Conference on Language Development*, Annabel Greenhill, Heather Littlefield, and Cheryl Tano (eds), 407–418. Somerville: Cascadilla Press.

McCarthy, John and Alan Prince. 1990. Foot and Word in Prosodic Morphology: The Arabic Broken Plurals. *Natural Language and Linguistic Theory* 8:209–282.

McCarthy, John and Alan Prince. 1993. *Prosodic Morphology I: ConstraintInteraction and Satisfaction*. Cambridge: MIT Press.

Nespor, Marina and Irene Vogel. 1986. *Prosodic phonology*. Dordrecht: Foris Publications.

Pepinsky, Thomas, Katherine Demuth, and Brian Roark. 2001. The status of 'filler syllables' in children's early speech. In A. Do, L. Dominguez, and A. Johansen (eds), *Proceedings of the 25th Annual Boston University Conference on Language Development*, 575–586. Somerville: Cascadilla Press.

Peters, Ann. 1983. *The units of language acquisition*. Cambridge, UK: Cambridge University Press.

Peters, Ann. 2001. Filler syllables: what is their status in emerging grammar? *Journal of Child Language* 28:229–242.

Peters, Ann, and Lisa Menn. 1993. False starts and Filler syllables: Ways to learn grammatical morphemes. *Language* 69:742–777.

Prince, Alan, and Paul Smolensky. 1993. *Optimality Theory: Constraint interaction in generative grammar*. Ms, Rutgers University, New Brunswick, and University of Colorado at Boulder.

Roark, Brian, and Katherine Demuth. 2000. Prosodic constraints and the learners environment: A corpus study. In *Proceedings of the 24th annual conference on language development*, S. Catherine Howell, Sarah A. Fish, and Thea Keith-Lucas (eds), 597–608. Somerville: Cascadilla Press.

Selkirk, Elisabeth. 1978/81. On prosodic structure and its relation to syntactic structure. In *Nordic Prosody II* Thorstein Fretheim (ed.), 111–140. Trondheim: Tapir.

Selkirk, Elisabeth. 1986. On Derived Domains in Sentence Phonology. *Phonology Yearbook* 3:371–405.

Selkirk, Elisabeth. 1995. The prosodic structure of function words. In *University of Massachusetts Occasional Papers in Linguistics: Papers in Optimality Theory*, Jill Beckman, Laura Walsh-Dickey and Suzanne Urbanczyk (eds). 439–469. Amherst: GLSA publications.

Tubul-Lavy, Gila. 2005. *The Phonology of Hebrew-Speaking Dyspraxic Children*. Ph.D. dissertation (in Hebrew).

van Oostendorp, Marc. 2000. *Phonological Projection: A Theory of Feature Content and Prosodic Structure*. Berlin: Mouton de Gruyter.

Veneziano, Edy and Hermine Sinclair. 2000. The changing status of 'filler syllables' on the way to grammatical morphemes. *Journal of Child language* 27:461–500.

BAALL

BRILL Brill's Annual of Afroasiatic Languages and Linguistics 4 (2012) 189–212 brill.com/baall

Phonological Constraints on Morphological Development: The Acquisition of Hebrew Verb Inflectional Suffixes*

Outi Bat-El
Department of Linguistics, Tel-Aviv University
obatel@post.tau.ac.il

Abstract
This paper studies the effect of phonological development on the acquisition of Hebrew verb inflectional suffixes, comparing between two monolingual typically developing children (SR and RM). Examination of the order at which the suffixes appeared in the children's speech reveals one distinction; SR produced the number (plural) suffix *-im* before the person (1st singular) suffix *-ti*, while RM produced these suffixes in the opposite order. All other suffixes were produced in the same order. As these suffixes differ in the presence vs. absence of a coda, I attribute the distinction between the children to the development of word final codas, which was faster in SR's speech than in RM's. This interaction between phonology and morphology is known as prosodic licensing, whereby the prosodic structure hosting a grammatical morpheme is a prerequisite for the production of this morpheme.

Keywords
language acquisition; phonology-morphology interface; verb inflection; word final codas; prosodic licensing; (a-)synchronization; variation; Hebrew

1. Introduction

Morpho-syntactic theories predict that person suffixes (1st) will appear after gender (feminine) and number (plural) suffixes (Shlonsky 1989, Harley and Ritter 2002, Armon-Lotem 2006). However, this is not always the case.

*) An earlier version of this paper was presented in BAALL's First Conference on Afroasiatic Grammar (Paris, 2010). I would like to thank the participants of this conference as well as the two anonymous reviewers, whose comments contributed to improving the present version of the paper. This study is part of the Child Language Project conducted in collaboration with Galit Adam and supported by ISF grant #544/04. The usual disclaimers apply.

 DOI: 10.1163/18776930-00400009

In this paper I consider the interaction of the morpho-syntactic predictions with phonological development in Hebrew, in particular the development of word final codas. I argue that children follow the order of acquisition predicted by the morpho-syntax only if their phonological development allows them to do so. I thus view the morpo-syntactic predictions as violable guidelines. Note that Hebrew morphology is relatively rich, and thus serves as a good opportunity to explore possible phonological/prosodic constraints on morphological development.

The data presented in this paper are drawn from a longitudinal study of two monolingual typically developing Hebrew-acquiring children, RM (girl) and SR (boy). A quantitative examination of the data shows that SR followed the morpho-syntactic predictions, producing the gender (feminine *-a*) and number (plural *-im*) suffixes before the person suffix (1st person *-ti*). RM produced the gender suffixes (feminine *-a* and *-i*) before the number suffix, as predicted by one of the syntactic theories. However, she produced the person suffix before the number suffix.

I argue that RM's deviation from the morpho-syntactic guidelines is due to phonological effects, in particular the development of word final codas. This phenomenon fits within the prosodic licensing principle (Lleó 2003, Demuth 2007 and references therein), according to which the prosodic structure hosting a grammatical morpheme is a prerequisite for the production of this morpheme. In each pair of suffixes, *-ti* vs. *-im* and *-a/-i* vs. *-im*, the codaless suffix appears in RM's speech before the codaful one. This phonological effect is also seen in the order of the acquisition of the three feminine suffixes, where both children produced the codaless suffixes *-i* and *-a* before the codaful suffix *-et*.

The fact that RM produced *-ti* before *-im* while SR produced *-im* before *-ti* is explained in terms of (a-)synchronization between the phonological and morphological development. Examination of the development of codas reveals that both children started producing the codaful suffix *-im* at the stage in which they had about 90% faithful codas in their production of nouns. SR started producing inflectional suffixes at this point, and his phonology thus allowed him to produce the codaful suffix. RM, on the other hand, started producing the inflectional suffixes before she reached 90% faithful codas. Thus, while waiting for her phonological grammar to be adequate for the production of a codaful suffix (plural *-im*), she produced the next in line codaless suffix (1st person *-ti*).

Note that I am using the term "produce" rather than "acquired", since the empirical basis of the present study is drawn from the children's productions rather than from experiments assessing their knowledge of the moprho-syntactic categories.

I start with background information regarding the relevant details on Hebrew verb inflectional suffixes (§2), the morpho-syntactic predictions (§3), and the research methods (§ 4). Then I present the quantitative data of the development of the suffixes (§ 5), with emphasis on the distinction between the two children and between the codaless and codaful suffixes. The quantitative data of final coda development is then compared with the development of the suffixes (§ 6). This comparison serves to explain the distinction between the children in terms of (a-)synchronization between phonological and morphological development. I conclude with discussion on the phonology-morphology interface, in light of earlier studies (§ 7).

2. Hebrew Verb Inflectional Suffixes

Hebrew verb stems are accompanied with suffixes, which display agreement with the (contextual or overt) subject noun. Past forms agree in number, gender, and person, while present and imperative forms agree only in number and gender. Throughout the tense/mood categories, the (3rd person) masculine singular does not have an inflectional suffix (marked in Table 1 with {}).[1]

Table 1: Hebrew verb inflectional suffixes (the relevant suffixes are in bold)

a. Suffixes (Nu = number, Pr = person, Gn = gender)

Past				**Present**[2]			**Imperative**[3]		
Nu	**Pr**	**Gn**		**Nu**	**Gn**		**Nu**	**Gn**	
Sg.	1		***-ti***	Sg.	fm.	***-et***, ***-a***	Sg.	fm.	***-i***
	2	fm.	*-t*		ms.	{}		ms.	{}
		ms.	*-ta*						
	3	fm.	***-a***						
		ms.	{}						
Pl.	1		*-nu*	Pl.	fm.	*-ot*	Pl.		*-u*
	2		*-tem*		ms.	***-im***			
	3		*-u*						

1) I use the symbol {} for the 3rd person, rather than the conventional ø-morpheme, to express my view that there is no morpheme there. That is, the morphological structure of *gadal* 'he grew', for example, is [*gadal*] and not [[*gadal*]ø]. This distinction, however, is not relevant to the present study.

2) Present tense verbs are actually participles, functioning not only as verbs but also as nouns and adjectives. Moreover, their morphology and morpho-phonology is identical to that of adjectives (and also nouns), rather than of verbs (Bat-El 2008). The database of this study excludes participles that are certainly nouns in children's use. For example, *mot͡sét͡s* refers to the noun 'pacifier' and to the verb 'to suck', but it is more likely to be used by the children as a noun.

3) The imperative suffixes are identical to those of the future, where in the latter person-number-gender distinctions are made with prefixes (e.g. *t* in *tiktef-í* 'you fm.sg. will pick', *j* in

b. Sample forms of the verb 'to sit'

Past		**Present**		**Imperative**	
jaʃv-á	'3rd fm.sg.'	joʃév-et	'fm.sg.'	ʃv-í	'fm.sg.'
jaʃáv	'3rd ms.sg.'	joʃév	'ms.sg.'	ʃév	'ms.sg.'
jaʃáv-ti	'1st sg.'	joʃv-ím	'ms.pl.'	ʃv-ú	'pl.'

The suffixes at the heart of the discussion here are the plural *-im* (present), the 1st person *-ti* (past), and the feminine *-a* (past and present). The feminine suffixes *-i* (imperative) and *-et* (present) are also considered. These suffixes are produced relatively early, and thus may reflect interaction with the acquisition of codas. Suffixes with similar phonological structure to those studied here (e.g. 1st person plural *-nu* (past), 3rd person plural *-u* (past), feminine plural *-ot* (present)) are produced later, after the final codas are produced faithfully.[4]

3. Morpho-Syntactic Predictions

The order of acquisition of verb inflectional suffixes is studied here with reference to the syntactic theories (§ 3.1) proposed in Shlonsky (1989) and Armon-Lotem (2006) and the morphological theory (§ 3.2) proposed in Harley and Ritter (2002). All three theories provide a hierarchical structure from which the order of acquisition can be predicted (at least partially), though only the syntactic theories refer directly to Hebrew.

3.1. *Syntactic Theories*

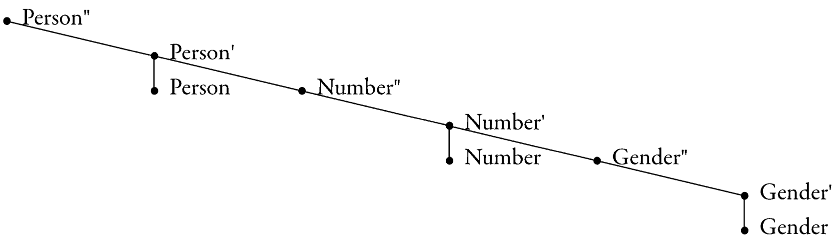
Shlonsky (1989) provides the following structure of agreement in Hebrew.[5]

jiktóf 'he will pick' and *jiktef-ú* 'they will pick'). Since only suffixes are relevant here, the imperative and future forms are both under the imperative category (e.g. *zúz-i/tazúz-i* 'move fm.sg. imperative/future'). Note that adults often use the future forms for imperatives (Bolozky 1979, Bat-El 2002).

4) It is possible that the interaction of these late acquired suffixes with the acquisition of codas would be visible in the speech of children with atypically slow phonological development.

5) This structure is based on the generalization that there is no verb in Hebrew "which is marked for number and not marked for gender and no verb which is marked for person but not marked for number" (Shlonsky 1989:5). This, however, is not entirely accurate since the 1st pr. past forms contrast in number but not in gender. In addition, unlike normative Hebrew, spoken Israeli Hebrew does not have gender distinction in the plural paradigms of the past and future forms.

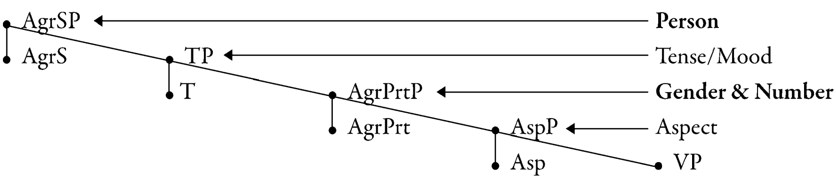
(1) Syntactic theory I (Shlonsky 1989): Gender > Number > Person



Assuming Armon-Lotem's (2006) proposal that children's development goes bottom-up, the structure in (1) above predicts the acquisition of gender before number, and of number before person.

However, Armon-Lotem's (2006) theory presented below predicts that gender and number would be produced at the same time, both before person.

(2) Syntactic theory II (Armon-Lotem 2006): Number & Gender > Person

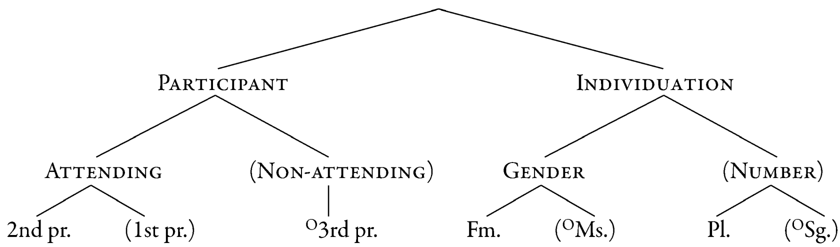


AgrS 'agreement subject', T 'tense/mood', AgrPrt 'agreement participle', Asp 'aspect'

3.2. *Morphological Theory*

Harley and Ritter (2002) propose a morphological feature geometry, developed for pronoun and agreement systems (see Hanson 2000 for the acquisition of pronouns). The construction of the tree is based on universal implicational relations (if a language has X, it also has Y, but not vice versa). The tree specifies markedness relations (the unmarked is in parentheses), assuming that an unmarked feature is acquired before its marked counterpart.

(3) Morphological theory (Harley and Ritter 2002):[6] Number > Gender



Categories that do not have a corresponding suffix in Hebrew are indicated with ^{O}

On the basis of the above feature geometry and markedness relations, the morphological theory predicts the production of number before gender. This relies on Greenberg's (1963) universal 32: "[w]henever a verb agrees with a nominal subject or object in gender it also agrees in number". The geometry makes no predictions with regard to the precedence relation between number/gender and person, since it does not specify markedness relations between the respective dominating nodes, i.e. Individuation and Participant. Recall, however, that the plural suffix *-im* is associated with present tense verbs while the person suffix *-ti* is associated with past tense verbs (§2). Thus, as noted by Elizabeth Ritter (electronic communication), since present is acquired before past, it is predicted that number will be acquired before person.

The predictions of the three theories with regard to the relevant suffixes are thus as follows:

(4) Predictions of all three theories

a.	Syntactic theory I:	Gender > Number > Person	(*-a*/*-i* > *-im* > *-ti*)
b.	Syntactic theory II:	Number & Gender > Person	(*-a*/*-i* & *-im* > *-ti*)
c.	Morphological theory:	Number > Gender	(*-im* > *-a*/*-i*)

There is no controversy among the theories with regard to number and person; the two syntactic theories predict the appearance of number (*-im*) before person (*-ti*), while the morphological theory is mute with regard to this issue. As for the order of number (*-im*) and gender (*-a*/*-i*), all options are available: both suffixes together (4b), gender before number (4a), and number before gender (4c).

6) I have revised here the original feature geometry to accommodate the relevant categories, i.e. gender, number, and person, where person is relevant only for the past tense (recall from §2 that person distinction is absent in the present tense and marked with prefixes in the imperative).

4. Methodology

The data presented in this study are drawn from the speech of two monolingual typically developing Hebrew-acquiring children, from an upper-middle socioeconomic background. The girl, RM, was an only child during the time of the recordings, and the boy, SR, was second to his sister. The children were recorded on a weekly basis for about one hour, starting at the end of the babbling stage, i.e. before the first word (see Adam and Bat-El 2009). The recording sessions took place in the children's natural environment, and the productions were drawn from natural speech and picture/object naming. The research assistants conducting the recording and transcription were graduate linguistics students with training in phonetics and phonology.

4.1. *Periods of Quantitative Examination*

In order to display the gradual development of verb inflectional suffixes, the data are organized in periods, according to the cumulative number of attempted verb types; each period corresponds to roughly 10 new verbs in the child's lexicon. Note that these periods do not imply stages, but rather serve as a methodological tool, which provides a baseline for a cross-subject comparison of quantitatively-based development. This methodology relies on the interrelation between lexical and phonological development in early stages of acquisition (Stoel-Gammon 2011).

Table 2 provides the scale of the first seven periods, starting with the first production of a verb; these are the periods where the suffixes under discussion appeared in the children's speech. Also specified are the ages of the children in each period and the number of cumulative attempted target verbs (CATV) for each child.

Table 2: Periods for quantitative examination

	SR		**RM**	
Period	**Age**	**CATV**	**Age**	**CATV**
1st word	1;02.00		1;03.13	
I	1;03.14–1;05.04	9	1;04.02–1;06.26	9
II	1;05.08–1;05.21	17	1;07.03–1;08.27	21
III	1;05.29–1;06.12	30	1;09.10–1;09.27	31
IV	1;06.20–1;06.26	39	1;10.06–1;10.28	38
V	1;07.02–1;07.09	49	1;11.18–1;11.25	48
VI	1;07.17–1;07.23	60	2;00.02–2;00.02	57
VII	1;08.03–1;09.00	70	2;00.09–2;00.09	70
↓				
XVIII	–2;02.22	184	–2;05.29	184

4.2. *Productivity*

In counting the inflectional suffixes, I included only productive suffixation, adopting a rather permissive measure of productivity. A suffix (X + Suf_i) was considered productive when one of the following condition was met:

a. It appeared earlier or during the same session with another verb stem (Y + Suf_i),
b. The base of the suffixed word appeared earlier without a suffix (X), or
c. The base of the suffixed word appeared earlier with another suffix (X + Suf_j).

Thus, only suffixed forms where the stem and the suffix appeared for the first time were excluded.

As the study is concerned with structural notions of development, the data include suffixed verbs that did not agree with their subject (5a) as well as suffixes that were not attached to the correct verb form (5b).

(5) a. SR (1;07.09): *sus dahar-á* 'horse ms. galloped fm.' (instead of *sus dahár*)
b. RM (1;11.25): *hi ʃover-á* 'she breaks' (instead of *hi ʃovér-et*)

In (5a), SR used the feminine suffix *-a* for a masculine subject (the feminine counterpart of *sus* 'horse' is *susa*), and in (5b) RM used the feminine suffix *-a* instead of *-et* for a verb in the present tense (see § 2 for the list of the suffixes). There were only a few such cases; in most cases the phrases, which often constituted just a verb (as Hebrew allows null subjects), were grammatical.

There were 10 verb forms (only in RM's data) where the suffix's coda was deleted, out of which 8 with the feminine suffix *-et* (e.g. *oséf-et* → *ofév-e* 'collects fm.sg.'; RM 2;01.12) and 2 with the plural suffix *-im* (e.g. *roc-ím* → *roc-í* 'want ms.pl.'; RM 2;05.09). These forms were excluded because they were rare, and produced more than two months after she started producing the codaful suffixes. That is, coda deletion in these cases cannot be attributed to an early developmental stage.

The fact that this strategy of coda avoidance was hardly used may suggest that grammatical markers, which are usually small phonological entities, are less likely to undergo deletion (Cassali 1997). However, as shown in Lleó (2003), children acquiring Spanish do delete the word final coda of the plural suffix *-es*, producing just the vowel. This variation requires further study.

4.3. *Criteria for Determining the Order of Acquisition*

The order in which the inflectional suffixes appeared in the children's speech was determined on the basis of two criteria:

a. Precedence: Suffix X is prior to suffix Y if X was productively produced in at least one period before Y.
b. Quantity: Suffix X is prior to suffix Y if X was produced with more verb types than Y.

In most cases, these two criteria converged, with the exception of SR's imperative feminine suffix *-i* (see § 5.3).

The quantity criterion, in turn, had two kinds of counts:

a. Types per session: A verb form was counted once for each session, regardless of the number of times it was produced, but was counted again when produced in other sessions.[7]
b. Total types: Each verb form was counted only once for the entire period under study here.

In all cases, type refers to base-plus-suffix, where the base refers to the target regardless of its form in the child's production.

For example, RM's two productions *oéxet* and *iléxet* for target *oléx-et* 'goes fm.sg.' were counted once (for the suffix *-et*) as they were both produced during the same session (2;02.11). Her later production *jéxet* (2;05.09) was counted again for the types per session count but not for the total types count. As it turned out, significant distinctions appeared only in the type per session counting, which might be due to the small number of total types.

5. The Development of Verb Inflectional Suffixes

This section provides the quantitative data concerned with the order of acquisition of person and number suffixes (§ 5.1) and gender and number suffixes (§ 5.2). The crucial phonological contrast in each pair of suffixes is that one has a coda and the other does not. The quantitative data provide the following findings:

a.	Person and number:	SR:	Number (*-im*) > Person (*-ti*)
		RM:	Person (*-ti*) > Number (*-im*)
b.	Gender and number:	SR:	Gender (*-a*) & Number (*-im*) (same session)
		RM:	Gender (*-i*, *-a*) > Number (*-im*)

[7] I have counted types per session rather than tokens in order to reduce the effect of repetition of favorite words. For example, out of RM's 561 tokens with the feminine suffix *-a*, 356 were with the word *rot͡sá* 'wants fm.sg.'.

In addition, both children produced the three feminine suffixes in the same order, *-i* > *-a* > *-et* (§ 5.3), though *-i* was rather rare in SR's speech.

5.1. *Number (-im) and Person (-ti)*

The syntactic theories predict that number will be produced before person. This order is also derived from the acquisition of the present tense before the past tense. The present tense, which is also the participle in Hebrew, serves as a bridge between the acquisition of nouns and verbs (Lustigman 2007), since the participles function also as nouns and adjectives (see § 2).

As shown in Table 3 and Figure 1, this prediction is borne out in SR's development but not in RM's, who produced person before number.

Table 3: Number *-im* vs. person *-ti* (Figure 1 plots type per session)

	SR		RM	
	-im	*-ti*	*-im*	*-ti*
First production	P-III (1;06.02)	P-VII (1;09.00)	P-V (1;11.18)	P-IV (1;10.28)
Type per session	64	38	53	117
Total type	39	27	33	42

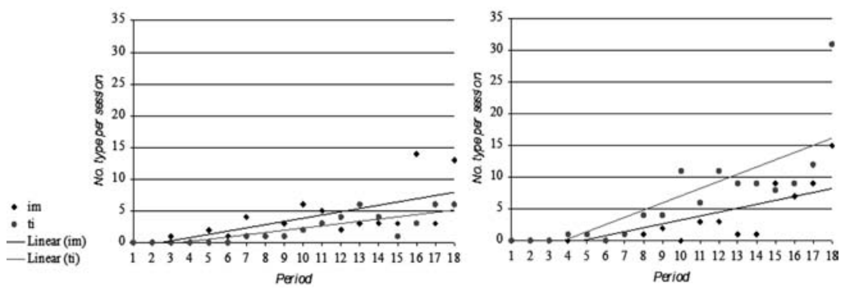


Figure 1

The two criteria for determining the order of acquisition (§ 4.3), precedence and quantity, converge for both children. SR's first production of *-im* (period III) was before his first production of *-ti* (period VII), and he produced more types per session and total types with *-im* (64 and 39) than with *-ti* (38 and 27). Similarly, RM's first production of *-ti* (period IV) was before her first production of *-im* (period V), and she produced more types per session and total types with *-ti* (117 and 42) than with *-im* (53 and 33).

The data above indicate that only SR follows the syntactic predictions (§ 3.1), acquiring the plural suffix *-im* before the first person suffix *-ti*. RM, I claim, exhibits the effect of the prosodic licensing, rather than of the syntactic guidelines, producing the codaless *-ti* before the codaful suffix *-im*. Examples of the children's productions are given in Table 4.

Table 4: Productions of *-im* and *-ti*

***-im* 'ms. pl. Present'**				***-ti* '1st pr. sg. Past'**			
Child	**Target**			**Child**	**Target**		
koθím	kofts͡ím	'jump'	SR (1;06.02)	báti	báti	'came'	SR (1;00.09)
falím	noflím	'fall'	SR (1;08.17)	θagáti	sagárti	'closed'	SR (1;11.02)
θajrím	mecajrím	'paint'	SR (1;10.26)	ibalbálti	itbalbálti	'confused'	SR (2;00.21)
olxím	olxím	'go'	SR (1;11.22)	badákti	badákti	'checked'	SR (2;02.06)
ʃtefím	ʃotfím	'wash'	RM (2;00.09)	esáti	mat͡sáti	'found'	RM (1;10.28)
samím	samím	'put'	RM (2;03.24)	ijámti	sijámti	'finished'	RM (2;00.16)
edagvím	menagvím	'wipe'	RM (2;04.19)	tefáfti	tafásti	'caught'	RM (2;00.30)
oxlím	oxlím	'eat'	RM (2;05.09)	asíti	asíti	'did'	RM (2;02.04)

It should be noted that due to morpho-phonological alternations, both suffixes give rise to word medial codas when the verb stem ends in a consonant. When the suffix starts with a consonant, the final stem consonant is a medial coda (e.g. *xi.pás.-ti* 'I searched'), and when the suffix starts with a vowel, the vowel in the stem final syllable is deleted and the final stem consonant resyllabifies as an onset (/*mexpes-im*/ → *me.xa****p****.s-ím* 'search ms.pl.'). Medial codas do not arise when the verb ends in a vowel (e.g. *ma.t͡sá.-ti* 'I found', *mo.t͡s-ím* 'find ms.pl.'). In Hebrew, as in many/several other languages, final codas are produced before medial codas (Ben-David 2001, this volume, Adi-Bensaid 2006, this volume). Indeed, 58 % (136/234) of RM's tokens with *-ti* were without a medial coda, and out of the 98 tokens with codas, 40 (41 %) were of the same target verb *sijá****m****ti* 'I finished'. Her favorite strategy for avoiding medial codas was to select vowel-final stems (48 %; 113/234), where the medial coda does not appear in the target (e.g. *así-ti* 'I did', *mat͡sá-ti* 'I found'). In a few cases (9 %; 20/234) she deleted the stem consonant, never the suffix consonant (e.g. *axá****l****-ti* 'I ate' → *xá-ti*), and in a handful of cases (3/234) she inserted a vowel (e.g *itlaxláx-ti* 'I got dirty' → *itejaxé-ti*). In targets with more than one medial coda, she often deleted at least one coda (e.g. *i****t****.ba****l****.bá****l****.ti* 'I got confused' → *i.ba****j****.bá****l****.ti*, *de.ba****l****.bá****l****.ti*, *i****t****.ba****j****.bá.ti*). SR, on the other hand, produced all medial codas before the suffix *-ti*, but like RM (though to a lesser extent) he preferred selecting vowel-final stems (34 %; 13/38) to host the *-ti*. Note that only 20 % of the verbs in the children's production lexicon were vowel-final (RM 37/184, SR 36/184).

5.2. *Number (*-im*) and Gender (*-a*)*

Another pair of suffixes contrasting in the presence vs. absence of a coda is that of number (plural *-im*) vs. gender (feminine *-a*).[8] According to syntactic theory II (§ 3.1), number and gender should be produced at the same time, as is the case with SR. According to syntactic theory I, gender should be produced before number, as is the case with RM. Neither child followed the morphological theory, which predicts the production of number before gender. Prosodic licensing makes that same predictions as syntactic theory I, given the presence vs. absence of a coda in *-im* vs. *-a*.

Table 5: Number *-im* vs. gender *-a* (Figure 2 plots type per session)

	SR		RM	
	-im	***-a***	***-im***	***-a***
First production	P-III (1;06.02)	P-III (1;06.02)	P-V (1;11.18)	P-III (1;09.10)
Type per session	64	73	53	108
Total type	39	34	33	34

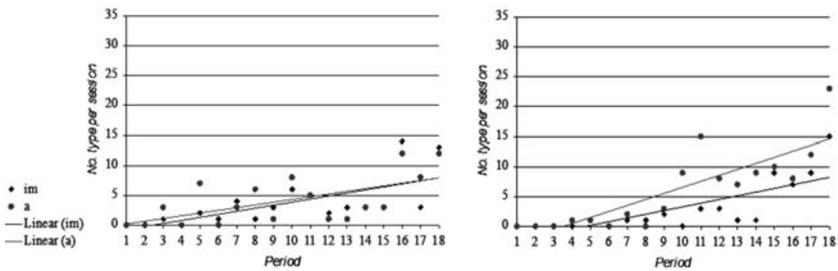


Figure 2

SR started producing *-a* and *-im* during the same period (III) and even during the same session (1;06.02), suggesting no precedence relation as predicted by syntactic theory II. The absence of a precedence relation is further supported by the quantity criterion, where *-a* enjoys a numerical advantage in types per session, while *-im* in total types.

RM started producing *-a* (period III) before *-im* (period V), following syntactic theory I. This precedence relation is supported by the quantity criterion, as there were more types per session for *-a* than for *-im*. However, there was no

8) The feminine suffix *-i* is ignored at this point due to the difference between the children (see § 5.3 below).

distinction in the total types (note that RM had another feminine suffix at her disposal; see § 5.3 below).

5.3. *Gender (*-i, -a, -et*)*

In addition to the codaless feminine suffixes *-a* and *-i*, there is also one codaful feminine suffix *-et*, appearing with regular present tense forms. The suffix *-et* has an allomorph *-at* appearing after the historical pharyngeals *ʔ* and *ħ*, which correspond in Modern Hebrew to null and *x* respectively (e.g. *jodá-at* 'knows fm.sg.', *potáx-at* 'opens fm.sg.'). As shown in Table 6 and Figure 3, both children produced the codaless feminine suffixes before the one with a coda.

Table 6: Gender (feminine) suffixes

	SR			RM		
	-i	*-a*	*-et*	*-i*	*-a*	*-et*
First production	P-I (1;05.04)	P-III (1;06.02)	P-V (1;07.02)	P-I (1;05.10)	P-III (1;09.10)	P-V (1;11.25)
Type per session	9	73	29	110	108	66
Total type	7	34	19	36	34	41

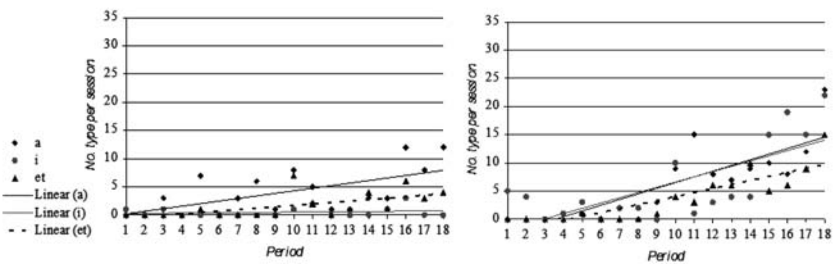


Figure 3

The only case where the precedence and quantity criteria did not converge was SR's feminine imperative *-i*, which appeared early in his productions but was rarely produced later on. Otherwise, both SR and RM reflect the preference of the codaless feminine suffixes over the codaful one in terms of the precedence and the quantity criteria. Examples are given in Table 7.

Morphologically, the acquisition of *-a* prior to *-et* might be surprising, since the default feminine singular suffix in the present tense is *-et*. The suffix *-a* is associated with past tense verbs, though it appears with phonologically defined classes of present tense verbs. However, the children have many good reasons to produce *-a* before *-et*.

Table 7: Productions of the feminine suffixes

-a **'Past & Present'**

Child	**Target**		
boxá	boxá	'cries'	SR (1;08.10)
niberá	niʃberá	'broke'	SR (1;11.07)
aðiká	maxzika	'holds'	SR (2;01.06)
paxtá	patxá	'opened'	SR (2;02.06)
ʃená	jeʃená	'sleeps'	RM (1;09.10)
ispará	niʃberá	'broke'	RM (2;01.27)
joxolá	jexolá	'can'	RM (2;03.29)
meʃgiʃá	margiʃá	'feels'	RM (2;04.19)

-i **'Imperative'**

Child	**Target**		
tazízi	tazízi	'move'	SR (1;05.04)
tisí	tiʃví	'sit'	SR (1;05.08)
bói	bói	'come'	SR (1;06.02)
tirí	tirí	'look'	SR (2;02.02)
kxi	kxi	'take'	RM (1;11.18)
teteftí	tiftexí	'open'	RM (2;02.25)
tetí	titní	'give'	RM (2;03.14)
texakí	texakí	'wait'	RM (2;04.19)

-et **'Present'**

Child	**Target**		
xélet	oxélet	'eat'	SR (1;10.07)
koféθet	kofét͡set	'jump'	SR (2;00.00)
miθaxéket	mesaxéket	'play'	SR (2;01.06)
nofélet	nofélet	'fall'	SR (2;02.22)
péðet	mekapélet	'fold'	RM (1;09.27)
exepéset	mexapéset	'search'	RM (2;02.25)
ʃutéfet	ʃotéfet	'wash'	RM (2;03.01)
évet	oévet	'love'	RM (2;04.19)

Phonologically, *-a* is preferred over *-et* due to the absence vs. presence of a coda, as in the case of *-ti* vs. *-im* in RM's development. In addition, there is a general preference for the vowel *a*, because it is the most frequent vowel in Hebrew and the longest vowel (thus perceptually more accessible). This is manifested in early stages of phonological development, more so in atypical speech (Adam and Bat-El 2008a).

Beyond phonology, the suffix *-a* is prominent in nouns, which are produced before verbs. Therefore, as suggested in Lustigman (2007), the suffix *-a* may serve as a comfortable transition from suffixed nouns to suffixed verbs.

Another good reason, that takes us back to phonology, is that in the present tense, the suffix *-a* appears with irregular verbs, which have a relatively simple prosodic structure. Some irregular verbs have a monosyllabic CVC stem, and thus their feminine counterpart is disyllabic CVCV, consisting of the unmarked CV syllable (e.g. *kám-a* 'she gets up', *áf-a* 'she flies'). Others have a CVCV stem, where the final vowel is deleted when the feminine suffix is added, and thus the feminine form is, again, CVCV (e.g. *ʃoté—ʃot-á* 'drinks ms.–fm.', *rot͡sé—rot͡s-á* 'wants ms.–fm'). In addition, irregular verbs (which take *-a*) have a higher token frequency (though a lower type frequency) than regular verbs (which take *-et*).

5.4. *Summary of Data*

Table 8 provides the full picture of all the suffixes discussed above.

Table 8: All suffixes

a. SR

	-a	*-i*	*-ti*	*-im*	*-et*	**Total**	**Others**[9]	**Grand Total**
1st production	P-III (1;06.02)	P-I (1;05.04)	P-VII (1;09.00)	P-III (1;06.02)	P-V (1;07.02)			
Type per session	73 30%	9 4%	38 15%	64 26%	29 12%	213 86%	34 14%	247
Total type	34 23%	7 5%	27 18%	39 27%	19 13%	126 86%	21 14%	147

b. RM

	-a	*-i*	*-ti*	*-im*	*-et*	**Total**	**Others**	**Grand Total**
1st production	P-III (1;09.10)	P-I (1;05.10)	P-IV (1;10.28)	P-V (1;11.18)	P-V (1;11.25)			
Type per session	108 21%	110 21%	117 23%	53 10%	66 13%	454 88%	61 12%	515
Total types	34 15%	36 16%	42 19%	33 15%	41 18%	186 83%	39 17%	225

9) Other suffixes, appearing later in the children's speech (types per session/total types):

	-u '3rd pl. Past'	*-ot* 'fm.pl. Present'	*-t* '2nd. fm.sg. Past'	*-nu* '1st pl. Past'	Total
SR:	30/17	2/2	2/2	–	34/21
RM:	12/9	4/4	19/11	26/15	61/39

Within the period under consideration here (up to 2;02.22 for SR and 2;05.29 for RM), the five suffixes discussed in this paper were dominant; 86%-88% of the suffixes in type per session and 83%-86% in total type. RM used more codaless suffixes than SR (where only the five suffixes discussed here are counted); in type per session, the rate of RM's codaless suffixes was 74% (335/454), while that of SR was 56% (120/213), and in terms of total types, the rate of RM's codaless suffixes was 60% (112/186), while that of SR was 54% (68/126).

Statistical significance (Fisher's two-tailed test) was found only for type per session. Comparing suffixes, RM showed significant distinction for all pairs of codaful vs. codaless suffixes: *-im* vs. *-ti* (p=.0006), *-im* vs. *-a* (p=.0002), and *-et* vs. *-a*&*-i* (p<.0001). SR was statistically (but not numerically) oblivious to the distinction between codaless and codaful suffixes, showing significance only in *-et* vs. *-a*&*-i* (p =.0003). Accordingly, there was a significant distinction between the children with reference to *-im* vs. *-ti* (p<.0001) and *-im* vs. *-a* (p=.0174) but not *-et* vs. *-a*&*-i*.

One could entertain a non-phonological explanation for RM's preference of *-ti* over *-im*.[10] Since *-ti* appears with past tense verbs only, and *-im* with present tense verbs only, it is possible that RM produced past forms before present forms (which is, in itself, unusual). If this were the case, we would expect most of RM's productions with the feminine suffix *-a* to also be past forms.

The feminine singular suffix *-a*, is the regular suffix of the past tense (*ráts͡-a* 'she ran'). However, it also emerges in the present tense, when the regular suffix *-et* is blocked (Bat-El 2008). It appears with monosyllabic stems (e.g. *ráts͡-a* 'runs fm.sg.'), vowel final stems (e.g. */rots͡e-a/* → *rots͡-á* 'wants fm.sg.'), and stems with a high vowel in the final syllable (e.g. *maxnis-á* 'puts in fm.sg.'). In all other cases, the regular *-et* is the feminine singular suffix in present tense (e.g. *koféts͡-et* 'jumps fm.sg.'). When the stem is monosyllabic, the past and the present forms are identical in the singular forms. That is, *rats͡* means both 'he ran' and 'runs ms.sg.', and *ráts͡-a* means both 'she ran' and 'runs fm.sg.'.

A simple count of the verb types with *-a* reveals that RM did not produce the past tense before the present tense. She produced 34 verb types with *-a* (see (13)), out of which 6 were monosyllabic stems where the past and the present forms are identical; e.g. *áf-a* 'flies/flied (3rd) fm.sg.' (2;00.09), *kám-a* 'get/got up (3rd) fm.sg.' (1;10.28). The verb 'to break' was produced in both the present and the past tense: present *ʃovéret* → *ʃoverá* (1.11.25) and past *ʃavrá* → *ʃavá* (2;01.12). Of the remaining 27 verb types with *-a*, only 8 (30%) were in the past tense; e.g. *kantá* → *katá* 'she bought' (2;01.12), *amrá* → *mará* 'she said' (2;01.19), *ts͡ijerá* → *ts͡irá* 'she painted' (2;05.29). This distribution suggests that there is no other

[10] I would like to thank Hagit Borer (personal communication) for raising this option.

explanation for RM's preference for *-ti* over *-im* but the phonological one, i.e. the preference for the codaless suffix.

6. Phonology-Morphology (a-)synchronization

Throughout the discussion above, I have claimed that the development of RM's verb inflectional suffixes is restricted by the development of her word final codas. SR's development did not show such effect, because, as I show below, his final codas had been almost fully developed by the time he started producing the suffixes. That is, both children demonstrate the role of prosodic licensing (Lleó 2003, Demuth 2007 and references therein; see also §7) in the development of verb inflectional suffixes, as the prosodic position of final codas was a prerequisite for the production of suffixes with codas.

The correlation between the relative rate of faithful codas and the production of the verb suffixes is presented in Table 9.[11] As shown, both children started producing the codaful suffix *-im* when they reached about 90% faithful codas; period III for SR and period V for RM.

Table 9: Phonological and morphological development

	SR			RM		
P	**Faithful codas**		**Suffix**	**Faithful codas**		**Suffix**
I	69%	(59/86)	(*-i*)	45%	(37/83)	*-i*
II	89%	(80/90)		67%	(83/124)	
III	**93%**	(68/73)	*-a*, ***-im***	84%	(88/105)	*-a*
IV	97%	(106/109)		87%	(103/118)	***-ti***
V	96%	(142/148)	*-et*	**90%**	(157/175)	***-im***, *-et*
VI	100%	(187/187)		82%	(73/89)	
VII	99%	(296/299)	***-ti***	87%	(86/99)	

The difference between the children is limited to the suffixes *-im* and *-ti*; all other suffixes were produced during the same periods. I attribute this difference to (a-)synchronization between morphological and phonological (prosodic) development.[12] Assuming the suffixes' development is dictated by the morph-syntax (§3), a synchronized interaction between phonology and morphology is one where the coda position is there to license the suffix's coda, as in SR's

[11] For further studies on the development of Hebrew codas see Ben-David (2001, this volume), Tubul-Lavy (2005), Adi-Bensaid (2006, this volume), Gishri (2009), and Bat-El (2012).
[12] See Bat-El (2009) for a-synchronization between segmental and prosodic development in atypical speech. Of course, a child's development may exhibit synchronization with regard to some properties and a-synchronization with regard to others, though it is yet to be studies what types of a-synchronization is limited to atypical development.

development. In an a-synchronized interaction, as in RM's development, the suffix's coda is not yet licensed. Taking the 90% faithful codas as the point of prosodic licensing, Table 10 illustrates the phonology-morphology (a)synchrnoziation.

Table 10: Phonology-morphology (a-)synchronization (FC—faithful codas)

		P-I	P-II	P-III	P-IV	P-V	P-VI	P-VII
SR:	Phonology			**90% FC**				
	Morphology	(*-i*)		***-a*, *-im***		***-et***		***-ti***
RM:	Phonology					**90% FC**		
	Morphology	*-i*		***-a***	***-ti***	***-im*, *-et***		

In the spirit of Optimality Theory (Prince and Smolensky 1993/2004), I assume that the constraint prohibiting codas, i.e. No Coda, is present in the grammar of both children. During early stages of acquisition, children produce codaless syllables, and thus No Coda is positioned high in the constraint hierarchy. This constraint is gradually demoted in the course of development (Tesar and Smolensky 1998), quite fast in the case of typically developing Hebrew-acquiring children, given that most Hebrew stems end with a coda (see Table 12).

Crucial for the notion of (a-)synchronization is the pace of No Coda demotion relative to the development of verb inflectional suffixes. As long as No Coda is ranked above Faith Affix, where the latter requires the production of the suffix, the children do not produce suffixes with codas. The interaction between phonology (No Coda) and morphology (Faith Affix) is illustrated below, assuming the acquisition of number before gender, as predicted by the morphological theory. I adopt this order, which both children did not follow, to highlight my claim that phonology has a fundamental effect on the order. That is, it is possible that SR's morphological development was also affected by No Coda, which blocked the production of the codaful plural suffix *-im*, thus allowing the codaless gender suffix *-a* to appear first.

Whatever the prediction of the morpho-syntactic theories is, the plural *-im* is not produced as long as No Coda outranks Faith Affix; this is true for both children. The difference between the children is thus due to the synchronization between the morpho-syntax and the constraint ranking. Note that RM's a-synchronization is not only due to slow phonological development, but also to fast morphological development. She demoted No Coda during period V (cf. SR—period III), but produced all four suffixes by period IV (cf. SR—period VII).

Table 11: Constraint ranking and suffix production

		Morpho-syntax		**Period**	***-im***	***-a***	***-et***	***-ti***	**Constraint ranking**		
a.	SR:	Number	*-im*		*				NoCoda	>>	FaithAffix[13]
		Gender	*-a*, *-et*	III	✓	✓	–		FaithAffix	>>	NoCoda
				V	✓	✓	✓				
		Person	*-ti*	VII	✓	✓	✓	✓			
b.	RM:	Number	*-im*		*				NoCoda	>>	FaithAffix
		Gender	*-a*, *-et*	III		✓	*				
		Person	*-ti*	IV		✓	*	✓			
				V	✓	✓	✓	✓	FaithAffix	>>	NoCoda

The slightly bigger ✓ indicates the first production of the suffix. An asterisk indicates that the production of the suffix is blocked due to the constraint ranking. A dash indicates that both phonology and morphology predict the production of the suffix at this point, but nevertheless it is not produced.

Further distinction should be drawn between stems and suffixes, as the children waited till most (90 %) of their stem's codas were faithfully produced before they started producing the codaful *-im*. That is, their phonological grammar for stem was more advanced than for stem + suffix. This can be expressed with the postulation of different faithfulness constraints for stems and affixes (McCarthy and Prince 1995), where MaxFC$^{\text{Stem}}$, which preserves the final codas of the target stems, outranks Faith Affix. In the course of demotion, No Coda first crosses MaxFC$^{\text{Stem}}$, allowing final codas in stems but not in suffixes (6b). Then it crosses the lower faithfulness constraint FaithAffix, allowing codas in both stems and suffixes (6c).[14]

(6) Stems vs. suffixes

a. No codas everwhere: **No Coda** >> MaxFC$^{\text{Stem}}$ >> FaithAffix
b. Codas in stems only: MaxFC$^{\text{Stem}}$ >> **No Coda** >> FaithAffix
c. Codas everywhere: MaxFC$^{\text{Stem}}$ >> FaithAffix >> **No Coda**

As argued in Borer and Rohrbacher (2002) and Adam and Bat-El (2008b), avoidance of affixes does not indicate that the child has not yet acquired (at least some) knowledge associated with the affixes. Rather, it reflects knowledge

[13] This ranking allows the production of the suffix without its coda (e.g. *rot͡s-ím* → *rot͡s-í* 'they want'). However, as noted in § 4.2, this strategy was hardly ever used. I assume that deletion of a segment from the suffix violates Faith Affix. This, however, requires further elaboration given that in Spanish (Lleó 2003) the coda of the suffix is deleted.

[14] RM distinguished not only between simple and complex verbs, but also between verbs and nouns (like SR with regard to the trochaic foot). Before producing *-im* in verbs, RM produced seven noun types with a plural suffix (*-im* or *-ot*), five of which were produced productively, i.e. their singular counterpart was also produced.

of morphological structure, and this knowledge allows the child to be selective, and distinguish between stems and the affixes (on selectivity, see Ferguson and Farwell 1975, Waterson 1978, Schwartz 1988, Becker 2007, this volume).

It should be noted that the phonological effect studied here is restricted to the prosodic position, where the segmental content does not seem to play a role.[15] As shown below, most Hebrew noun stems have a final coda, more so in mono- and disyllabic stems (about 75 %) than in trisyllabic (59 %). The most common word final consonant is *t*, which functions also as a derivational (feminine) suffix; word final *m* enjoys a much lower frequency.

Table 12: Word final codas in Hebrew nouns (based on Bolozky and Becker 2006)[16]

	Monosyllabic		Disyllabic		Trisyllabic		Total	
Final *t*	13 %	(57/445)	15 %	(627/4262)	61 %	(1428/2329)	30 %	(2112/7036)
Final *m*	8 %	(34/445)	6 %	(244/4262)	3 %	(60/2329)	5 %	(338/7036)
Final C	75 %	(445/597)	76 %	(4262/5633)	59 %	(2329/4028)	69 %	(7036/10258)

The absence of segmental effect is manifested in SR's development, where *-im* is produced before *-et*, despite the higher frequency of *t* codas compared with *m* codas. Also the foot structure does not affect the morphological development, since the preferred trochaic foot (Adam and Bat-El 2009) assigned by the suffix *-et* (e.g. *joʃévet* 'she sits') does not give priority to this suffix, as the codaless feminine suffix *-a* is produced before the codaful *-et* (§ 5.3). These properties do not interact with the morphological development because they have already been fully acquired by the time the children have started producing the verb inflectional suffixes.

7. Phonology-Morphology Interface

Assuming the prosodic licensing hypothesis, whereby a prosodic structure is a prerequisite for the hosting of grammatical morpheme, the phonology-morphology interface is unidirectional, i.e. phonological (prosodic) development affects morphological development. This directionality was found in studies on prosodic restrictions on the development of grammatical morphemes, such as function words in English (Gerken 1996, Demuth and McCullough

[15] As show in Cohen (this volume), SR's prosodic development was faster than RM's, but RM's segmental development (vowels) was faster than SR's.

[16] The counting does not include inflectional suffixes such as plural *-im* 'ms.' and *-ot* 'fm.', and the gender-assigning feminine suffixes, as in *rakdán—rakdanít* 'dancer', *t͡salám—t͡salémet* 'photographer'.

2009), determiners in French (Demuth and Tremblay 2008), articles in Spanish and German (Lleó 2001), nouns class markers in Sesotho (Demuth 1994), and tense in Hebrew SLI children (Owen et al. 2001).

As for coda development, Lleó (2003) shows that the acquisition of Spanish plural suffix *-s* (e.g. *cásas* 'houses') is delayed (like RM's *-im*) due its position in an unstressed syllable. Another type of phonological effect on the acquisition of codas is reported in Marshall and van der Lely (2007), where English-acquiring children with grammatical SLI are more likely to produce the English past tense suffix when the resulting form ends in a simple coda (e.g. *sewed*) than when it ends in a complex coda (e.g. *wrapped*).

However, the opposite direction is also found, i.e. that morphological development affects prosodic development. Freitas et al. (2001) argue that the nominal suffix ʃ in European Portuguese serves as a bootstrapping for the acquisition of word final codas (regardless of stress). Similarly, as reported in Stemberger and Bernhardt (1996), an English-acquiring child produced complex codas in suffixed forms (e.g. *raks* → *wa:ts* 'rocks') during the stage in which complex codas in tautomorphemic words were still reduced (e.g. *faks* → *fa:s* 'fox'). Note the contrast between this child, whose morphology bootstrapped the production of complex codas, and the SLI children studied in Marshall and van der Lely (2007), whose phonology inhibited morphologically derived complex codas.

Future studies should explore the factors determining directionality in the phonology-morphology interface. Since phonology is acquired, at least partially, before morphology, it is expected that phonological development would affect morphological development. However, the frequency of the relevant structure in the ambient language may play a role. It is possible that word final codas in European Portuguese are produced only when the plural suffix starts appearing because syllables with codas are rare in the language (about 17%), and word final codas are limited to alveolar liquids and palatal fricatives (Vigário et al. 2006). In Hebrew, word final codas are rather common (see 18), and thus they play a greater role in the children's development.

So at this point of research it can be concluded that the default directionality in the phonology-morphology interface is that phonological development (limited here to prosody) affects morphological development. This directionality can be reversed in cases of poverty in the phonological input.

References

Adam, Galit and Outi Bat-El. 2008a. Segmental effects on syllable selection: Evidence from Hebrew. In A. Gavarró and M. Freitas (eds), *Language Acquisition and Development: Proceedings of GALA 2007*, 1–11. Newcastle: Cambridge Scholars Publishing.

Adam, Galit and Outi Bat-El. 2008b. Morphological knowledge without morphological structure. In S. Armon-Lotem, G. Danon, and S. Rothstein (eds), *Current Issues in Generative Hebrew Linguistics*, 197–222. Amsterdam: John Benjamins.

Adam, Galit and Outi Bat-El. 2009. When do universal preferences emerge in language development? The acquisition of Hebrew stress. *Brill's Annual of Afroasiatic Languages and Linguistics* 1:1–28.

Adi-Bensaid, Limor. 2006. *The Prosodic Development of Hebrew-Speaking Hearing Impaired Children*. Ph.D. dissertation, Tel-Aviv University.

Armon-Lotem, Sharon. 2006. Subject use and the acquisition of verbal agreement in Hebrew. In N. Gagarina and I. Guelzow (eds), *Acquisition of Verb Grammar and Verb Arguments*, 269–291. Dordrecht: Kluwer Academic Publishers.

Bat-El, Outi. 2002. True truncation in colloquial Hebrew imperatives. *Language* 78:651–683.

Bat-El, Outi. 2008. Morphologically Conditioned V–∅ alternation in Hebrew: Distinction among Nouns, Adjectives&Participles, and Verbs. In S. Armon-Lotem, G. Danon, and S. Rothstein (eds), *Current Issues in Generative Hebrew Linguistics*, 27–60. Amsterdam: John Benjamins.

Bat-El, Outi. 2009. Harmonic domains and synchronization in typically and atypically developing Hebrew-speaking children. *Language Sciences* 31:117–135.

Bat-El, Outi. 2012. The role of sonority in the acquisition of Hebrew word final codas. In S. Parker (ed.), *The Sonority Controversy*, 193–212. Berlin: Mouton de Gruyter.

Becker, Michael. 2007. Prudent error-driven learning with OT-CC. A paper presented in NecPhon 1, UMass.

Ben-David, Avivit. 2001. *Language Acquisition and Phonological Theory: Universal and Variable Processes Across Children and Across Languages*. Ph.D. dissertation, Tel-Aviv University. [in Hebrew]

Bolozky, Shmuel. 1979. On the new imperative in colloquial Hebrew. *Hebrew Annual Review* 3:17–24.

Bolozky, Shmuel and Michael Becker. 2006. Living Lexicon of Hebrew Nouns. Ms., University of Massachusetts Amherst. Available at http://becker.phonologist.org/LLHN.

Borer, Hagit and Bernhard Rohrbacher. 2002. Minding the absent: Arguments for the Full Competence Hypothesis. *Language Acquisition* 10:123–175.

Cassali, Roderic. 1997. Vowel elision in hiatus contexts: Which vowel goes? *Language* 73: 493–533.

Gishri, Michal. 2009. *The Role of Prominence in the Acquisition of Medial Codas in Hebrew: Evidence from a Slow Developer*. M.A. thesis. Tel-Aviv University.

Demuth, Katherine. 1994. On the 'underspecification' of functional categories in early grammars. In B. Lust, M. Suñer, and J. Whitman (eds), *Syntactic Theory and First Language Acquisition: Cross-linguistic Perspectives*, 119–134. Hillsdale, NJ: Lawrence Erlbaum Associates.

Demuth, Katherine. 2007. Acquisition at the prosody-morphology interface. In A. Belikova, L. Meroni, and M. Umeda (eds), *Proceedings of the 2nd Conference on Generative Approaches to Language Acquisition North America (GALANA)*, 84–91. Somerville, MA: Cascadilla.

Demuth, Katherine and Elizabeth McCullough. 2009. The prosodic (re)organization of children's early English articles. *Journal of Child Language* 36:173–200.

Demuth, Katherine and Annie Tremblay. 2008. Prosodically-conditioned variability in children's production of French determiners. *Journal of Child Language* 35:99–127.

Ferguson, Charles and Carol Farwell. 1975. Words and sounds in early language acquisition. *Language* 51:419–439.

Freitas, Joõ, Matilde Miguel, and Isabel Faria. 2001. Interaction between prosody and morphosyntax: Plurals within codas in the acquisition of European Portuguese. In J. Weissenborn and B. Höhle (eds), *Approaches to Bootstrapping* v. 2, 45–57. Amsterdam: John Benjamins.

Gerken, LouAnn. 1996. Prosodic structure in young children's language production. *Language* 72:683–712.

Greenberg, Joshep. 1963. Some universals of grammar with particular reference to the order of meaningful elements. In J. Greenberg (ed.), *Universals of Language*, 73–113. Cambridge, MA: MIT Press.

Hanson, Rebecca. 2000. Pronoun acquisition and the morphological feature geometry. In S. Atkey, J. Carson, and M. Dobrovolsky (eds), *Calgary Working Papers in Linguistics*, 1–14.

Harley, Heidi and Elizabeth Ritter. 2002. Person and number in pronouns: A feature-geometric analysis. *Language* 78:45–69.

Lleó, Conxita. 2001. The interface of phonology and syntax: The emergence of the article in the early acquistion of Spanish and German. In J. Weissenborn and B. Höhle (eds), *Approaches to Bootstrapping* v. 2, 23–44. Amsterdam: John Benjamins.

Lleó, Conxita. 2003. Prosodic licensing of codas. *Probus* 15:257–281.

Lustigman, Lyle. 2007. *Selectivity in Early Child Grammar: The Case of Hebrew Verb Morphology*. M.A. thesis, Tel-Aviv University.

Marshall, Chloe and Heather van der Lely. 2007. The impact of phonological complexity on past tense inflection in children with Grammatical-SLI. *Advances in Speech-Language Pathology* 9:191–203.

McCarthy, John and Alan Prince. 1995. Faithfulness and reduplicative Identity. In J. Beckman, L. Walsh Dickey and S. Urbanczyk (eds), *University of Massachusetts Occasional Papers in Linguistics*: *Papers in Optimality Theory*, 249–384. University of Massachusetts, Amherst: GLSA.

Owen, Amanda, Esther Dromi, Laurence Leonard. 2001. The phonology-morphology interface in the speech of Hebrew-speaking children with specific language impairment. *Journal of Communication Disorders* 34:323–337.

Prince, Alan and Paul Smolensky. 1993/2004. *Optimality Theory: Constraint Interaction in Generative Grammar*. Oxford, Basil Blackwell. [1993, TR 2, Rutgers University Cognitive Science Center].

Shlonsky, Ur 1989. The hierarchical representation of subject verb agreement. Ms., University of Geneva.

Schwartz, Richard. 1988. Phonological factors in early lexical acquisition. In M. Smith and J. Locke (eds), *The Emergent Lexicon: The Child's Development of a Linguistic Vocabulary*, 185–222. San Diego: Academic Press.

Stemberger, Joseph and Barbara Bernhardt. 1996. Phonological constraint and morphological development. In E. Hughes, M. Hughes, and A. Greenhill (eds), *Proceedings of the*

21st Annual Boston University Conference on Language Development, 603–614. Somerville, MA: Cascadilla Press.

Stoel-Gammon, Carol. 2011. Relationships between lexical and phonological development in young children. *Journal of Child Language* 38:1–34.

Tesar, Bruce and Paul Smolensky. 1998. Learnability in Optimality Theory. *Linguistic Inquiry* 29:229–268.

Tubul-Lavy, Gila. 2005. *The Phonology of Hebrew-speaking Dyspraxic Children*. Ph.D. dissertation, Tel-Aviv University [in Hebrew].

Vigário, Marina, Maria João Freitas, and Sónia Frota. 2006. Grammar and frequency effects in the acquisition of prosodic words in European Portuguese. *Language and Speech* 49:175–203.

Waterson, Natalie. 1978. Growth of complexity in phonological development. In N. Waterson and C. Snow (eds), *The Development of Communication*, 415–442. Chichester: Wiley.

BAALL
BRILL Brill's Annual of Afroasiatic Languages and Linguistics 4 (2012) 213–231 brill.com/baall

Non-Finiteness in Early Hebrew Verbs*

Lyle Lustigman
Department of Linguistics, Tel-Aviv University
lustigman6@yahoo.com

Abstract
The study investigates the gradual development of morphological specification, as reflected in use of early non-finite verb forms in the speech of three Hebrew-acquiring children (mean age range 1;4–2;2). Children acquiring different languages have been shown to make use of non-finite forms in their initial verb usage. Use of uninflected verbs in matrix clauses has been attributed to the Root or Optional Infinitives phenomenon in generative frameworks, or to the generally stepwise path of acquisition in developmental approaches. Analyses of the longitudinal data presented here suggest that Hebrew-acquiring children do not use infinitival forms before they begin to master inflections productively. Instead, they rely, for several months, on non-affixed "bare stems" as their initial verb forms. Prefix-marked "full" infinitives occur later, typically in well-formed syntactic contexts, alongside productive use of affixed Present-tense (*benoni*) participial forms. Hebrew-acquiring children thus appear to make selective use of different types of nonfinite forms (initial bare stems followed by Infinitives and *benoni*), each representing different levels of inflectional knowledge. It is therefore argued here that non-finiteness in early child language is in itself a developmental concept consisting of several sub-phases each of which demonstrates a particular level of linguistic knowledge, motivated by typological features of the ambient language.

Keywords
early grammar; verb inflections; non-finiteness; Hebrew

1. Introduction

The study examines non-finite verb forms in early child Hebrew, where "non-finite" refers to verbs that are not explicitly marked for Tense and/or Aspect. Non-finiteness has been shown to characterize children's initial use of verbs in different languages (e.g. Blom and Wijnen 2000 for Dutch, Hyams 1986 for English, and Rizzi 1993/1994 for Italian) and is interpreted as reflecting different levels of inflectional knowledge in early verb productions, ranging from no knowleldge at all (Dressler et al. 1987) to full knowledge of inflectional representations (Poeppel and Wexler 1993).

*) This is a revised version of an earlier draft, based on comments of two external reviewers. I am grateful to Ruth Berman for her helpful input at all stages of the study.

DOI: 10.1163/18776930-00400010

Hebrew is an interesting case in this respect, since it lacks a single unequivocal "base" form of verbs (unlike English *talk, sleep*), and its infinitival form is marked by a non-stressed prefix, making it a less obvious candidate for initial verb production (compare, for example, Italian *parláre* 'to-talk', *dormíre* 'to-sleep' or Spanish *hablar* 'to-talk', *dormir* 'to sleep', with Hebrew *ledaber* 'to-talk', *lišon* 'to-sleep').[1] Hebrew-acquiring children, instead, resort to a language-particular, non-adult, strategy for realizing non-finiteness in their early verb usage, by means of what Berman and Armon-Lotem (1996) term "stripped forms" or "bare stems" (e.g. *šon*, *daber* for the lexemes 'sleep', 'talk' respectively). These truncated forms do not occur as such in the ambient language, so they cannot be dismissed as merely rote-learned or repetitions. Therefore, they provide an important source of evidence for children's knowledge of verbs during this period. The shift from such non-adult-like bare stems to normative Infinitive forms is analyzed below as shedding new light on non-finiteness in early child language in relation to findings from acquisition of other languages, and as characterizing the more general developmental transition from "child-speaker" to "native speaker" (Berman 1993, Slobin 1990).

1.1. *Non-Finiteness in Acquisition*

In a generative framework, children's use of uninflected verbs in matrix clauses is attributed to a phenomenon termed Root or Optional Infinitives (Wexler 1993, Haegeman 1995), at a stage where children's grammar optionally allows use of ungrammatical non-inflected forms, prior to parameter-setting or maturation of the relevant grammatical principles (Borer and Wexler 1992). RI (Root Infinitive) analyses differ with respect to whether and how inflectional categories such as Tense are specified in children's syntactic representation. The analyses range from crediting children with full syntactic representation (Phillips 1996, 2010) to claiming that some functional projections are optional (Wexler 1993, 1998). Others attribute the non-surfacing of Tense to other grammatical features such as missing "+/−Past" (Wexler 1993), the absence of a Number category in the "tense-chain" in the target language (Hoekstra and Hyams 1996, Schaeffer and Ben-Shalom 2004), the optional lack of a Tense projection in Root Infinitives (Wijnen 1998), or to truncation of functional nodes of the syntactic tree (Rizzi 1993/1994, 1994).

Input-based approaches account for the rate and duration of the Optional Infinitive (OI) stage as deriving from distributional features of child directed speech. Thus, the generative Variational Learning Model (Legate and Yang 2007)

---

1) Non-English words have final stress, unless specified by an *accent aigu* as (ante)penultimate.

attributes the cross-linguistic variation in RI rates to the amount of evidence for +Tense marking in the target language, in the form of a gradual process of parameter-setting based on competing potential grammars. Alternatively, the constructivist Model of Syntax Acquisition in Children (MOSAIC) (Freudenthal et al. 2006, 2010) predicts RI rates at the OI stage on the basis of strings of "compound finites" such as *can **I play*** from the right edge of utterances in the input.

Other developmental approaches attribute the lack of inflectional marking in early verb usage to the more general stepwise route of acquisition rather than as a specific phenomenon of "non-finiteness" (Wittek and Tomasello 2002, Theakston and Lieven 2008). For example, Brown (1973) took into account morphological structure in acquisition of English only from the emergence of initial verb and noun inflections at what he defines as Stage II. Tomasello's (2003) perspective on early child grammar analyzes morphological markings not in terms of operations applying to non-inflected or base forms, but as representing connectionist networks of paradigmatically related forms (Bybee 1995)—with non-finite forms not referred to as in themselves reflecting a special phase in morphological knowledge. A morphologically motivated developmental model is provided by Dressler, and contrasts the initial phase of Premorphology, when morphology has not yet dissociated from other cognitive, non-language-specific systems, with the subsequent acquisition of morphological knowledge (Dressler and Karpf 1995, Dressler et al. 2003). Other developmentally motivated analyses in more richly inflected languages than English delineate a gradual path in the mastery of verb inflections in terms of the relative productivity of early inflectional categories such as Person and Number (e.g. Gathercole et al. 2002 for Spanish, Pizzuto and Caselli 1994 for Italian, Armon-Lotem and Berman 2003 for Hebrew) or the temporal and aspectual reference of early verbs (Weist et al. 1984 for Polish). While in many ways compatible with the developmentally motivated approach of the present study, these analyses do not address directly the issue of non-finiteness in acquisition.

1.2. *Research on Hebrew Verb Acquisition*

The Hebrew verb system, as briefly outlined below (§ 1.2.1) has been the topic of rich prior research (§ 1.2.2), including studies of Root Infinitives (Armon-Lotem 1996, Schaeffer and Ben-Shalom 2004). To the best of my knowledge, however, the role and nature of nonfinite forms in acquisition of this system has not formerly been addressed as such.

1.2.1. The Verb System of Modern Hebrew

Modern Hebrew has an impoverished system of TMA marking compared with its Biblical antecedents (Hatav 1997, Goldfajn 1998), and yet the contemporary verb system presents the language-acquiring child with a rich range of categories and forms (Berman 1978a, Schwarzwald 1981). There are five Mood/Tense categories, with no grammatical Aspect. Moreover, all (although not only) verbs in the language must be constructed in one of the prosodic templates of the *binyan* verb-patterns (Bolozky 1986, Berman, 1993, 2003a, Schwarzwald 1996, 2002, Bat-El 2002). Table 1 illustrates verbs based on the consonants *g-d-l* in three high-frequency *binyan* patterns: P1 *qal* (for a verb meaning Intransitive 'grow'), P3 *pi'el* (Transitive 'raise'), and P5 *hif'il* (Causative 'make-bigger, enlarge'), with inflectional markings for Number (Singular/Plural), Gender (Masculine/Feminine), and Person (1st, 2nd, 3rd).

Table 1 shows that speakers have a vast array of structural choices to make whenever they produce a verb in Hebrew. Aside from constructing verbs in their appropriate verb pattern, all tensed verbs agree with their Subject noun for Number and Gender, with Person marked only in Past and Future and (by default 2nd person) Imperative. The *benoni* 'intermediate' participials that also express Present Tense are marked like nouns and adjectives for Number and Gender, but not for Person—so that they lie between the fully tensed Past and Future, on the one hand, and the non-tensed Infinitive, on the other (Berman 1978a, 1990).

In sum, Hebrew-speaking children encounter what might appear a bewildering array of structural options every time they produce a verb, including those that are most basic and have a high frequency. Important to the present context, the lack of an unequivocal "base" form of verbs means that children must use inflected forms right from the start, en route to mastery of the complex array of largely synthetic inflections in their language.

1.2.2. Studies of Hebrew Verb Acquisition

Prior studies of Hebrew verbs demonstrate that in Hebrew as in other languages, while inflections may surface early on, initial use of grammatical markers is not necessarily productive, but largely rote-learned (Berman 1978b, 1985, Uziel-Karl 2002, Clark and Berman 2004, Ravid 2008, Lustigman 2012). Various studies show that, as in other languages, acquisition of verb inflections is gradual and piecemeal, with some categories emerging earlier than others (Berman and Dromi 1984, Armon-Lotem 1996, Ravid 1997): Present-tense forms together with Infinitives and Imperatives were found to occur most frequently in early speech, while Past-tense forms occur mainly with activity verbs (e.g. those

Table 1: Tense/Mood values of verbs based on the consonants *gdl* in three *binyan* patterns (1, 3, and 5), inflected for Number, Gender, and Person.

<table>
<tr><th>Per, No, Gen</th><th>Tense/Mood
Past</th><th>Present</th><th>future</th><th>Imperative</th><th>Infinitive</th></tr>
<tr><td>1st Sg</td><td>1-gadálti
3-gidálti
5-higdálti</td><td>1-gadel/a
3-megadel/et
5-magdil/a</td><td>1-ʔegdal
3-ʔagadel
5-ʔagdil</td><td rowspan="2"></td><td rowspan="10">1-ligdol
2-legadel
3-lehagdil</td></tr>
<tr><td>1st Pl</td><td>1-gadálnu
3-gidálnu
5-higdálnu</td><td>1-gdelim/ot
3-megadlim/ot
5-magdilim/ot</td><td>1-nigdal
3-negadel
5-nagdil</td></tr>
<tr><td>2nd Sg Ms</td><td>1-gadálta
3-gidálta
5-higdálta</td><td>1-gadel
3-megadel
5-magdil</td><td>1-tigdal
3-tegadel
5-tagdil</td><td>1-tigdal/gdal
3-tegadel/gadel
5-tagdil/hagdel</td></tr>
<tr><td>2nd Sg Fm</td><td>1-gadalt
3-gidalt
5-higdalt</td><td>1-gdela
3-megadélet
5-magdila</td><td>1-tigdeli
3-tegadli
5-tagdili</td><td>1-tigdeli/gidli
3-tegadli/gadli
5-tagdíli/hagdíli</td></tr>
<tr><td>2nd Pl Ms</td><td>1-gadáltem
3-gidáltem
5-higdáltem</td><td>1-gdelim
3-megadlim
5-magdilim</td><td rowspan="2">1-tigdelu
3-tegadlu
5-tagdilu</td><td rowspan="2">1-tigdelu/gidlu
3-tegadlu/gadlu
5-tagdílu/hagdílu</td></tr>
<tr><td>2nd Pl Fm</td><td>1-gadálten
3-gidálten
5-higdálten</td><td>1-gdelot
3-megadlot
5-magdilot</td></tr>
<tr><td>3rd Sg Ms</td><td>1-gadal
3-gidel
5-higdil</td><td>1-gadel
3-megadel
5-magdil</td><td>1-yigdal
3-yegadel
5-yagdil</td><td rowspan="4"></td></tr>
<tr><td>3rd Sg Fm</td><td>1-gadla
3-gidla
5-higdíla</td><td>1-gdela
3-megadélet
5-magdila</td><td>1-tigdal
3-tegadel
5-tagdil</td></tr>
<tr><td>3rd Pl Ms</td><td rowspan="2">1-gadlu
3-gidlu
5-higdilu</td><td>1-gdelim
3-megadlim
5-magdilim</td><td rowspan="2">1-yigdelu
3-yegadlu
5-yagdilu</td></tr>
<tr><td>3rd Pl Fm</td><td>1-gdelot
3-megadlot
5-magdilot</td></tr>
</table>

meaning 'did', 'went', 'happened', particularly change-of-state verbs like those meaning 'broke', 'fell', 'came').

Critical to the present analysis is the finding that children's early verbs typically take the form of "bare stems" (Berman and Armon-Lotem 1996, Armon-Lotem and Berman 2003, Adam and Bat-El 2008, Lustigman 2012). These include non-affixed Past or Present Tense forms (e.g. *halax* 'went' or *boxe* 'is-crying') and also truncated forms that either can be interpreted as Infinitives (e.g. *šon*, *toax*—corresponding to the Infinitivals *lišon* 'to-sleep', *liftoax* 'to-open', respectively), or are ambiguous between various target forms (e.g. *tapes* can stand for *letapes* 'to-climb', *metapes* 'climbs' *yetapes* 'will-climb' and other inflected forms in the paradigm). The present study aims to demonstrate the crucial role played by such forms in early Hebrew verb grammar.

Children also need to acquire *binyan* verb-pattern alternations demonstrated above, reflecting a system of derivational morphology which, in Hebrew as in other languages, develops later than basic verb inflection (Clark and Berman 2004). Initially, children treat each verb as an unanalyzed amalgam, unrelated to a particular verb-pattern, hence not involving the morphological alternations required by changes in transitivity, as in *ha-yéled nafal* 'the-boy fell'—*ha-yéled hipil et ha-kos* 'the-boy made-fall = dropped ACC the glass' and *ha-kadur hit-galgel* 'the-ball rolled'—*hu gilgel et ha-kadur* 'he rolled ACC the-ball' (Berman 1982, 1993, 2003b, Ravid 2008). Nevertheless, as will be shown below, the *binyan* system has a marked impact on the structure of children's early non-finite verb forms.

Numerous studies demonstrate that in Hebrew, as in other languages, early syntax emerges in tangent with inflectional morphology (Berman and Dromi 1984, Berman 1985, 1993, Armon-Lotem and Berman 2003, Armon-Lotem 2006). Acquisition of verb-argument structures demonstrates a gradual developmental route (Uziel-Karl 2002), with more prototypical, "pathbreaking" verbs occurring in children's early combinations (Ninio 1999a,b, 2001). In two-place predications, young children appear to favor prototypical SVO configurations—with the post-verbal noun generally marked by a preposition (Berman, 1993). The present study examines children's early word-combinations as reflecting morphology-syntax interfaces along both the paradigmatic and syntagmatic axes in the use of verbs.

Focus here is on what Hebrew-acquiring children select as their initial verb forms, taking into account how formal features of inflectional categories affect the order of acquisition such that certain verb forms (bare stems and later infinitival forms) acquire a "preferred status".

2. Description of the Study

The study analyzes early verb forms from three longitudinal samples of Hebrew-acquiring children (mean age-range 1;4–2;2). Each data sample was analyzed in relation to level of productivity of verb-affixation, yielding two main developmental phases, as specified in § 2.2.1.

2.1. *Database*

The three children, all from well-educated, middle-class families resident in central Israel, were audio-recorded for one hour per week by a familiar caregiver (mother or aunt), in the course of everyday activities in their home environment. Children's and adult's utterances were transcribed in broad phonemic transcription following the CHILDES conventions (MacWhinney 2005), adapted to conform optimally to the non-Latinate orthography and contemporary pronunciation of Israeli Hebrew. The speech output of SR and RM was also phonetically transcribed, and a corresponding phonetic target form entered for the children where possible.[2] All verb forms from all three children were analyzed.

2.2. *Analytical Procedures*

All lexical verbs—excluding copular and existential operators—were analyzed, starting with the earliest verb form documented for each child, divided into two developmental phases (§ 2.2.1). All verb-forms in each child's speech output were coded in relation to possible target forms and the grammatical knowledge they reflect (§ 2.2.2).

2.2.1. Criteria for Developmental Phases

Developmental phases in early Hebrew verb-usage are specified here in terms of the level of productivity they manifest, with "productive" use of verb inflection defined in relation to the syntactic environments in which verbs are used as well as to other verb forms occurring in the same period of time.

---

[2] The data from the boy SR (recorded by the author, his aunt), and the girl RM were collected in the Child Language Project of Bat-El and Adam, Tel-Aviv University, ISF Research Grant #554/04; and from LR from the Child Language Database of the Berman lab at Tel-Aviv University, a subset of which is available on the Berman corpus on CHILDES (http://childes.psy.cmu.edu/data/Other/Hebre). The entire recorded database for LR has also been digitalized, so the analyses of her output are also based on sound recordings. Thanks are due to Brian MacWhinney and Aviad Albert for providing digitalization facilities.

As noted earlier (§ 1.3), Hebrew verbs are inflected to agree with their grammatical subject in Number and Gender, and in Past and Future also in Person. A key facet of this study, as detailed in § 3 below, is the fact that in Hebrew, children's early verbs fail to manifest any such Agreement. This can be accounted for as due to either omission of obligatory inflectional markers or occurrence of unanalyzed, rote-learned inflectional affixes.

In the present analysis, children's use of verb inflection is considered **productive** only when the affixes in their speech output are appropriate to the Subject-Verb agreement context in which they occur, hence are not merely rote-learned unanalyzed forms (Lustigman 2012). Importantly, this criterion for productivity does not require that **all** verbs be affixed correctly. In fact, omission of required inflectional marking in early Hebrew verbs is common over a relatively prolonged period of time, extending into the period when inflections begin to occur productively. In other words, productive use of inflectional affixes does not mean that all possible verb inflections are correctly assigned in every case but, rather, that children no longer rely on unanalyzed affixed forms.

By applying this criterion, children's verb-usage falls into two developmental phases: Phase I, in which no productive inflections are identified, including only non-affixed "bare stems" and unanalyzed affixed forms—as detailed in the following section; and Phase II, where productive inflectional affixation emerges.

2.2.2. Coding Categories

Because of the productivity criterion defined above, all verb forms were initially (in Phrase I) either (1) "unanalyzed", in which case they might include external affixes, or (2) "bare stems" lacking in external affixes. Inflectionally affixed forms (3) emerged later (in Phase II).

Unanalyzed forms or "amalgams" (MacWhinney 1975) include mainly rote-learned high-frequency affixes as well as forms occurring in familiar routines like songs and games, or immediate repetitions of input forms. These were all grouped together without further discussion, since it is not clear what type of inflectional knowledge (if at all) such forms reflect.

Bare-stem forms include three classes of items, two of which are not adult-like in form and so are defined as "truncated". (i) **Opaque** truncated bare stems cannot be assigned a clear target form. This is typically due to inflectional opacity; for example, the truncated stem *tapes* can stand for either *letapes* 'to-climb', *metapes* 'is-climbing', or *yetapes* 'will-climb'. In some cases, this is also compounded by derivational opacity; for example, the truncated stem *nadned* is not only inflectionally opaque (similarly to the earlier example of *tapes*), it is also ambiguous as between two lexemes: transitive *lenadned* 'to-push (someone on a) swing' and intransitive *lehitnadned* 'to-swing (oneself)'. An even more marked type of lexical opacity occurs when the target lexeme is unclear, e.g. *pes* could be the bare stem of the verb *lexapes* 'to-look-for' as well as *letapes* 'to-climb'. The *binyan* verb-pattern plays a crucial role in determining the level of opacity of verb stems, since some patterns exhibit more allomorphy in stems in switching between Tenses. Compare, for example, ***metapes*** 'is-climbing' and ***yetapes*** 'will-climb' in P3 that share the same stem; with ***potéax*** 'is-opening' and ***yiftax*** 'will-open' in P1 that have distinguishable stems and as such allow less opacity. (ii) Truncated **Infinitival** stem-forms are a second class of truncated bare stems. These occur uniquely in Infinitives, but without the obligatory *lV* prefix—for example, the form *tóax* has only one possible target—*liftóax* 'to-open'. (iii) **Adult-like** stems that are non-truncated forms—in the shape of Past or Present tense verbs, restricted to 3rd Person (in Past tense, and irrelevant in Present), Masculine, Singular. These are sometimes taken as the morphologically least marked verb forms in the language, since they have no external affixes, and so can be used as "citation forms" (e.g. Berman 1997, 2003a). Examples from the data-base of each of these three types of bare stems include the following realizations of the verb-root *y-š-n* in the P1 *qal* morphological pattern yielding the lexeme 'sleep': (a) opaque *šan* [SR 1;7], which could be interpreted as either Past 3rd Masculine Singular *yašan* 'slept, was sleeping' or as Hortative or Future 1st Person Plural *nišan* 'let's sleep', as Imperative or Future 2nd Person Masculine Singular *tišan* '(you will) sleep!', or even Future 3rd person Masculine Singular *yišan*; (b) Infinitival *šon* [LR 1;9] for Infinitival *lišon* 'to-sleep'; and (c) Adult-like Present Tense Masculine Singular *yašen* [RM 1;11] 'sleep(s), is-sleeping'.

Inflectionally Affixed Forms were specified for clearly inflected verbs with an unambiguous inflectional and lexical target, even in cases where they were not adult-like. Occurring only from Phase II on, these include the form *šena* [SR 1;9], for example, which even though truncated, had a clear target—*yešena* 'is-sleeping+Fm'. Both truncated and adult-like affixed forms were coded for inflectional category, and classified either as Infinitives (marked by an *lV*- prefix), *Benoni* (all externally affixed present-tense forms), Past Tense, or Other, including mainly affixed Imperatives or Future and occasional Passive Participles or resultative adjectives (Berman 1994).

3. Results and Analysis

Table 2 displays the breakdown of the three types of bare stems out of the total verbs used by each child in Phase I.

Table 2: Distribution of verb forms during Phase I.

Child			SR		LR		RM	
Age			1;4.17–1;8.10		1;5.19–1;11.14		1;3.20–2;0.16	
Total Verb forms			**184**		**674**		**415**	
Bare stems	Truncated	Opaque	77	(42%)	248	(37%)	245	(59%)
		Inf. stem	11	(6%)	44	(7%)	47	(11%)
	Adult-like Past/Pres		75	(41%)	130	(19%)	43	(10%)
	Total bare stems		**163**	**(89%)**	**422**	**(63%)**	**335**	**(81%)**
Unanalyzed			21	(11%)	252	(37%)	58	(14%)
Infinitives			–		–		22	(5%)

All three children show a clear preference for bare stems in their early verb usage, in line with findings from smaller samples of data from five other Hebrew-acquiring children (Berman and Armon-Lotem 1996, Armon-Lotem and Berman 2003). The rest of the Phase I verbs in the sample were unanalyzed affixed forms. These include (typically truncated) Feminine-marked forms like *lélet* for *mištolélet* 'goofing-off' (cf. masculine *mištolél*) or *ca* for *roca* 'wants' (cf. masculine *roce*). Even more clearly rote-learned, hence unanalyzed forms are Feminine Imperative *tíni* [SR] or *gíli!* [LR] for *tni li* 'give+Fm me' (cf. masculine *ten li*), and Present tense *tora* for *at ro'a* 'you(Fm) see+Fm' (cf. Masculine *ro'e*), *lósa* for *lo roca* 'don't want'—all instances of amalgam-like forms of verbs "fused" with a following or preceding pronoun or negator. RM, whose Phase I was longer than that of the other two children, did make relatively wide use of *lV*-infinitives (22 occurrences), but only towards the end of her Phase I (from age 1;11.18), eight months after her first verbs.

In children's Phase I verb-usage, then, non-finiteness is realized by bare stems. As argued further below, these reflect sensitivity to Hebrew verb-structure, in the form of children's preference for stems over externally affixed forms, demonstrated, inter alia, by their initial avoidance of the *lV-* infinitive-marking prefix. As argued in Adam and Bat-El (2008), the phenomenon of bare verb forms cannot be attributed purely to phonological constraints, or in particular to omission of unstressed inflectional affixes, since during the same developmental period, children produce many di- and even trisyllabic (non-verbal) forms that correspond to the relevant target words, some of which include unstressed inflectional affixes (e.g. *táktorim* for the plural noun *tráktor-**im*** 'tractors' [SR 1;7]; *ugiyá* 'cookie' [LR 1;9]).

In the months following Phase I, all children continue to use the three types of bare stems identified earlier, but these are increasingly supplemented by productive affixed verb forms like those in Table 3, and other verb-like modal operators (e.g. *carix* 'must, should' [SR 1;10]) and Imperatives (e.g. *léx-i* 'go+FmSg!' [LR 2;1]).

(1) Productive affixation (in the months following Phase I)

a. *lV-* prefixed infinitives
li-špox 'to-spill' [RM 2;1]
b. Affixed *benoni* 'intermediate' non-tensed Present participial forms
me-taps-im 'climbing+Pl' [SR 2;0], *me-saxék-et* 'is-playing+Fm' [LR 2;4]
c. Affixed Past tense forms
kan-ta 'bought+FmSg' [RM 2;1]

The distribution of verb forms in Phase II is specified in Table 3.

Table 3: Distribution of verb forms during Phase II

Child			**SR**		**LR**		**RM**	
Age			1;8.17–2;0.00		1;11.15–2;2.30		2;0.30–2;03.29	
Total Verb forms			**504**		**811**		**1009**	
Bare stems	Truncated	Opaque	150	(30%)	101	(12%)	245	(25%)
		Inf. stem	8	(1.5%)	7[a]	(0.9%)	65	(6%)
	Adult-like Past/Pres		136	(27%)	134	(17%)	96	(9.5%)
	Total bare stems		**294**	**(58%)**	**242**	**(30%)**	**406**	**(40%)**
Affixed forms	**Infinitive**		**107**	**(21%)**	**161**	**(20%)**	**119**	**(12%)**
	benoni		**65**	**(13%)**	**229**[b]	**(28%)**	**264**[b]	**(26%)**
	Past		28	(6%)	81	(10%)	163[c]	(16%)
	Others		10	(2%)	98	(12%)	57	(6%)

a. Including one construction of *roca* 'want(Fm)' + Infinitival stem
b. Uses of roce/roca 'want' with Infinitives were not included as benoni forms, so as not to "inflate" the percentage of benoni forms in the data.
c. The bulk (103) in 1st Person Singular, on accomplishment type verbs

The total number of verbs used by all three children in Phase II is far higher than in Phase I (Table 2), indicating relatively less reliance on non-predicating utterances and/or non-lexical (copular) predicates (Dromi and Berman 1986, Berman and Slobin, 1994). Use of truncated forms drops sharply (from around half to around a quarter of all verbs), while prefixed Infinitives account for 12% to 21% of all verb forms, in various, mainly irrealis, functions.

(1) Prefixed infinitives (Phase II)

lo lipol! 'not to-fall = don't fall!' [SR 1;9 commanding his doll not to fall]
ma la'asot? 'what to-do = what should I/we do?' [LR 2;0]
leorid ta-na'aláyim 'to-take-off shoes' [RM 2;0 asking her mom to take off her shoes]

Phase II also shows an increase in Adult-like Past and Present verb-forms, most markedly in SR's usage (including unmarked masculine self-reference). Phase II thus manifests largely productive rather than unanalyzed or rote-learned use of inflectional affixes, including emergence of *lV-* infinitives.

Importantly, in both phases, the children used non-finite verb forms not only in isolation, but also in phrase- and clause-level combinations, including: Subj+Verb combinations (e.g. *Kuki šon* 'Kuki sleep' [LR 1;9]), Verb+Obj (e.g. *cayer máyim* 'draw water' [RM 2;0]), Verb+Adv (e.g. *torer odpam* 'wake-up again' [SR 1;9]), and combinations of a verb with two or more elements (e.g. *ma (a)ta xel a-(s)farim?* 'what (=why) you eat the-books?' [LR 2;0], *sukarya ten Shachar* 'candy give *Shachar*' [SR 1;8]). This fact has implications for the interrelation between verb morphology and early syntax, as discussed below.

4. Discussion

A clear generalization emerging from this study is that Infinitives, obligatorily marked in Hebrew by *lV-* prefixes, fail to occur in the initial verb repertoire of Hebrew-speaking children. In fact, several months elapse before such forms surface in their speech output. Yet the bulk of children's verb forms in this period can be defined as "non-finite", since they lack the inflectional marking required by Hebrew verbs. In other words, non-finiteness in early child Hebrew (and, it will be argued, possibly in other languages, too) does not start out with Infinitives.

Instead, children at first use non-affixed stem-like forms, with the choice of what constitutes a "verb stem" governed by the structural options of their language. In Hebrew, in marked contrast to a language like English, these are typically not forms that occur as verbs in the adult language, yet they are not a mere epiphenomenon, but a robust occurrence in early Hebrew child language. Since they are non-adult-like, they are child-constructed in surface form; and, since their target forms are often ambiguous or non-distinct, they are available for use in a variety of word-combining syntactic contexts. Moreover, they reveal sensitivity to structural facets of verb-formation in Hebrew: They typically conform to the syllabic structure of one of the five prosodic templates of the *binyan* system of verb-pattern morphology; and they consistently involve truncation of external affixes (both prefixes and suffixes), while preserving the stem consonants, so revealing sensitivity to morpheme boundaries (Adam and Bat-El 2008). That is, although the verb-stems of early Hebrew do not involve paradigmatic inflection (and in this they differ from the later-emerging Infinitives), they do reflect sensitivity to structural constraints on verb-formation in the language.

The second phase of the children's verb usage demonstrated initial productive use of inflectional affixes, gradually (but not completely) replacing bare stems (see also Bat-El this volume). These inflected forms were mainly Infinitives and *benoni* verbs, followed by Past Tense and Imperative/Future forms. As argued in Lustigman (2012), the favoring of infinitival and *benoni* forms can be attributed to the "neutral" pragmatic and grammatical status of these two categories.

Infinitives, as morphologically invariant and semantically multifunctional forms serving a range of irrealis functions (imperatives, prohibitions, conditionals, subjunctives), enable Hebrew-acquiring children to express various non-reportative communicative functions; while the Hebrew-specific *benoni* 'intermediate' category serves to express both immediate and extended Present as well as participial functions, and is also structurally neutral, inflected only for Number and Gender—like Nouns and Adjectives—but, unlike verbs in Past and Future, not for Person, hence definable as "non-tensed" (Berman 1978). Infinitives and *benoni* forms thus provide Hebrew-acquiring children with typologically well-motivated, yet not fully finite means of transition to adult-like productivity in verb inflection.

As noted in the introduction, the co-existence of inflected alongside non-finite forms of verbs, sometimes even of the same lexeme, is accounted for in RI analyses by the "optionality" of functional categories in child language, whether as represented in their grammar or realized on the surface (Wexler 1993, Wijnen 1998). Hebrew's rich system of verb inflections makes it more like Spanish or Italian than English or Dutch. Moreover, since their language lacks auxiliary verbs, Hebrew-speaking children are not exposed to "compound finite" strings resulting from Aux-inversion, such as *daddy go*. The fact that they rely on non-finite forms over a relatively long period thus cannot be accounted for by either parameter-setting or statistical learning based on the input language (Yang 2002, Freudenthal et al. 2006, 2010, Legate and Yang 2007).

Rather, the view taken here is that children's linguistic knowledge develops incrementally and is characterized by a "long developmental route" in acquisition of grammatical structures (Berman 1986, 2004). In the domain of verb structure, it is argued here that non-finiteness evolves in two phases, of bare stems and of initial inflection, reflecting a shift from broad morphophonological sensitivity to target-language verb structure (in Phase I) to paradigmatically motivated preferences for grammatically constrained inflectional categories (Phase II). This suggests that the use of optional RIs—at a time when children use non-finite forms alongside tensed verbs in contexts that require finite marking—might be explained as reflecting a more general type of "transitional" phenomenon. In the case in point, the transition from stems to externally affixed forms reveals an **interim** level of knowledge, defined by developmentally oriented approaches as a phase in which grammatical (as well as other types of) representations have not yet established (Karmiloff-Smith, 1979, 1986, Berman 1986, 2004).

The typology of the ambient language affords Hebrew-acquiring children a variety of options in selecting non-finite verb forms, even though—or possibly just because—their inflectionally rich language, while lacking in an unequivocal base form of verbs, opens up to them a range of "multi-functional" stems.

Hebrew is thus a case where forms classified as "non-finite" (in that they lack tense-marking) can be broken down into a more fine-grained and gradual process of acquisition, where different factors shape children's early verbs at different phases of knowledge.

In cross-linguistic perspective, generalizations derived from this Hebrew-based study may have implications for how non-finite verb forms are integrated into early grammar in general. A marked language-specific impact accounts for initial non-finite stem forms in Hebrew, both those that mirror and those that diverge from target forms. Other languages, too, lack an unequivocally unmarked base form of verbs like English *cry, eat*, or *open*. Some RI analyses propose that children acquiring such languages rely heavily on infinitival forms in their early verb usage in "RI languages" like Dutch or German (e.g. Wijnen 1998), or else they skip a non-finite RI stage, using inflected forms right from the start, as in Spanish or Italian (e.g. Rizzi, 1993/1994). While detailed analysis of relevant samples in various languages lies beyond the scope of the present study, an initial examination of phonetically transcribed and morphologically coded data from other languages suggests that, in fact, children acquiring both types of languages, like their Hebrew-acquiring peers, rely on stem-like forms in their initial verb output.

English constitutes a special case in terms of early verb grammar, since it provides children with an adult-like stem form in the shape of the base form of verbs. English-acquiring children thus have ready resort to such forms; however, since adults' English also includes numerous non-inflected verbs, base forms of verbs in themselves fail to provide evidence for children's knowledge of inflection. Early verbs in **French** are also disregarded here, since the fact that the Infinitive-marking final *-r* is not pronounced creates opacity as to whether forms are inflectionally affixed or not.

The verbal paradigm of **Arabic** is similar to that of Hebrew, since Arabic verbs are also formed in a larger set of similarly constrained morphological verb-patterns, although Arabic lacks a form corresponding to the infinitive of Hebrew and European languages. In her study of three children acquiring Kuwaiti Arabic, Aljenaie (2010) shows that they all used what she termed a "default form" in the shape of a truncated imperfective bare stem (e.g. *tiiħ* instead of *it-tiiħ* 'falls/will-fall') along with the non-affixed 3rd Person Masculine Singular Past form (e.g. *raaħ* 'went').

Examination of early **Spanish** verb forms from the Ornat and Aguirre corpora on CHILDES (http://childes.psy.cmu.edu/data) indicates that many forms in children's speech analyzed as Infinitival (on the %mor tier) were in fact truncated stem-like forms lacking the adult infinitival *r*-final suffix (e.g. *bubí* for *subír* 'go down', *tomá* for *tomar* 'take'). In two months (ages 1;7–1;9) of verb productions by the girl Maria in the Ornat corpus, 30 out of 43 verb forms (70%) took the form of non-affixed stems, ambiguous between (at least) 3rd Person Singular and infinitival forms without the infinitival *-r* suffix. For example, *apa* [Maria 1;8] could stand for either *tapar* 'to-cover' or *tapa* 'covers', *aca* [Maria 1;7] for either *secar* 'to-dry' or *seca* 'dries', while the form *ven* [Maria 1;8] could be the stem of several paradigms of the verb *venire* 'to-arrive'. The same pattern of preference for non-fully affixed stems were observed for **Italian** verbs in the Antelmi corpus on CHILDES: Out of 49 verb forms of the girl Dian, between ages 1;8–1;10, 14 appeared rote-learned (e.g. *vóio* for *vóglio* 'want+1stSg' [Dian 1;8]), another 8 appeared to be inflectionally affixed (e.g. *levo* 'take-off+1stSg', *puscisce* for *pulísce* 'cleans'), while over half (27 =55%) were ambiguous truncated stems (e.g. *tude* for *chiúdere* 'to-close' or *chiúde* 'closes' [Dian 1;8], *mangia* for either *mangiáre* 'to-eat' or *mángia* 'eats' [Dian 1;10], *piange* for either *piángere* 'to-cry' or *piánge* 'cries' [Dian 1;10]).

Hyams (2005) suggests that children acquiring **Greek**, a language that has no infinitival form, use "bare perfective" forms as their early verbs (e.g. *pezi* 'play', *kupisi* 'wipe'). Such forms are ambiguous between bare participles (lacking a required auxiliary) and bare 3rd Person Singular perfective verbs (lacking the obligatory Tense/Modal morphology). As such, these may also be considered juvenile stem-like forms that are not fully specified in terms of their inflectional features. Relatedly, a look at early **Dutch** verbs from the Schaerlaekens corpus on CHILDES, revealed that 11 of the 12 verbs used in a single session [Arnold 1;10] were either in the form of truncated Infinitives, without the infinitival suffix *-en* (e.g. *insteke* for *instéken* 'insert', *pele* for *spélen* 'play', *ompappe* for *omláppen* 'lap') or of adult-like stems (e.g. *bijt* 'bite', *pak* 'take')

These cross-linguistic observations combine with the Hebrew-specific analysis to shed fresh light on the issue of non-finiteness in early child language in general. The findings presented here indicate that in their early verb usage, children acquiring quite different languages are guided by an initial preference for **stem-like forms**, with the particular type of stem they adopt depending on the target language. In English, where stems are available in the input, children will use them "as is" as their non-finite early forms. In languages like Spanish, Italian, Greek, Arabic, or Hebrew and, to some extent, Dutch, children will use truncated bare stems along with available adult-like non-affixed stem-forms (typically 3rd Person Masculine Singular). Importantly, in Hebrew, once prefix-marked infinitive forms occur (in Phase II), they are nearly always used appropriately from the point of view of the ambient language. More extensive investigation of a larger database in different languages should reinforce the present Hebrew-based proposals on the nature and role of "non-finiteness".

Children's use of bare stems as a general strategy for breaking into the verb system across languages provides further evidence for the transition from "child-speaker" to "native speaker" (Slobin 1990, Berman 1993). Reliance on stem forms constitutes a juvenile feature of early language use that, across different languages, interacts with children's concurrent attentiveness to the structural specifics of the ambient language, such as types of stems, stem allomorphy, and location of affixes. Further, as early as Phase I, stem forms occur not only in isolation, but also in combination with other clausal elements (as appears to be the case in the other language samples, too). The fact that syntagmatic combination precedes productive paradigmatic inflection means that non-finiteness plays a role not only in breaking into verb-internal morphology, but also in early phrase- and clause-structure. The structural, and often also semantic, non-distinctiveness of non-finites (here, bare stems, infinitives, and present-tense) qualifies them uniquely for use in a range of syntactic contexts, conferring on "non-finiteness" a pervasive role as a possibly necessary feature of early child language.

References

Adam, Galit and Outi Bat-El. 2008. Morphological knowledge without morphological structure. In ed. S. Armon-Lotem, G. Danon, and S. Rothstein (eds), *Current Issues in Generative Hebrew Linguistics*, 197–222. Amsterdam: John Benjamins.

Aljenaie, Khawla. 2010. Verbal inflection in the acquisition of Kuwaiti Arabic. *Journal of Child Language* 37:841–863.

Armon-Lotem, Sharon. 1996. What Hebrew early verbs teach us about root infinitives. In C. Koster and F. Wijnen (eds), *Proceedings of the Groningen Assembly on Language Acquisition*, 77–86. Netherlands: Centre Language and Cognition, Groningen.

Armon-Lotem, Sharon. 2006. Subject use and the acquisition of verbal agreement in Hebrew. In N. Gagarina and I. Gülzow (eds), *The Acquisition of Verbs and their Grammar: The Effect of Particular Languages*, 45–70. Dordrecht: Springer.

Armon-Lotem, Sharon and Ruth A. Berman. 2003. The emergence of grammar: Early verbs and beyond. *Journal of Child Language* 30: 845–878.

Bat-El, Outi. 2002. Semitic verb structure within a universal perspective. In J. Shimron (ed.), *Language Processing and Acquisition in Languages of Semitic, Root-based, Morphology*, 29–59. Amsterdam: John Benjamins.

Bat-El, Outi. this volume. Phonological constraints on morphological development: The acquisition of Hebrew verb inflectional suffixes.

Berman, Ruth. 1978a. *Modern Hebrew Structure*. Tel Aviv: University Publishing Projects.

Berman, Ruth. 1978b. Early verbs: How and why a child uses her first words. *International Journal of Psycholinguistics* 5:21–29.

Berman, Ruth. 1982. Verb-pattern alternation: The interface of morphology, syntax, and semantics in Hebrew child language. *Journal of Child Language* 9:169–191.

Berman, Ruth. 1985. Acquisition of Hebrew. In D. Slobin (ed.), *Crosslinguistic Study of Language Acquisition* v. 1, 255–371. Hillsdale, NJ: Erlbaum.

Berman, Ruth. 1986. A step-by-step model of language learning. In I. Levin (ed.), *Stage and Structure: Re-opening the Debate*, 191–219. Norwood, N.J: Ablex.

Berman, Ruth. 1990. Acquiring an (S)VO language: Subjectless sentences in children's Hebrew. *Linguistics* 28:1135–1166.

Berman, Ruth. 1993. Developmental perspectives on transitivity: A confluence of cues. In Y. Levy (ed.), *Other Children, Other Languages: Issues in the Theory of Acquisition*,189–241. Hillsdale, NJ: Erlbaum.

Berman, Ruth A. 1994. Formal, lexical, and semantic factors in the acquisition of Hebrew resultative particles. In S. Gahl, A. Dolbey, and K. Johnson, *Papers from the 20th Annual Meeting of the Berkeley Linguistic Society*, 82–92. Berkley, CA: Berkley Linguistics Society.

Berman, Ruth A. 1997. Israeli Hebrew. In R. Hetzron (ed.), *The Semitic Languages*, 312–333. London: Routledge.

Berman, Ruth A. 2003a. Modern Hebrew, revised version. In B. Comrie (ed.), *Languages of the World*, 118–123. Oxford International Encyclopedia of Linguistics, rev. ed. Oxford University Press.

Berman, Ruth A. 2003b. Children's lexical innovations: Developmental perspectives on Hebrew verb-structure. In J. Shimron (ed.), *Language Processing and Language Acquisition in a Root-based Morphology*, 243–291. Amsterdam: John Benjamins.

Berman, Ruth A. and Sharon Armon-Lotem. 1996. How grammatical are early verbs? In C. Martinot (ed.), *Annales Littéraires de l'Université de Franche-Comté: Actes duColloque International sur l'Acquisition de la syntaxe*, 17–60.

Berman, Ruth A. and Esther Dromi. 1984. On marking time without aspect in child language. *Papers and Reports on Child Language Development* 23:21–32.

Berman, Ruth A. and Dan I. Slobin. *Relating Events in Narrative: A Crosslinguistic Developmental Study*. Hillsdale: Erlbaum.

Blom, Elma. and Frank Wijnen. 2000. How Dutch children's root infinitives become modal. In C. Howell, S. Fish and T. Keith-Lucas (eds), *Proceedings of the 24th Annual BUCLD*. Medford, MA: Cascadilla Press.

Bolozky, Shmuel. 1986. Semantic productivity and word frequency in Modern Hebrew verb formation. *Hebrew Studies* 27:38–46.

Borer, Hagit and Kenneth Wexler. 1992. Bi-unique relations and the maturation of grammatical principles. *Natural Language and Linguistic Theory* 10: 147–189.

Brown, Roger. 1973. *A First Language: The Early Stages*. Cambridge, MA: Harvard University Press.

Bybee, Joan. 1995. Regular morphology and the lexicon. *Language and Cognitive Processes* 10:425–455.

Clark, Eve and Ruth Berman. 2004. Acquiring morphology. In G. Booij, C. Lehmann, and J. Mugdan, *Morphology Handbook on Inflection and Word Formation*, 1795–1805. Berlin: Mouton de Gruyter.

Dressler, Wolfgang and Annemarie Karpf. 1995. The theoretical relevance of pre- and proto-morphology in language acquisition. In G. Booij and J. van Marle (eds), *Yearbook of Morphology*, 99–122. Dordrecht: Kluwer Academic Publishers.

Dressler, Wolfgang, Marianne Kilani-Schoch, and Sabine Klampfer. 2003. How does a child detect morphology? Evidence from production. In H. Baayen and R. Schreuder (eds), *Morphological Structure in Language Processing*, 391–425. Berlin: Mouton de Gruyter.

Dressler, Wolfgang, Willi Myerthaler, Oswald Panagl, and Wolfgang. Wurzel (eds). 1987. *Leitmotifs in Natural Morphology*. Amsterdam: John Benjamins.

Dromi, Esther and Ruth Berman. 1986. Language-general and language-specific in developing syntax. *Journal of Child Language* 14:371–387.

Freudenthal, Daniel, Julian Pine, and Fernand Gobet. 2006. Modelling the development of children's use of optional infinitives in Dutch and English using MOSAIC. *Cognitive Science* 30:277–310.

Freudenthal, Daniel, Julian Pine, and Fernand Gobet. 2010. Explaining quantitative variation in the rate of optional infinitive errors across languages: A comparison of MOSAIC and the Variational Learning Model. *Journal of Child Language* 37:643–669.

Gathercole, Virginia C. Mueller, Eugenia Sebastián, and Pilar Soto. 2002. The emergence of linguistic person in Spanish-speaking children. *Language Learning* 52:679–722.

Goldfajn, Tal. 1998. *Word Order and Time in Biblical Hebrew Narrative*. New York: Oxford University Press.

Haegeman, Lliane. 1995. Root infinitives, tense, and truncated structures in Dutch. *Language Acquisition* 4:205–255.

Hatav, Galia. 1997. *The Semantics of Aspect and Modality: Evidence from English and Biblical Hebrew*. Amsterdam: John Benjamins.

Hoekstra, Teun and Nina Hyams. 1998. Aspects of root infinitives. *Lingua* 106:81–112.

Hyams, Nina. 1986. *Language Acquisition and the Theory of Parameters*. Dordrecht: Reidel.

Hyams, Nina. 2005. Child non-finite clauses and the mood-aspect connection: Evidence from child Greek. In P. Kempchinsky and R. Slabakova (eds), *Aspectual Inquiries*, 293–315. Dordrecht: Academic Publishers.

Karmiloff-Smith, Annette. 1979. *A Functional Approach to Child Language*. Cambridge: Cambridge University Press.

Karmiloff-Smith, Annette. 1986. Stage/structure versus phase/process in modeling linguistic and cognitive development. In I. Levin (ed.), *Stage and structure: reopening the debate*, 164–190. New York: Ablex.

Legate, Julie Anne and Charles Yang. 2007. Morphosyntactic learning and the development of tense. *Language Acquisition* 14:315–344.

Lustigman, Lyle. 2012. Developing structural specification: Productivity in early Hebrew verb usage. *First language*. DOI: 10.1177/0142723711426828.

MacWhinney, Brian. 1975. Rules, rote, and analogy in morphological formation by Hungarian children. *Journal of Child Language* 2:65–77.

MacWhinney, Brian. 2005. *The CHILDES Project: Tools for Analyzing Talk 1: The Format and Programs* (3rd edition). Mahwah, NJ: Erlbaum.

Ninio, Anat. 1999a. Model learning in syntactic development: Intransitive verbs. *International Journal of Bilingualism* 3:111–131.

Ninio, Anat. 1999b. Pathbreaking verbs in syntactic development and the question of prototypical transitivity. *Journal of Child Language* 26:619–653.

Ninio, Anat. 2001. Pragmatic keywords and the first combining verbs in children's speech. *First Language* 21:433–460.

Phillips, Colin. 1996. Root Infinitives are finite. In A. Stringfellow, D. Cahana-Amitay, E. Hughes, and A. Zukowski (eds), *Proceedings of the 20th Annual BUCLD*, 588–599. Somerville, MA: Cascadilla Press.

Phillips, Colin. 2010. Syntax at age two: Cross-linguistic differences. *Language Acquisition* 17:70–120.

Pizzuto, Elena, and Maria Caselli. 1994. The acquisition of Italian verb morphology in a cross-linguistic perspective. In Y. Levy (ed.), *Other Children, Other Languages: Issues in the Theory of Language Acquisition*, 137–187. Hillsdale, NJ: Erlbaum.

Poeppel, David and Kenneth Wexler. 1993. The full competence hypothesis of clause structure in early German. *Language* 69:1–33.

Ravid, Dorit. 1997. Early morphological development a duo: Pre- to protomorphology in Hebrew-speaking twins. *Papers and Studies in Contrastive Linguistics* 33: 79–102.

Ravid, Dorit. 2008. The emergence of the verb category in Hebrew-acquiring children: A new psycholinguistic perspective. A paper presented at a conference on brain and language, Bar-Ilan University, Ramat-Gan [in Hebrew].

Rizzi, Luigi. 1993/1994. Some notes on linguistic theory and language development: The case of root infinitives. *Language Acquisition* 3:371–393.

Rizzi, Luigi. 1994. Early null subjects and root null subjects. In T. Hoekstra and B. Schwartz (eds), *Language Acquisition Studies in Generative Grammar*, 151–176. Amsterdam: John Benjamins.

Schaeffer, Jeannette and Dorit Ben-Shalom. 2004. On root infinitives in child Hebrew. *Language Acquisition* 12:83–96.

Schwarzwald, Ora. 1981. *Grammar and Reality in the Hebrew Verb*. Ramat Gan: Bar-Ilan University Press [in Hebrew].

Schwarzwald, Ora. 1996. Syllable structure, alternations and verb Complexity: The Modern Hebrew verb patterns reexamined. *Israel Oriental Studies* 16:99–112.

Schwarzwald, Ora. 2002. *Hebrew Morphology*. Tel Aviv: The Open University [in Hebrew].

Slobin, Dan. 1990. The development from child speaker to native speaker. In J. Stigler, R. Shweder, and G. Herdt (eds), *Cultural psychology: Essays on comparative human development*, 233–256. Cambridge: Cambridge University Press.

Theakston, Anna and Elena Lieven. 2008. The influence of discourse context on children's provision of auxiliary *be*. *Journal of Child Language* 35:129–158.

Tomasello, Michael. 2003. *Constructing a Language: A Usage-based Theory of Language Acquisition*. Harvard University Press.

Uziel-Karl, Sigal. 2002. *A Multidimensional Perspective on the Acquisition of Verb-Argument Structure*. Ph.D. dissertation, Tel-Aviv University. Tel-Aviv.

Weist Richard, HannaWysocka, Katarzyna Witkowska-Stadnik, Ewa Buczowska, and Emilia Konieczna. 1984. The Defective Tense Hypothesis: On the emergence of tense and aspect in child Polish. *Journal of Child Language* 11:347–374.

Wexler, Kenneth. 1993. Optional Infinitives, Head Movement and the Economy of Derivations in Child Grammar. In D. Lightfoot and N. Hornstein (eds), *Verb Movement*, 305–382. Cambridge: Cambridge University Press.

Wexler, Kenneth. 1998. Very early parameter setting and the unique checking constraint: A new explanation of the optional infinitive stage. *Lingua* 106:23–79.

Wijnen, Frank. 1998. The temporal interpretation of Dutch children's root infinitivals: The effect of eventivity. *First Language* 18:379–402.

Wittek, Angelika and Michael Tomasello. 2002. German children's productivity with tense morphology: The Perfekt. *Journal of Child Language* 29:567–590.

BAALL
BRILL Brill's Annual of Afroasiatic Languages and Linguistics 4 (2012) 232–251 brill.com/baall

The Assignment of Gender in L2 Hebrew: The Role of the L1 Gender System

Sharon Armon-Lotem and Orit Amiram
Department of English, Bar-Ilan University
sharon.armon-lotem@biu.ac.il and oritile@gmail.com

Abstract
Grammatical gender poses a serious problem to second language (L2) learners as well as to proficient speakers of L2. This paper tests what contributes to this difficulty in L2 Hebrew. Gender identification in the absence of lexical information was tested for 30 Hebrew L2 learners and 20 Hebrew near-native speakers whose L1 has gender morphology, e.g. Russian, or not, e.g. English, as well as 10 adult native speakers of Hebrew. The participants were tested on assigning grammatical gender to novel animate nouns in Hebrew. The findings show that difficulties are due to L1 interference, by indirect reliance on L1 strategies in determining gender for novel animate nouns in L2, rather than access to Universal Grammar or across the board reliance on native adult strategies.

Keywords
agreement; grammatical gender; morphology; second language acquisition; Hebrew

1. Introduction

Hebrew grammatical gender poses a problem to second language (L2) learners as well as to L2 proficient speakers, but not to first language (L1) acquirers. Native speakers of languages that have morphological gender and speakers of languages that do not have morphological gender, all find it difficult to use gender when acquiring Hebrew as a second language. This paper aims at clarifying what contributes to this difficulty. How does natural gender interact with morpho-phonological gender in determining the grammatical gender of nouns in L2? Do L1 features which are transferred into L2 influence L2 learners in acquiring this system, or is it all about learning individual lexical items? Does Universal Grammar (UG) play any role in the process, and if so, what is this role? Can parameterized features be reset? As far as L1 acquisition is concerned, it has been found that in gender assignment to novel animate nouns young children rely on morpho-phonological cues. By contrast, adults, when tested in their L1, rely on semantic information (Amiram 2002, Karmiloff-Smith 1978, Levy 1980). Previous studies have found that adult L2 learners give priority to morphological

 DOI: 10.1163/18776930-00400011

cues over semantic ones, and tried to relate the problem and the findings to the degree of access to UG.

This study proposes that difficulties witnessed in the acquisition of gender in L2 Hebrew are due to L1 interference. L1 might influence gender assignment in L2 in two ways: (i) by direct transfer of lexical information for inanimate nouns, when the L1 has its own gender system, and (ii) by indirect reliance on L1 strategies in determining gender for novel animate nouns in L2. This study tests the latter way, proposing that in the absence of L1 lexical information (since novel nouns are involved), the strategy used for determining gender in L2 reflects the gender properties of L1: whether gender is an interpretable or an uninterpretable feature in L1. It is further proposed that interference is not necessarily of rote learned information marked in the lexicon, but influences the attention paid to the different cues. That is, L2 learners give priority to cues which are dominant in their L1, unlike children acquiring their first language who cannot rely on previous linguistic experience.

In order to test which cues are used by L2 learners when they cannot rely on L1 rote learned information, this study investigates how L2 Hebrew learners whose L1 has gender morphology, e.g. Russian, or not, e.g. English, determine the grammatical gender of novel [+animate] nouns in Hebrew. In other words, this study investigates whether, in their choice of grammatical gender, L2 learners rely on morpho-phonological information, like 2–3 year old children, on semantic information (natural gender), like adults and older children, or perhaps vary according to their L1. That is, this study aims to determine the degree to which L1 interferes in identifying the gender of nouns in L2 at the strategic level and the level at which this interference occurs.

The paper starts with a short presentation of gender in human languages, focusing on grammatical gender in Hebrew in comparison with Russian and English, followed by a discussion of the literature on gender assignment in L2 (§2). The experimental procedure (§3) and the findings from Hebrew L2 learners (§4) are then presented. Participants are divided according to the gender properties of their L1: to speakers whose L1 has gender as a classifying category for nouns and gender morphology, e.g. Russian, and speakers whose L1 does not have gender as a classifying category for nouns nor gender morphology, e.g. English. The knowledge of the Hebrew gender system is measured by the linguistic manipulation of novel [+animate] nouns. These findings are discussed and the crucial role of L1 in earlier and later stages of adult L2 acquisition is evaluated (§5).

2. Gender in Nouns

Many morphologically rich languages, such as Hebrew, Arabic, Russian, French, German, and Spanish, have an inherent gender system (see Ralli 2002). Morphologically rich languages demonstrate productive morphological processes (e.g. inflection, agglutination) which generate a large number of word forms for a given word stem. In these fusional languages, gender is a prominent part; an inherent feature which is manifested in most parts of speech. Alexiadou, Haegeman and Stavrou (2007) point out that while number can be chosen by the speaker, the value of gender cannot; it is a part of the lexical entry. Corbett (1991) suggests that in these languages gender serves as a noun classification system; once the noun has been selected, gender information is an integral part of its meaning, and other parts of speech syntactically agree with it. Gender assignment to [+animate] nouns, usually reflects semantic information, e.g. *a cow* is *she* but *a bull* is *he*, but there is no way in which gender assignment to [–animate] nouns can be captured semantically. Corbett generalizes that gender assignment to [–animate] nouns is either neuter (as in Germanic languages, which sort nouns along animate/inanimate division), or randomly marked as feminine or masculine in the lexicon (as in Hebrew, which sorts out nouns along the masculine/feminine division).

In Russian, the sorting is made both ways, generating a three-way system which distinguishes feminine, masculine and neuter. A Russian noun consists of a stem (with or without derivational morphemes) and an inflectional morpheme. In the nominative case, for example, nouns have either zero inflectional morpheme (in masculine nouns (e.g. *stol* 'table', *boj* 'fight') and in feminine nouns ending in soft "ь" (e.g. *dver'* 'door', *mysh'* 'mouse')); an inflectional morpheme /-a/ (mostly in feminine nouns; e.g. *knig-a* 'book', *gazet-a* 'newspaper'); or an inflectional morpheme /-o/ or /-e/ (in neutral nouns; e.g. *okn-o* 'window', *pol-e* 'field'). Nonetheless, once a noun is assigned a particular gender, its use in languages such as Hebrew and Russian is rule-governed.

In Hebrew and Russian, gender differences are usually manifested morphologically (e.g. by the coda of the noun) both in the singular and plural forms, and trigger agreement between the noun and other parts of speech within the sentence, such as adjectives, deictics, and verbs. In other languages with formal gender system, like French, German, or Yiddish there is a very partial morphological gender and the lexical knowledge is mostly memorized. Yet, in languages which do not have gender morphology, like English, natural gender distinctions, if found, are limited to some [+animate] nouns (e.g. *waitress*, *actress*, *seamstress* etc.) and the pronominal system referring to them, and are not marked in the morphosyntax of the language.

One possible account for this difference between grammatical gender as a rather arbitrary classification system, in which gender sub-divides nouns into sub-classes, and morpho-phonological gender as its rule governed spell out, is provided by Marantz (1997), for example. Marantz suggests a model of distributed morphology, where the gender feature is a property of N roots in the narrow lexicon, the set of lemmas, which is used by the computational system. On the other hand, the phonological and morphological forms are stored in the vocabulary which comprises the associations between sets of grammatical features and phonological features, and spells out the abstract features after the derivation. In Russian and Hebrew, the N root contains the gender feature making it interpretable, while in English it does not.

Yet, some researchers (e.g. Picallo 1991, Ritter 1993) assume that although gender is a feature of the head noun in all languages being part of the lexical entry, it is projected into a functional category, Gender Phrase, which makes syntactic agreement possible. The general mechanism of syntactic agreement (as presented in Chomsky 2000, 2001) requires that the nominal head is c-commanded by the category which agrees with it. Within this model, agreement is achieved when uninterpretable features of a verb or an adjective, which C-command a noun, are checked/valued by the interpretable features of the noun. This mechanism also applies to Hebrew. For noun-adjective agreement within the determiner phrase, the AP has to c-command the noun/NP at the stage when agreement occurs. For subject-verb agreement at the sentence level, T has to c-command the subject at the time in the derivation when agreement takes place, and then merge morphologically with the verb. The present study, however, did not test syntactic agreement but rather the availability of gender interpretable features to L2 learners of Hebrew.

In the process of language acquisition, the gender of nouns can be identified by morpho-phonological, syntactic, and semantic cues. Children acquiring the language initially memorize the gender of each noun, but soon discover the rules which govern it. When gender assignment is rule-governed, speakers can predict the gender of nouns on the basis of three potential indicators in their input. The first indicator is the morpho-phonological information coming from the morphology of the word, e.g. the ending of the word. The second is the syntactic information revealed by nominal agreement on determiners, verbs and adjectives. The third is the semantic information coming from a prototypical gender related appearance. On the other hand, in languages in which gender is not morphologically marked, such as English, gender assignment is relevant only to a limited number of categories, and the best indicator is the natural gender of [+animate] nouns, i.e., a semantic cue.

2.1. *Grammatical Gender in Hebrew*

Hebrew is an example of a language in which gender is a highly prominent feature in the classification of nouns. All nouns have grammatical gender, either masculine or feminine and agreement in gender is marked on most parts of speech (not including adverbs, the definite article, and some prepositions) as illustrated in (1):

(1)	a.	ha-yeled	ha-navon	mecayer	et	ha-bayit	shelo
		the-boy	the-clever.ms.sg.	draws.ms.sg	ACC	the-house	POSS.ms.sg.
		'The clever boy draws his house'					
	b.	ha-yalda	ha-nevona	mecayeret	et	ha-bayit	shela
		the-girl	the-clever.fm.sg.	draws.fm.sg.	ACC	the-house	POSS.fm.sg.
		'The clever girl draws her house'					
	c.	ha-yeladim	ha-nevonim	mecayrim	et	ha-bayit	shelahem
		the-boys	the-clever.ms.pl.	draw.ms.pl.	ACC	the-house	POSS.ms.pl.
		'The clever boys draw their house'					
	d.	ha-yeladot	ha-nevonot	mecayrot	et	ha-bayit	shelahen
		the-girls	the-clever.fm.pl.	draw.fm.pl.	ACC	the-house	POSS.fm.pl.
		'The clever girls draw their house'					

The morpho-phonological features of the noun's final syllable reflect its gender. Nouns ending in a stressed /-a/, /-it/, or an unstressed /-et/ or /-at/ are feminine and take an /-ot/ suffix for plural (e.g. *bubá* 'a doll'—*bubót* 'dolls', *karít* 'a cushion'—*kariyót* 'cushions', *rakévet* 'a train'—*rakavót* 'trains', *caláxat* 'a plate'—*calaxót* 'plates'). All other nouns are generally masculine and take /-im/ for plurality. Animate nouns show the full range of gender inflections (e.g. *xatúl* 'a cat ms.', *xatulá* 'a cat fm.', *xatulím* 'cats ms.' and *xatulót* 'cats fm.'). This morphophonological gender system is presented in Table 1.

Table 1: Gender and number morphology in Hebrew

Singular ending		Plural ending	
Masculine	**Feminine**	**Masculine**	**Feminine**
-Ø	-a	-im	-ot
	-at		
	-it		
	-et		

There are many rote learned exceptions to this morphologicaly based gender system, more with masculine than with feminine nouns. For example, *beicá* 'an egg', which is grammatically and morphologically feminine, but takes the masculine plural suffix /-im/ (*beicím* 'eggs') rather than the feminine plural /-ot/. On the other hand, *kir* 'a wall', which is grammatically and morphologically masculine, takes the feminine plural suffix /-ot/ (*kirót* 'walls') rather than the masculine plural suffix /-im/. Crucial in this context is Bat-El's (1997) observation that the plural suffix is not specified for gender but rather subcategorized for gender, as it does not change the gender of the base; e.g. the plural form *xalonot* 'windows' does not attract feminine agreement, although it ends with /-ot/, since its singular counterpart *xalon* 'window' is masculine. Yet, in some cases the morpho-phonological rule seems to be gender blind. A loan word like *goríla* is masculine in Hebrew despite its final vowel /-a/, but its plural, *gorílot*, follows the feminine plural rule. Likewise, a feminine noun with no feminine marking on the singular, like *pilégesh* 'concubine' has a plural *pilagshím*, following the masculine plural rule. These last two examples, demonstrate the strength of the morpho-phonological rule on the one hand, but at the same time point to a potential weakness is the system, since the morpho-phonological rule overrides the inherent gender of these two nouns. These exceptions do not undermine the claim that if the speakers choose /-im/ for a plural form they are assigning masculine gender to the noun, and if they choose /-ot/ they are assigning feminine gender to the noun, since these choices capture a generalization which applies to most nouns in Hebrew.

When encountering a novel [–animate] noun, the adult Hebrew speaker has to determine its gender in order to be able to use it properly. This can be done either based on the morpho-phonological features, or on the syntactic agreement with relating parts of speech, e.g. with a verb or an adjective. For [+animate] nouns, gender could also be identified by its semantic natural gender. This is also true when children acquire Hebrew as L1 or when adults and children acquire Hebrew as L2.

For the acquisition of gender in Hebrew as a first language, Berman's (1985) findings show that masculine is acquired before the morphologically marked feminine, in the singular and the plural. Berman (1981) and Levy (1983) point out that Hebrew speaking children first pay attention to the formal features of nouns when making gender assignment. Levy attributes the early acquisition of formal gender rules to the great reliability of formal rules in Hebrew and to the "surface rhyming phenomenon" which occurs with the plural and feminine inflection, e.g. *ha-yelad**ot** ha-ktan**ot** kofc**ot*** 'the little girls jump', or *ha-klav**im** ha-gdol**im** rac**im*** 'the big dogs run'. In acquiring noun-adjective agreement, for example, children move from lexical knowledge of the nominal-morphological system to syntactic knowledge of the structure where agreement applies, that is, from rote-learned knowledge to rule-based knowledge (Berman 1985).

Levy (1983) points out that phonological properties determining inflectional patterns are mastered during the early stages, that is, between 2 and 3 years of age. The children work out the formal distributional patterns and do especially well when those are systematic as in Hebrew. Children aged 2–3 seem not to take advantage of semantic features (emerging from the natural gender) of the noun. Amiram (2002) shows, however, that this is true in conflicting situations for plural formation, where children aged 2–3 rely on morpho-phonological information, and older children (4 and up) rely on semantic information. Yet, this is not the case for verbal agreement. There she found that children attend to semantic information coming from natural gender, rather than morpho-phonological information.

2.2. *Gender in L2 Acquisition*

White, Valenzuela, Kozlowska-Macgregor, and Leung (2004) report that the difficulties in gender assignment presented to L2 learners do not depend on the gender properties of L1. Both, native speakers of Spanish, that has grammatical gender, and native speakers of English, that does not, have difficulties with gender agreement in L2 French, after 1–2 years of exposure. More specifically, in an elicited production task, they showed difficulties with gender agreement on determiners and adjectives. Hawkins (1998) found that even proficient L2 French speakers, whose L1 is English, have problems with grammatical gender in these structures.

Difficulties in gender acquisition, it has been argued, are best explained by some level of transfer from L1. If the process of L2 acquisition involved full access (to UG) with no transfer (e.g. Flynn 1987), acquiring gender in L2 would be as easy as it is in L1 acquisition. However, if the process involves resetting of the values for the gender parameter transferred from L1 (as in the Full Transfer/Full Access hypothesis; Schwartz and Sprouse 1996) these difficulties are expected. Schwartz and Sprouse (1996) predict that at the onset of L2 acquisition, everything should transfer except the phonological form of the lexical entry.

Along this line, Carroll (1989) suggests that when a native speaker of a language that has grammatical gender learns another language with grammatical gender s/he might transfer the lexical content of an entry. In contrast, when a speaker of a language like English tries to acquire gender in L2, Carroll (1989) predicts failure in acquisition since gender feature is not lexically employed in the learner's L1.

Assuming some degree of transfer, the question is what transfers from L1; what "lexical content" is. Is it the knowledge that nouns should be assigned syntactic gender (as an interpretable feature), or perhaps the knowledge that syntactic agreement should hold between the noun and other parts of speech in a phrase or a sentence which carry uninterpretable agreement features?

Hawkins and Chan (1997) suggest in the Failed Functional Feature Hypothesis (FFFH), also referred to in the literature as the Representational Deficit

Hypothesis (Hawkins 2005) or the Interpretability Hypothesis (Tsimpli 2003), that adult L2 learners cannot acquire uninterpretable features which are not available in their L1. That is, when a speaker of a language with formal gender learns another language with formal gender we expect a successful acquisition, since gender is already a feature of the nouns in L1. But a speaker of a language like English, from which gender feature cannot be transferred, will find it very difficult to acquire the uninterpretable features on determiners and adjectives to achieve concord with the nouns.

Both Carroll (1989) and Hawkins and Chan (1997) observe, though, that proficient L2 speakers are near-native regardless of their L1. That is, their predictions are relevant only for L2 learners but not for proficient speakers. This is, in fact, what the Full Transfer/Full Access hypothesis (Schwartz and Sprouse 1996) predicts; initially, L2 learners rely on their L1 (full transfer), however, given the full access to UG, they are able to reset their transferred L1 knowledge to fit the target language.

In an attempt to explain how resetting is done, Lardiere (2009) suggests that formal morphological contrasts between L1 and L2 are actually detectable by adult learners, even if a feature is missing in L1. She further argues that L2 learners are able to reset their L2 parameters by observing any formal contrast and "associating a difference in a minimally contrasting form with some difference in meaning or grammatical function and constructing some sort of representation for it" (Lardiere 2009:214). By contrast, Oh (2010) argues that adult L2 learners are able to recover even from negative transfer (i.e., when a feature is not available in the L1) only after the semantics of a construction is acquired. Once the semantics of gender is acquired, the syntax will follow.

Neither Lardiere nor Oh discuss, however, the grammatical cues which could trigger the resetting of the L1 knowledge. Nor do they discuss the influence of the L1 experience on the accessibility of these cues in L2. To this end, it is crucial to test when and how L2 learners assign gender to nouns.

Andersen (1984), Sokolik and Smith (1992), and Oliphant (1998) suggest that adult L2 learners, like children in L1 acquisition, pay attention to morphosyntactic information rather than to semantic information, but are sensitive to semantic cues in conflicting situations. Oliphant (1998), for example, tested L2 learners of Italian, whose L1 is English, for their ability to assign gender based on morphological, syntactic, and semantic cues. She found that the learners were sensitive to cues in the word-final morphemes that reliably indicate gender. Moreover, when presented with complementary cues, they scored even better. When presented, however, with conflicting cues, participants found it to be more problematic and scored lower, especially when the natural gender was in discord with other cues. Oliphant relates this to the mature strategy noted by Karmiloff-Smith (1979) for older French speaking children, who took into consideration semantic cues as well as morphological ones. Oliphant argues that this applies to the adult L2 learners of Italian, despite the fact that Italian has gender concord. Similarly, in a study of adult beginner L2 learners of French, whose L1 was English, Carroll (1999) found that they were predisposed to semantic cues showing no sensitivity to phonological cues, but argued that this reflected not a mature strategy, but rather a generalization from the English pronouns whose gender is semantically based. In all the above studies, L1 was English whose gender marking is rather limited. In order to complete the picture it is important to examine which cues are available when L1 has a full classification of nouns by their gender as well as concord for gender.

2.3. *Predictions*

Oliphant's (1998) study suggests that a mature semantic strategy interferes with L2 gender assignment. Is it really a mature strategy which interferes with the L2 behavior? Could gender be a domain in which an English L1 strategy interferes with the L2 behavior as Carroll (1999) suggests? Would the learner's strategy be different with an L1 in which gender is a feature of nouns like Italian or Russian? Is interference limited to information stored in the lexicon? Does interference affect the sensitivity to the different cues?

In order to test whether interference goes beyond lexical information, influencing the strategies used for assigning grammatical gender, L2 speakers of Hebrew with different L1s, English (in which gender is limited to the pronouns and no concord is found) and Russian (in which gender assignment is rule-governed and gender concord is found), were tested. The testing looked into gender assignment to novel nouns whose morphological and semantic gender are in accordance with each other (complementary cues) as opposed to nouns with contrasting morphological and semantic gender (conflicting cues).

If there is no transfer from L1, no differences which correlate with the L1 are expected to be found among the two groups of learners (L1 Russian, and L1 English). If, however, there is transfer from L1, it is predicted that differences will be found between L2 Hebrew learners with L1 Russian and L2 Hebrew learners with L1 English. We expect that, despite the fact that in Hebrew formal information is highly accessible, L2 learners with L1 English will be more sensitive to semantic information, while L2 learners with L1 Russian will be more sensitive to formal information. Such findings would indicate that interference affects the attention paid to the different cues, that is, it affects the strategy used by L2 learners for bootstrapping their way through the gender maze. For proficient learners, however, we expect to find no difference since they were already able to reset the system, accessing to UG.

To conclude, if there is transfer from L1, we expect to find L1 interference in the way L2 learners use gender cues. That is, though in L1 acquisition, formal information seems to play a crucial role, in L2 acquisition, when conflicting information is available, L2 learners will rely on their L1 experience, rather than on UG. Having said so, it is still possible that in order to reset their parameters, they will have to access UG.

3. Method

In order to test the predictions made hereby, a picture elicitation task was used. The task tested the effects of L1 on strategies for gender assignment in L2 as manifested by a plural formation task. For the present task, there were 12 [+animate] novel nouns. Participants were presented with 12 pictures of stereotypically masculine and feminine aliens, accompanied by complementary and conflicting formal cues and were asked to generate the plural form. Since, in Hebrew, gender is morphologically marked both in the singular and in the plural form, the assumption is that the plural morpheme indicates which gender the participants assigned to the noun. In the conflicting situation, this indicates which cue the participants favored.

3.1. *Participants*

Two groups of participants, all of whom university students, were tested: a group of beginner learners, new immigrants who had been exposed to Hebrew for less than a year, and a group of proficient speakers of Hebrew who had lived in Israel for 8–12 years arriving in their adolescence. Each group was divided into L1 subgroups.

The first group consisted of 30 Hebrew L2 learners: 15 with L1 English, and 15 with L1 Russian. All L2 learners had been learning Hebrew in an *ulpan* (language school for adults) in Israel for 1–12 months and had had no previous exposure to Hebrew. They had all lived in Israel for less than a year. The average age was 22 years old. This group made it possible to test for L1 transfer.

The second group included 20 adult proficient speakers of Hebrew as L2: 10 with L1 English and 10 with L1 Russian. The proficient speakers had all lived in Israel for more than 8 years, that is, they attended high school in Israel, and were in their mid-twenties at the time of testing. Proficient speakers were tested in order to find out whether L1 still had an influence on the L2 strategies, beyond the initial phases of L2 acquisition, or whether the speakers were able to reset their knowledge.

A control group of 10 university students, native speakers of Hebrew, was tested in order to find out which strategy is used by adult native Hebrew speakers.

Figure 1: A masculine alien and a feminine alien

3.2. *Testing Procedure*

All participants were presented with 12 pictures of 12 different aliens. In order to provide a semantic cue, six of the pictures were stereotypically feminine and six stereotypically masculine, as in Figure 1.

In order to provide a formal cue, within each set, three had Hebrew morphologically masculine names, e.g. *gubub*, *takdun*, where the expected morpho-phonological plural form is *gububim* and *takdunim*, and the other three had Hebrew morphologically feminine names ending with the stressed syllable /-a/, e.g. *pimpa, gurma*, where the expected morpho-phonological plural form is *pimpot* and *gurmot*. This yielded six test items with complementary cues: three male aliens with masculine names (*kafkul, gubub*, *takdun)*, three female aliens with feminine names (*munda*, *pimpa, gurma)*, and six test items with conflicting cues: three male aliens with feminine names (*xalina, tanda, pinga*) and three female aliens with masculine names (*silun, radel, dumun*). The pictures where presented in random order, requesting the plural. The task was administered in a classroom and the participants were asked to write down their answers.

In order to make sure that the names are not perceived as proper names, but rather names for kinds, three precautions were taken. First, the names were not pronounced as proper names e.g. *tanda* has a stress on the final syllable and not on the first syllable as might be used for proper nouns. Second, each item

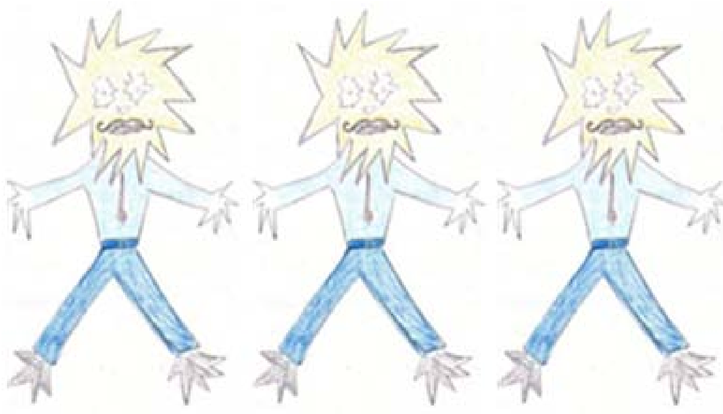


Figure 2: Three masculine aliens

was presented at least once with a definite article, again in order to rule out a proper name reading. In addition, the quantifier *harbe* 'many', which is gender neutral and cannot be used with proper names, was used in eliciting the plural answer.

Each time, the participants were presented with a picture of a single alien as in Figure 1, accompanied by its name. Next, they were presented with a picture showing three aliens of the same kind (as in the picture in Figure 2), and were asked to say what they saw.

The presentation is illustrated in (2):

(2) Experimenter (pointing to a picture of a masculine alien): *kan roim et ha-tanda*
Translation: Here we see the *tanda* (with feminine morphology)
Experimenter (pointing to a picture of three masculine aliens): *ve ma roim kan? kan roim harbe …*
Translation: And what do we see here? Here we see many …
Expected response: *tandaim* (if guided by semantic cue) or *tandot* (if guided by morphophonological cue).

3.3. *Categories of Analysis*

The findings were analyzed first for items with complementary cues (natural gender-Male and morphological gender-masculine, and natural gender-Female and morphological gender-feminine), and then for items with conflicting cues (natural gender-Female and morphological gender-masculine, and natural gender-Male and morphological gender-feminine). The items with complementary cues reveal nothing about the gender cue the participants relied on in their choice of plural endings. They only serve for comparison and to control for the participants' knowledge of the system and understanding of the task. That is, the items with complementary cues are expected to show if the participants have already mastered the Hebrew plural rule according to which most masculine nouns end with /-im/ and most feminine nous end with /-ot/ (see presentation in (2) and the discussion that follows). On the other hand, the items with conflicting cues are insightful, indicating which cues are more reliable for the participants. It is assumed that if the participants chose to inflect a masculine looking alien with the masculine suffix /-im/ even though its label was morpho-phonologically feminine (ending with /-a/), the participant relied on the semantic information. Similarly, it is assumed that if the participants chose to inflect a feminine looking alien with the feminine suffix /-ot/, even though its label was morpho-phonologically masculine (ending with a Ø-morpheme), the participant relied on the semantic information. Gender effects are analyzed only where a significant difference is found. The findings were measured by numbers and percentage.

4. Findings

The findings are presented for complementary cues vs. conflicting cues, combining the different genders. For complementary cues, findings are presented as the percentage of correct responses. For conflicting cues findings are presented as the percentage of semantically cued responses. Comparison with native speakers is provided to reveal the monolingual adult strategy. This is followed by a more detailed analysis of the gender effect for L2 learners where a significant difference was found between masculine and feminine.

Figure 3 presents the percentage of correct responses in complementary cases conflating the two gender categories, comparing the different group of L2 participants across language (for L1 effect) and within language (for proficiency effect). Figure 3 shows that all participants (including the L2 learners) were highly proficient in generating the plural form of the aliens in the complementary case. A one-way ANOVA shows no significant difference between the 5 participant groups, $F(4,55) = 1.7$, $p = 0.16$. These findings show that all participants already know the formal rules which govern the plural generation in the Hebrew gender system and understand of the task.

Figure 4 presents the percentage of semantically cued responses in conflicting cases, conflating the two gender categories, comparing the different groups of L2 participants across language (for L1 effect) and within language (for proficiency effect). Since the findings in Figure 3 show that the participants know the plural formation rules and follow them with hardly any exceptions in the complementary cases, it is assumed that any divergence from these rules will be

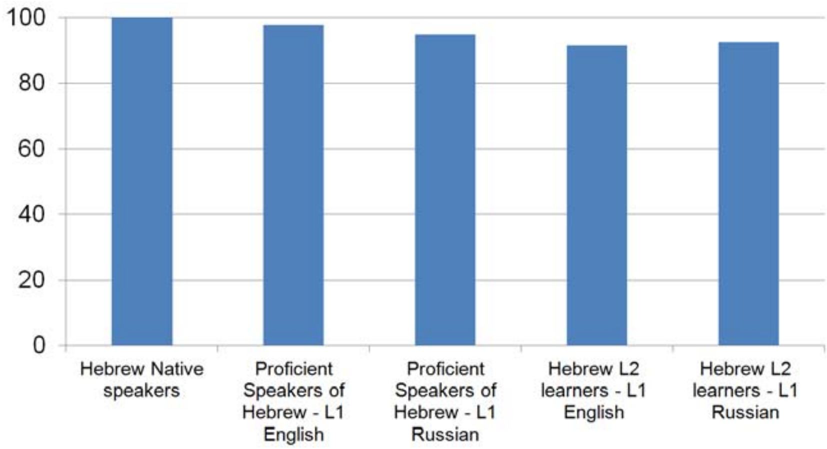


Figure 3: Correct responses in complementary cases in %

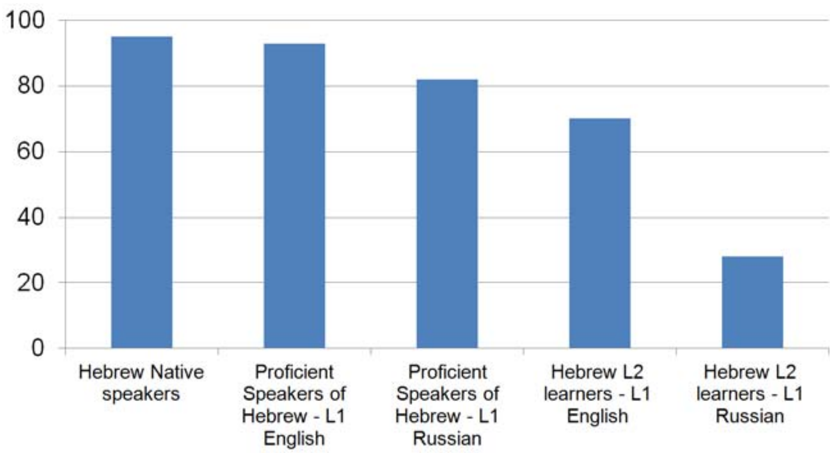


Figure 4: Reliance on semantic cues in conflicting cases in %

attributed to the conflict between the morpho-phonological information and the semantic information. It is assumed that participants who chose to inflect a masculine looking alien with the masculine suffix /-im/ even though its label was morpho-phonologically feminine (ending with /-a/), e.g. *tanda-tandaim* and *pinga-pingim*, relied on the semantic cue. Similarly, participants who chose to inflect a feminine looking alien with the feminine suffix /-ot/, even though its label was morpho-phonologically masculine (ending with a Ø-morpheme), e.g.

silun-silunot and *dumun-dumunot*, relied on the semantic cue. Participants who relied on the morpho-phonological cues were expected to follow the morpho-phonological rule generating *tandot*, *pingot*, *silunim* and *dumunim*, respectively.

Figure 4 shows that not all groups relied on semantic cues to the same extent in generating the plural form in the conflicting cases. A one-way ANOVA shows a significant difference between the 5 participant groups, $F(4,55) = 26.98$, $p < 0.0001$. Post-hoc Tukey traces the result to a significant difference between the monolinguals and the two learners' groups ($p < 0.05$) with no difference between the monolinguals and the proficient speakers. Furthermore, while there was no significant difference between the two L2 proficient groups, there was a significant within language effect for L2 proficient speakers vs. L2 learners ($p < 0.05$ for English, and $p < 0.01$ for Russian). Finally, the post-hoc Tukey tests also showed a significant difference between the two learners' groups ($p < 0.01$). These findings show that although Hebrew native speakers as well as L2 proficient speakers rely heavily on semantic cues, showing almost no sensitivity to morphological gender, generating forms like *tandaim* or *silunot*, L2-learners do so to a much lesser extent, paying attention to morphological information.

Table 2 presents the means and standard deviation for the L2 groups' reliance on semantic cues, followed by a 2-way ANOVA for language and proficiency level.

Table 2: L2 speakers' reliance on semantic cues in conflicting cases in %—Mean and SD

	L1 English		**L1 Russian**		**Total (proficiency)**	
Proficient Speakers of Hebrew	93.3	(12)	81.5	(9)	87.4	(12)
Hebrew L2 learners	70	(26)	27.8	(24)	48.9	(33)
Total (Language)	79.3	(24)	49.2	(33)		

A two-way ANOVA shows an L1 effect $F(1,46) = 41.78$, $p < 0.0001$ as well as a proficiency level effect $F(1,46) = 26.52$, $p < 0.0001$, and an L1 X proficiency level effect $F(1,46) = 6.34$, $p = 0.015$. These findings show that proficient L2-speakers of Hebrew rely on semantic cues more than L2 learners, and that speakers of L1 English rely on semantic cues more than those whose L1 is Russian. The significant interaction suggests that the degree to which this happens depends on both factors: the nature of L1 and the level of L2. Hebrew learners whose L1 is Russian rely on morphological cues more than learners whose L1 is English. However, even when Russian is the L1, the level of L2 matters. Those who are proficient in Hebrew rely on morphological cues less than those who are not (namely, the learners of Hebrew). Nevertheless, even proficient speakers whose L1 is Russian rely on morphological cues more than proficient speakers of Hebrew, whose L1 is English.

Since L2 learners show reliance on semantic cues in only half of the conflicting items and sensitivity to morpho-phonological cues in the other half, we further present the distribution of the use of morpho-phonological cues for the two gender morphemes (Ø-morpheme for masculine and /-a/ for feminine). Table 3 presents a more detailed analysis of the gender effect on L2 learners compared to L2 proficient speakers with complementary and conflicting items, including mean raw score out of a total of 3 per morpheme as well as percentage of reliance on morphological cues.

Table 3: L2 learners' reliance on morpho-phonological cues—mean raw scores and %

	Complementary items		Conflicting items	
	Feminine -a	**Masculine -Ø**	**Feminine -a**	**Masculine -Ø**
L1-English	3 (100%)	2.46 (82%)	1.2 (40%)	0.6 (20%)
L1-Russian	3 (100%)	2.53 (84%)	2.4 (80%)	1.93 (64%)

A three-way ANOVA (Cues combination × Morphological gender × L1) replicate the findings for effect of Cue combination, $F(1,112) = 75.27$, $p < 0.0001$ and L1, $F(1,112) = 21.49$, $p < 0.0001$, as well as showing an effect for Morphological gender, $F(1,112) = 13.58$, $p = 0.0004$, with feminine morpheme /-a/ being a more reliable source of gender cue than the masculine Ø-morpheme. This is true for complementary as well as conflicting items regardless of the L1.

In sum, the major finding of this study is that the two groups of L2 learners show preference for different cues in gender assignment while simultaneously differing from both monolingual and proficient L2 speakers. The second finding is that L1 affects the choice of cues by all L2-ers in a similar manner.

5. Discussion and Conclusion

The present paper tested the strategies used by Hebrew L2 learners and proficient L2 speakers for assigning gender to [+animate] nouns in Hebrew. We tested how Hebrew bilinguals whose L1 classifies nouns by gender and has concord (Russian) and Hebrew bilinguals whose L1 does not classify nouns by gender and has no concord (English) assign grammatical gender to novel [+animate] nouns. It was shown that Hebrew bilinguals whose L1 classifies nouns by gender and has concord rely on morphological cues more than Hebrew bilinguals whose L1 is not sensitive to gender. This applies both to L2 learners and L2 proficient speakers.

Looking at all L2 learners, we find that they rely on morpho-phonological information half of the time, as suggested by the formal primacy hypothesis (Karmiloff-Smith 1978, 1979) for younger children. This could have been interpreted as an indication of similar processes in L1 and L2 acquisition under full access to UG, since both L1-ers and L2-ers seem to rely on morpho-phonological information. Nonetheless, splitting the L2 learners by their L1 shows that only L2 learners whose L1 has a gender feature on N transfer it to their L2 and rely on morpho-phonological cues. In contrast, L2 learners whose L1 does not have a gender feature on N, rely more heavily on semantic cues. This could have been interpreted as a more mature strategy (as in Oliphant 1998). However, in light of the findings for speakers with L1 Russian, we suggest, as Carroll (1999) did, that the performance of the L2 learners whose L1 is English reflects an interference of an L1 English. Since English lacks a gender feature on N and differentiates gender only for some animate pronouns and nouns, L2 learners whose L1 is English, rely more heavily on semantic cues. In other words, in their choice of grammatical gender, L2 learners, regardless of their L1, do not show full access to UG which would yield an acquisition pattern which is similar to monolingual acquisition, but rather transfer features from their L1.

Noteworthy is that none of the L2 learners fully resembled children or adults in their linguistic choice. While in L1 acquisition, children rely on different cues for different tasks, and adults rely primarily on semantic cues, both groups of L2 learners relied simultaneously on the different cues within the same task. Though giving preference to the cues which were supported by L1 transfer, the L2 learners never ignored the other cues. This is what makes even the speakers whose L1 marks gender different from children who always opt for morpho-phonological cues.

Proficient L2 speakers do not differ from native speakers opting for semantic cues, as has already been noted by both Carroll (1989) and Hawkins and Chan (1997). Nonetheless, our findings do show an L1 effect even for proficient speakers. Both groups of proficient speakers opt for semantic cues more than for morpho-phonological cues, but speakers whose L1 is Russian opt for morpho-phonological cues more than speakers whose L1 is English. This raises the question of whether L2 knowledge of the proficient speakers reflects access to UG and acquisition of the uninterpretable features necessary for concord, or alternatively, whether it is due to long immersion in the L2, leading to more mature strategies (cf. Hawkins and Chan 1997, Carroll 1989). The present study, which tests only plural formation, but not concord, is unable to fully answer this question, but the aforementioned influence of L1 transfer clearly calls for further research along these lines.

Our findings also suggest that the Hebrew feminine morpheme /-a/ is a more available cue in the process of L2 acquisition of Hebrew. This is different from Berman's (1985) findings for the acquisition of Hebrew as a first language where masculine is acquired before feminine. Our findings show that while Berman argues that the feminine suffixes are more fragile and require more learning and processing, they are overtly available, and as such, more reliable as a source of morpho-phonological information. As shown in Table 2, in the conflicting cases the morpho-phonological feminine plural rule is applied significantly more than the morpho-phonological masculine. This suggests that even though the morpheme /-a/ is acquired after the masculine Ø-morpheme, it is a more reliable source of gender cue, reflecting the rigid form-function mapping of the feminine morpheme /-a/. In Hebrew there are hardly any masculine objects with a final stress on the feminine suffix /-a/, whereas the opposite (Ø-morpheme being feminine, e.g. *cipor* 'bird', *kaf* 'spoon', etc.) is more common.

The sensitivity to feminine morphology accounts for the difference found between native speakers of Hebrew and proficient speakers of Hebrew, who mostly rely on semantic cues, and L2 learners who pay more attention to morphological cues when faced with a male alien with feminine name. Moreover, the same observation applies to the difference between L2 proficient speakers and L2-learners with L1 English, where a significant difference is found only for male aliens with feminine names.

Thus, the combination of languages and levels of acquisition made it possible to reveal one of the sources of the difficulties in acquiring the gender system in L2. In gender assignment to [+animate] nouns, L2 learners whose L1 has grammatical gender pay more attention to formal information, while L2 learners whose L1 has no gender feature on N, pay more attention to semantic information. These findings support a full transfer of the knowledge whether all nouns have an intrinsic gender or not (Hawkins and Chan 1997). Moreover, the performance of the proficient speakers suggests that L1 influence affects proficient L2 speakers as well but to a lesser extent, depending on their L1. That is, even if Lardiere (2009) is right in assuming that L2ers are able to detect uninterpretable features not available in the L1, this does not predict full blocking of L1 transfer even in proficient speakers of L2 as is evident by the influence of the L1.

To conclude, unlike in L1 acquisition, where formal information seems to play a crucial role, in L2 acquisition, when faced with conflicting information, learners initially tend to rely on L1 transfer/grammar, rather than on UG. There is an effect to a speaker's L1 even 8 years after the beginning of the learning process, in comparison to the behavior of new L2 learners. This paper can serve as a scientific reference and starting point for further research concerning the gender of inanimate objects or the difference between inherent gender and gender detected by concord.

References

Alexiadou, A., Haegeman, L. and M. Stavrou. 2007. *Noun Phrases in Generative Perspective*. Berlin: Mouton de Gruyter.

Amiram, O. 2002. *The Assignment of Grammatical Gender in Hebrew: Evidence from Language Acquisition*. M.A. Thesis, Bar Ilan University.

Andersen, R.W. 1984. What's gender good for anyway? In *Second languages: A cross-linguistic perspective*, ed. by R. Andersen, 77–100. Rowley, MA: Newbury House.

Bat-El, O. 1997. On the visibility of word internal morphological features. *Linguistics* 35: 289–316.

Berman, R.A. 1981. Regularity vs. Anomaly: The Acquisition of Hebrew Inflectional Morphology. *Journal of Child Language* 8:265–282.

Berman, R. 1985. Acquisition of Hebrew. In *The crosslinguistic study of language acquisition*, vol 1, ed. by Dan Isaac Slobin, 255–371, Hillsdale, N.J: Erlbaum.

Carroll, S.E. 1999. Putting input in its proper place, *Second Language Research* 15:337–388.

Carroll, S.E. 1989. Second language acquisition and the computational paradigm. *Language Learning* 39:535–594.

Chomsky, N. 2000. Minimalist inquiries: The framework. In Step by step: Essays in minimalist syntax in honor of Howard Lasnik, ed. R. Martin, D. Michaels & J. Uriagereka, 89–155. Cambridge, MA: MIT Press.

Chomsky, N. 2001. Derivation by phase. In Ken Hale: A life in language, ed. M. Kenstowicz 1–52. Cambridge, MA: MIT Press.

Corbett, G. 1991. *Gender*. Cambridge University Press.

Hawkins, R. 2005. Revisiting *wh*-movement: The availability of an uninterpretable [wh] feature in interlanguage grammars. In *Proceedings of the 7th Generative Approaches to Second Language Acquisition Conference (GASLA 2004)*, ed. by L. Dekydtspotter, D.R. Sprouse, and A. Liljestrand, 124–137. Somerville, MA: Cascadilla Proceedings Project.

Hawkins, R. 1998. Explaining the difficulty of French gender attribution for speakers of English. Paper presented at EUROSLA 8, Paris.

Hawkins, R. and Chan, C.Y.-H. 1997. The partial availability of Universal Grammar in second language acquisition: the 'Failed Functional Features Hypothesis.' *Second Language Research* 13:187–226.

Karmiloff-Smith, A. 1978. The interplay between Syntax, Semantics, and Phonology in language acquisition process. In *Advances in the psychology of language—language development and mother-child interaction*, ed. by R.N. Campbell and T. Smith, 1–23, Plenum Press, Cambridge.

Karmiloff-Smith, A. 1979. A functional approach to child language. A study of determiners and reference. Cambridge.

Lardiere, D. 2009. Some thoughts on the contrastive analysis of features in second language acquisition. *Second Language Research* 25:173–227.

Levy, Y. 1980. *Gender in children's language: A study in first language acquisition*. Doctoral dissertation, Hebrew University. (In Hebrew)

Levy, Y. 1983. The Acquisition of Hebrew Plurals: The Case of the Missing Gender Category. *Journal of Child Language* 10:107–121.

Marantz, A. 1997. No Escape from Syntax: Don't Try Morphological Analysis in the Privacy of Your Own Lexicon. *University of Pennsylvania Working Papers in Linguistics (UPWPL)*, 4:201–225.

Oh, E. 2010. Recovery from first-language transfer: The second language acquisition of English double objects by Korean speakers. *Second Language Research*. 26: 407–439.

Oliphant, K. 1998. Acquisition of Grammatical Gender in Italian as a Foreign Language. *Canadian Modern Language Review* 54:239–262.

Picallo, M.C. 1991. Nominals and nominalization in Catalan. *Probus* 3:279–316.

Ritter, E. 1993. Where's gender? *Linguistic Inquiry* 24:795–803.

Ralli, A. 2002. The role of morphology in gender determination: evidence from Modern Greek. *Linguistics* 40:519–551.

Schwartz, B.D. and Sprouse, R.A. 1996. L2 cognitive states and the Full Transfer/Full Access model. *Second language research* 12:40–72.

Sokolik, M.E., and Smith, M.E. 1992. Assignment of gender to French nouns in primary and secondary language: A connectionist model. *Second Language Research* 8:39–58.

Tsimpli, I.M. 2003. Clitics and determiners in L2 Greek. In *Proceedings of the 6th Generative Approaches to Second Language Acquisition Conference (GASLA2002)* ed. by J.M. Liceras, H. Zobl and H. Goodluck, 331–339. Somerville, MA: Cascadilla Proceedings Project.

White, L., E. Valenzuela, M. Kozlowska-Macgregor and Y-K.I. Leung. 2004. Gender agreement in nonnative Spanish: evidence against failed features. *Applied Psycholinguistics* 25: 105–133.

BRILL Brill's Annual of Afroasiatic Languages and Linguistics 4 (2012) BAALL brill.com/baall

Contents

DOI: 10.1163/18776930-00400014