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MINIMAL VIOLATION OF FAITHFULNESS:

CHAIN SHIFT AND LOCAL CONJUNCTION IN THE ACQUISITION OF HEBREW ONSETS

Thesis submitted for the degree of M.A.

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ABSTRACT

During the course of prosodic acquisition, children are reported to produce word-initial onsetless forms. Data obtained in a longitudinal study of 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, while in target words with an initial complex onset the cluster is merely reduced and realized as a simple onset, creating a chain shift of the form $_w$[CCV→$_w$[CV →$_w$[V, 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). The analysis is provided within the constraint-based framework of Optimality Theory (Prince & Smolensky 1993/2004), where surface forms are selected according to a language specific constraint ranking. The main question to be addressed is how can we account for different outputs for input-simple onsets compared to input-complex onsets at the same stage of phonological development? And, given the principles of universal markedness and the role they play in language acquisition, how can we account for the production of onsetless forms for target words that have an onset?

Based on the findings of this study, I argue the underlying motivation for omission stems from an increase in prosodic complexity, as the data show a clear tendency to omit the onset in polysyllabic, but not monosyllabic productions. I propose an analysis based on local constraint conjunction (Green 1993; Smolensky 1993) to provide a unified developmental account of simple and complex onsets in Hebrew.

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1 INTRODUCTION

This study 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 in target words with an initial complex onset the cluster is merely reduced and realized as a simple onset (e.g *gviná* 'cheese' → *giná*). This state of affairs falls within the criteria of a chain shift (Dinnsen & Barlow 1998; Kirchner 1995, 1996), whereby the output of cluster simplification (*gviná* → *giná*) is the input of onset deletion (*giná* → *iná*).

The data were collected in a longitudinal study of two typically developing children (R and S) and one atypically-developing child (Y). All three children produced onsetless polysyllabic words, but only Y produced monosyllabic onsetless words. Furthermore, while R and S did not seem to omit the onset entirely in word-initial complex onset targets but rather reduced it to a singleton, Y produced onsetless words for both simple-onset and complex-onset targets. This is consistent with the findings of Ben-David (2001) and Greenlee (1974), who reported omissions of both members of the cluster in the acquisition of complex onsets.

Y, who had been previously established as a slow developer (Adam & Bat-El 2008a), provides additional quantitative (as his development stretched over a longer period of time) and qualitative data (evident in the production of onsetless monosyllabic words as well as complex-onset targets) thus completing the picture of simple and complex onset acquisition in Hebrew. The findings will be presented and discussed in sections

2.2 and 2.3, with reference to prosodic and segmental effects and the comparison between typical and atypical acquisition.

An optimality theoretic account of the acquisition of onsets in Hebrew will be presented in section 3. In the framework of Optimality theory (Prince & Smolensky 1993/2004), surface forms are selected according to a language specific constraint ranking. The outputs *giná* and *iná* for the corresponding inputs /*gvina*/ and /*gina*/ violate faithfulness (since the surface forms differ from the underlying forms). Therefore, these outputs must be preferred on the basis of markedness constraints (Moreton & Smolensky 2002). This implies that *giná* is less marked than *gviná* and *iná* is less marked than *giná*. In terms of constraints, the markedness constraint disfavoring *giná* must be ranked above the constraint disfavoring *iná*. In Optimality Theory, the candidate that holds the least number of violations for the higher ranked constraints is selected as optimal, therefore *iná* is expected to win over *giná* regardless of the input. While a rule-based framework can account for chain shift effects using a counter-feeding order of rules, the existence of both forms on the surface poses a challenge to the non-derivational framework of Optimality Theory.

This issue will be addressed in section 3.2, where an analysis based on local constraint conjunction (Green 1993; Smolensky 1993) will be proposed. This notion refers to the combined effect of conjoined constraints as opposed to the effect of each constraint independently, and has been previously proposed by Kirchner (1995, 1996) in order to account for synchronic chain shifts.

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 speech is usually characterized by processes that reduce relative markedness, not increase it. This issue will be addressed in section 3.1, where it will be argued that the underlying motivation for the omission of word-initial onsets is an increase in prosodic complexity. It will also be argued that there is a difference in the role of word-initial prominence between child and adult language, relating to considerations of developing systems versus fully developed ones.

1.1 LANGUAGE BACKGROUND

1.1.1 Segmental inventory

The segmental inventory of Hebrew, adopted from Ben-David (2001), is presented in the charts in (1) and (2):

(1) Modern Hebrew consonants

	Labial		Coronal			Dorsal		Glottal
	Bilabial	Labio-dental	Alveolar	Palato-alveolar	Palatal	Velar	Uvular	
Stop	p b		t d			k g		ʔ
Nasal	m		n					
Fricative		f v	s z	ʃ ʒ		x		h
Affricate			ts	tʃ dʒ				
Liquid			l				ʁ	
Glide					j			

The chart represents the consonants in Modern Hebrew (MH henceforth), as pronounced by the majority of speakers. Allophones are not included in the chart (e.g. [ŋ] as in *máŋgo* 'mango'; voiced glottal fricative [ɦ] as in *nóɦal* 'procedure'), as well as the pharyngeal consonants [ʕ] and [ħ], pronounced by speakers of some oriental dialects (Laufer 1990), and the trill variants [r] and [ʀ] of the uvular approximant [ʁ], pronounced by some speakers. The consonants [ʒ] (e.g. *ʒakét* 'jacket'), [tʃ] (e.g. *tʃips* ‘chips’) and [dʒ] (e.g. *dʒuk* ‘cockroach’, colloquial) appear mostly in loan words and their frequency in the language is relatively low, however as Ben-David (2001) notes, they appear to function as phonemes in the language in both adult and child speech and are therefore treated as such.

Finally, the status of the glide [w] in Hebrew is somewhat vague. Its distribution in the language is limited to loan words (e.g. *wíski* ‘whiskey’) and, for the most part, interjections such as *waw* ‘wow!’ and *wála* ‘you don’t say! (Slang, Arabic)’. Although this consonant is produced by children, non-major lexical items were excluded from the analysis in this study (see section 2.1), and therefore the unclear status of this consonant is mostly non-relevant to the present study.

(2) Modern Hebrew vowels

	Front	Back
High	i	u
Mid	e	o
Low		a

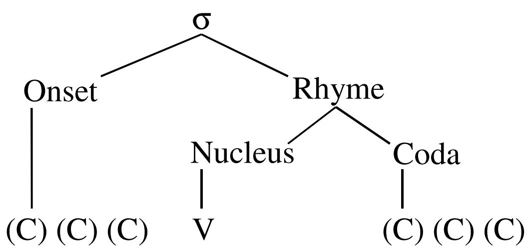
The vowel system of Hebrew consists of five vowels, as shown in (2) above. The low vowel [a] is central (Laufer 1990).

1.1.2 Syllable structure

The syllable structure of major class words in MH is illustrated in (3). CV and CVC are the most common syllable structures, but an onset is not obligatory and there are many vowel-initial syllables (Ben-David 2001). The onset or coda position may consist of a single consonant or a consonant cluster, although the distribution of complex coda structures is restricted to certain verb forms (feminine singular forms in past tense, e.g. *laxáʃt* ‘(you) whispered fm. sg.’) and loan words (e.g. *golf* ‘golf’).

Consonant clusters in onset position are common and abide some minimal restrictions.[1] They appear mostly word-initially and allow both sonority rise (e.g. *pʁaxím* 'flowers)' and plateau (e.g. *ptaxím* 'openings'). Vowel length is not contrastive in MH and adjacent vowels are mapped onto separate syllables (e.g. *pá.ar* 'gap'; *jo.áv* 'Yoav', a proper name).[2] There are no branching nuclei. Diphthongs such as /ei/ (e.g. *lifnéi* 'before'), /ai/ (e.g. *dai* 'enough'), /ui/ (e.g. *nisúi* 'experiment') and /oi/ (*noi* 'ornamentation') can be regarded as a vowel followed by a glide (Laufer 1990; Ben-David 2001).

(3) Syllable structure in Hebrew lexical words



1.1.3 Stress

Stress in MH may fall on the final, penultimate or antepenultimate syllable, but the majority of prosodic words in MH bear stress on the final syllable (Bat-El 1989; Ben-David 2001; Graf & Ussishkin 2003; Bolozky & Becker 2006; Adam & Bat-El 2008b). Stress assignment in the nominal system is unpredictable, as some nouns are stressed by default phonological pattern while others are lexically marked for stress

[1] Triconsonantal clusters are rare in Hebrew and are typical of loan words, e.g. *spʁajt* 'Sprite', *ʃʁimps* 'shrimp'.

[2] Vowel sequences are sometimes separated by a glottal stop [ʔ] or fricative [h], e.g. *zeév* ~ *zeʔév* 'wolf'; *nóal* ~ *nóhal* 'procedure', however in colloquial speech these consonants are usually omitted in unstressed or non-utterance-initial positions. As Laufer (1990) notes, this may vary according to style and rate of speech. Speakers of oriental dialects may also pronounce the pharyngeal [ʕ] e.g. *ʃaʕón* 'clock'.

(see Bat-El 1993; Graf 2000). This is evident in contrastive forms such as *bóker* 'morning' ~ *bokér* 'cowboy'. In verbal forms stress falls on either the final or penultimate syllable, in a predictable manner depending on the phonological properties of the morphological constituents (Bolozky 1978; Bat-El 1989; Adam 2002).

MH is quantity-insensitive, therefore the location of stress cannot be determined on the basis of syllable structure (Bolozky 1982; Bat-El 1993; Graf & Ussishkin 2003). Secondary stress applies iteratively, usually occurring on every other syllable from the location of primary stress (Bolozky 1982).

1.2 THE ACQUISITION OF SIMPLE ONSETS

The acquisition of syllable structure has been well studied cross-linguistically. Like other aspects of language acquisition, the markedness of structures plays a key role in the process. As CV is considered to be the universally unmarked syllable structure, simple onset consonants emerge in children's productions in the very beginning of acquisition (e.g. Fikkert 1994, Levelt et al. 2000 on the acquisition of Dutch; Ben-David 2001 on the acquisition of Hebrew).

Despite the co-occurrence of different consonants in children's early segmental inventories, not all consonants are acquired simultaneously in all positions - the distribution of consonants can often be context-specific. Sonority, voicing and manner contrasts have been shown to play a part in consonant preservation and production in children with typical as well as delayed phonological development. Data collected from developing systems around the world show that voiced consonants of low sonority tend to emerge in onset position prior to their voiceless counterparts. The connection between syllables and sonority has been documented cross-linguistically (see Blevins 1995; Clements 1990) to yield the following generalization: the unmarked or *harmonic* syllable consists of a low sonority onset and a high sonority rhyme (comprised of a sonority peak which may or may not be followed by one or more coda consonants). In other words, low sonority onsets and high sonority codas contribute to the optimization of the syllable. The basic sonority scale is given in (4):

(4) Sonority scale (adapted from Blevins 1995 and Clements 1990; see also Giegerich 1992)

Sonorants								Obstruents		
Vowels	>	Glides	>	Liquids	>	Nasals	>	Fricatives	>	Stops

Following this generalization, the syllable comprising the word *dan* 'Dan' (a proper name), for example, is more harmonic than the syllable comprising the word *nad* 'wandered ms. sg.'.

Research on the acquisition of phonemic contrasts reveals a preference for production of stops in prevocalic positions and sonorants as well as fricatives in postvocalic position in the early stages. Ben-David (2001) found that in these stages, stops and nasals, but not fricatives and liquids, were produced in onset position and the opposite was observed in coda productions when coda consonants began to surface. She also found substitutions of fricatives and sonorants in onset position with stops (e.g. *sagól* 'purple' produced as *tagól*). According to Ben-David, this implies the existence of a stage where stops are the preferred consonants in onset position. Additional reference to the role of sonority and manner of articulation in the acquisition of onsets can be found in Dinnsen (1996); Dinnsen & Farris-Trimble (2009); Fikkert (1994); Gnanadesikan (1995/2004); Grunwell (1982); Pater (1997); Pater & Barlow (2003).

The acquisition of voicing contrast is also affected by position within the syllable. Ben-David (2001) found that substitutions of voiceless consonants with voiced ones (e.g. *pil* 'elephant' produced as *bil*) occurred mostly in onset position (while the opposite occurred in coda position). This context-sensitive voicing is also mentioned by Dinnsen & Farris-Trimble (2009); Grijzenhaut & Joppen (1999) and Grunwell (1982).

In Ben-David's (2001) account of the acquisition of Hebrew, the stages of onset acquisition are also said to include the omission of onset consonants (e.g. *úbi* for *dúbi* 'teddy bear'), reduplication of consonants (e.g. *búbi* for *dúbi* 'teddy bear') and finally faithful productions of the onset consonants. Onset omission has been witnessed in the acquisition of other languages as well (see Ben-David 2001, Buckley 2003 and references therein). The present research will take a closer look at the omission of onsets and the involvement of segmental and prosodic factors in the process of their acquisition.

1.3 THE ACQUISITION OF COMPLEX ONSETS

The most common pattern reported in acquisition of clusters is reduction to a singleton. The same principles that govern the acquisition of simple onsets (discussed in the previous section) are very much active in the acquisition of branching onsets, as many accounts report the selection of the least sonorous member of the cluster in instances of cluster reduction (e.g. Fikkert 1994; Gnanadesikan 1995/2004; Pater & Barlow 2003).[3] Other reports refer to position and directionality (e.g. Ben-David 2001; Lleo & Prinz 1996). Less common patterns of cluster simplification are coalescence, metathesis and vowel epenthesis (e.g. Barlow & Dinnsen 1998; Ben-

[3] An exception to this generalization is the case of initial /s/ clusters. The status of these sequences has been the focus of many studies; see for example Barlow (2001) and Geirut (1999).

David 2001; Chin & Dinnsen 1992; Freitas 2003; Lukaszewicz 2007). An example of the patterns mentioned above is provided in (5):

(5) Strategies for cluster simplification

		Target	**Production**
a.	Markedness-based reduction		giná
b.	Position-based reduction		viná
c.	Coalescence	gviná ‘cheese’	biná
d.	Metathesis		givná
e.	Vowel epenthesis		geviná

The example above shows various productions of the target word *gviná* ‘cheese’ as a result of different strategies for cluster simplification. This demonstrates what McCarthy (2002) terms “homogeneity of target/heterogeneity of process”, i.e. different ways to achieve the same target. In (5a) the stop-fricative cluster *g-v* is reduced to a simple onset in which the stop (the unmarked among the two in onset position) is retained. In (5b) the first member of the cluster is omitted, thus retaining contiguity of the sequence $\cancel{g_1}v_2i_3n_4a_5$ (rather than $g_1\cancel{v_2}i_3n_4a_5$). Output (5c) is a merger of the two members, retaining manner of articulation from the first, and place of articulation from the second.

Outputs (5d) and (5e) are simplifications of the cluster that do not result in the omission of a consonant, but are rather an attempt to produce both members of the cluster. In (5d) metathesis occurs between the second member of the cluster and the adjacent vowel, altering the syllable structure from CCV to CVC. In (5e) a vowel is inserted between the two members of the cluster. In terms of cluster simplification, the result is the same as in (5d), only this time the addition of the vowel results in the addition of a syllable to the word.

Ben-David (2001) argues that coalescence and epenthesis represent a later stage in complex-onset acquisition, where clusters still do not surface but both members of the cluster are produced (see Bloch 2011 for a quantitative account and discussion of applied strategies in cluster acquisition in Hebrew). Ben-David also found evidence of an initial stage where both members of the cluster are omitted entirely (e.g. *gviná* → *iná* 'cheese'). This claim will be examined and discussed in section 2.3 in light of qualitative data analyzed in the present study, looking at both typical and atypical acquisition.

1.4 TYPICAL AND ATYPICAL ACQUISITION OF PHONOLOGY

Variability is an inherent part of language, whether it is in fully developed languages, between individuals or within the same individual.

During the course of language development, children must acquire the structures and contrasts of the target language. While it is widely acknowledged that acquisition is systematic in that the same processes are attested in child speech universally (e.g. cluster simplification, gliding, consonant harmony etc.), it is also accompanied by both inter-child and intra-child variation.

Given the wide spectrum of variation witnessed in the course of acquisition, how do we define atypical phenomena?

At the heart of this discussion lies the question of quantity versus quality. Do atypical systems differ from typical ones in the nature of processes that take place, or in the extent to which these processes occur? Many studies show the same processes can be found in both typical and atypical development. According to Grunwell (1982), it is the co-occurrence of persisting normal processes with patterns typical of later stages of development that often leads to idiosyncratic productions (see for example Bat-El 2009). The latter category includes patterns that have not yet been reported in normal development, often characterized by relatively weak resemblance between production and target and simplification processes that significantly reduce contrast, but as Bernhardt & Stemberger (1998:15) note, these idiosyncratic productions do not usually exceed the bounds of phonology.

The longer duration often characterizing atypical development leads to significant age differences between atypically developing individuals and typically developing ones. Such differences can be the source of many idiosyncratic productions, since they enable an unusual combination of limited phonology in motorically mature systems (excluding cases of limitations on production due to motoric disability). Therefore, a significant gap in development increases the chance for output variability exhibited in atypical development (for example: the production of consonant clusters, characteristic of later stages of development, co-occurring with consonant harmony, prevalent in early language development, within the same word). However, it is also the longer persistence of patterns that provides us with a unique extended view on acquisition, making the transition from one stage to another more noticeable (Bernhardt & Stemberger 1998; Gishri 2009).

This study will attempt to shed some more light on the characteristics of atypical development and its contribution to research, by comparing the speech of two typically-developing children with the speech of an atypically-developing child, diagnosed with Pervasive Developmental Disorder (PDD).

2 THE ACQUISITION OF HEBREW ONSETS

2.1 RESEARCH METHODS

The data analyzed in this study is drawn from a longitudinal study of three mono-lingual children: R (1;04-2;03 female), S (1;02-2;0 male), and Y (1;03-2;10 male, diagnosed with mild Pervasive Developmental Disorder)[4]. The children were recorded by the investigator in 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 various naming tasks. The recordings were transcribed by the investigator using the CHAT transcription format designed for CHILDES.[5] 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 present study. 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, e.g. *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', *kwa-kwa* 'frog croak') were also excluded, as well as glottal-fricative (h)-initial targets (e.g. *hipopotám* 'hippopotamus') as this consonant is often omitted in colloquial speech (*hipopotám* ~ *ipopotám*).

Verbs were not included in the analysis for two main reasons, the first being that verbs are acquired much later compared to nominals. Subsequently, early productions include mostly nouns, while verbs begin to appear later in development. As this study offers a developmental account of onset acquisition, the absence of verbs in the early

[4] The data is drawn from the database of the Adam and Bat-El Child Language Project (supported by ISF grant 554/04).

[5] With the exception of one child (R), who was recorded by one investigator and transcribed by another for the most part, sessions with each child were transcribed by the same investigator who recorded them. Transcribers held frequent meetings and followed the same guidelines and conventions as directed by the project supervisors.

stages makes it difficult to compare the acquisition of these forms with non-verbal ones. In addition, very few verbal forms in Hebrew have a word-initial complex onset, which makes it difficult to compare such forms with word-initial simple onset verb forms.

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, therefore 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* ~ *tipúr*> for *sipúr* 'story', <*pláster* ~ *kláster*> for *pláster* 'band-aid'). However, in the analysis of segmental effects substitutions were separated from fully faithful productions of word-initial onset consonants. Productions of the same target word that varied in segmental aspects other than the word-initial onset consonant (e.g. word-medial onset, coda consonants or vowel quality) were counted only once for all purposes (e.g. <*magévet* ~ *makévet*> for *magévet* 'towel', <*gamál* ~ *gamáj* ~ *gamá* ~ *gemál* ~ *gemá*> for *gamál* 'camel'; [*amá*] ~ [*amál*] ~ [*emá*] would only count as one instance of omission for the target *gamál*), however incorrect stress assignment by the child and productions that varied significantly (prosodically and/or segmentally) from the target were not included in the analysis (e.g. R 1;08.07 [*páupau*] for *paamón* 'bell'). Rare instances of complex-onset productions for simple-onset targets were also excluded (e.g. R 2;01.19 [*blixól*] for *mikxól* 'paint brush').

Finally, productions that differed in the number of syllables were not considered repetitions and were counted separately (e.g. <*púax* ~ *tapúax*> for *tapúax* 'apple'). In segmental analysis of truncated forms, the consonant corresponding to word-initial position in the production was considered to be omitted (e.g. [*úax*] for the target *tapúax* 'apple' would be considered an omission of [p]). When in doubt, consonant identity was determined according to contiguity (e.g. [*afáim*] for *magafáim* 'boots' would be counted as an omission of [g], not [m]; [*injá*] for *sufganjá* 'doughnut' would be counted as an omission of [g] despite the altered vowel). In case of a clash between vowel quality and contiguity, the production was excluded from the segmental count only (e.g. [*evá*] for *levivá* 'potato patty').

Excluding the forms mentioned above helps capture the extent of onset omission more accurately, by ensuring the observed productions are indeed the result of this process and thus strengthening the claim.

The children differ significantly in the progress of their development. Adam & Bat-El (2008a) found that although the children began producing their first words at a similar age (R at 1;03.27, S at 1;02.00 and Y at 1;02.29), Y reached 250 cumulative attempted target words seven months after S. R reached 250 cumulative attempted target words five months after S. That is, in terms of lexical development S is the fastest, Y the slowest and R is in between. Y's relatively slow development (recall that he was diagnosed with mild PDD) is further substantiated by the duration of the monosyllabic (sub-minimal) stage: S and R's monosyllabic stage was relatively short (five and seven months respectively) while Y's lasted well over a year. The percentage of monosyllabic productions at the highest point for S and R was 53% and 68% respectively, and 92% for Y.

I adopt Adam and Bat-El's (2008a) methodological tool of the division of periods on the basis of lexical development. The latter is measured by cumulative target attempts on a scale of approximately 50 new word types per period, presented in (6):

(6) Periods of lexical development based on cumulative target attempts

Period		R		S		Y	
		Age range	Types	Age range	Types	Age range	Types
1	~10	1;03.27-1;04.09	12	1;02.00-1;03.05	11	1;02.29-1;03.27	10
2	~50	1;04.18-1;05.29	49	1;03.14-1;04.17	47	1;04.03-1;07.12	55
3	~100	1;06.05-1;08.01	98	1;04.24-1;05.08	111	1;07.23-1;09.04	102
4	~150	1;08.07-1;09.18	155	1;05.15-1;05.21	152	1;09.18-1;10.30	149
5	~200	1;09.27-1;10.13	197	1;05.29-1;06.12	207	1;11.05-2;00.03	199
6	~250	1;10.28-1;11.18	280	1;06.20-1;06.26	275	2;00.26-2;01.22	260
7	~300	1;11.25	307	1;07.02	298	2;02.07-2;02.21	299
8	~350	2;00.02-2;00.09	365	1;07.09-1;07.17	366	2;02.28-2;03.12	349
9	~400	2;00.16	406	1;07.23-1;08.10	406	2;03.19-2;05.00	399
10	~450	2;00.30-2;01.06	444	1;08.17-1;09.00	457	2;05.07-2;05.14	442
11	~500	2;01.12-2;01.19	500	1;09.09-1;09.19	506	2;05.21-2;06.18	497
12	~550	2;01.27-2;02.04	542	1;09.27-1;10.26	555	2;06.25-2;07.29	558
13	~600	2;02.11-2;02.25	615	1;11.02-1;11.07	594	2;08.20-2;09.10	601
14	~650	2;03.01	651	1;11.16-1;11.22	632	2;09.17-2;10.07	624

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 ACQUISITION – DATA AND GENERALIZATIONS

All three children produced word-initial onsetless syllables. Some examples are provided in (7):

(7) Productions of word-initial onsetless syllables

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

2.2.1 Rate of omission

The percentage of faithful and onsetless productions out of the total number of attempted targets for each child is given in (8).

(8) Rate of faithful and onsetless polysyllabic productions

Child	Period	Age	Target		Production	
			Structure	Total	$_{w}$[CV	$_{w}$[V
R	1-14	1;04-2;03	$_{w}$[CV	728	625 85.9%	103 **14.1%**
S	1-14	1;02-2;00	$_{w}$[CV	1075	879 81.8%	196 **18.2%**
Y	1-14	1;03-2;10	$_{w}$[CV	750	571 76.1%	179 **23.9%**

As shown in the table above, all children omitted the onset word-initially. The findings indicate the highest rate of omission is found for Y, who as noted above, exhibits a slower pace of development and a longer monosyllabic stage. Recall that Y had been diagnosed with mild PDD and is thus considered to be an atypically developing child.

2.2.2 The effect of stress

The table in (9) compares the percentage of omitted onset consonants in stressed syllables with the omission rate in unstressed syllables for each child:

(9) Omission in stressed vs. unstressed syllables

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

The data were analyzed using Fisher's exact test. Significance was set at $p < 0.05$. While R and Y show a greater tendency to preserve the onset in stressed syllables (p=0.026, p=0.0006 respectively), S's productions indicate the opposite. Not only does S not tend to preserve the onset in stressed syllables, he actually omits it more in this position (p=0.01).

Previous studies have shown the effect of stress on syllable truncation (Echols & Newport 1992; Gerken 1994; Wijnen et al. 1994, among others) reporting a higher tendency for unstressed syllables to be omitted. The findings of Adi-Bensaid (2006) in her study of hearing impaired children acquiring Hebrew show a clear effect of stress on word-initial onset preservation in disyllabic words. The children showed a tendency to preserve the onset in disyllabic words with penultimate stress more than in words with ultimate stress. Ben-David's (2001) account of Hebrew acquisition, as well as the findings reported in Adam & Bat-El (2008b) provide further evidence of the role of stress in the acquisition of prosodic structures, and Gishri (2009) shows the role of prominence in the acquisition of medial codas in Hebrew. These effects can be attributed to the higher perceptual salience of stressed syllables (see section 3.1 for additional discussion of prominence). In light of these reports, S's tendency to omit the onset in stressed rather than unstressed syllables is unexpected.

2.2.3 Segmental effects

In her account of the acquisition of Hebrew, Ben-David (2001) observed that all consonant groups undergo deletion in onset position. A closer look at the present data reveals some consonants are more susceptible than others. For all three children, sonorants exhibit the highest omission rate. The omission rate of sonorant vs. obstruent consonants is given in (10):[6]

[6] The total number of targets is different from the number in the table presenting the omission rate. This is due to the exclusion of certain productions from the segmental analysis, as discussed in section 2.1.

(10) Omission rate of sonorants vs. obstruents

Child	Sonorants			Obstruents		
	Total	Omitted		Total	Omitted	
R	217	52	**24%**	508	49	**10%**
S	259	101	**39%**	764	83	**11%**
Y	197	122	**62%**	523	46	**9%**

It is clear that sonorant consonants are omitted at a much higher rate compared to obstruents. As observed earlier in section 2.2.1, omission rates tend to be higher for Y. 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. The basic sonority scale of consonants presented in section 1.2 is given below:

(11) Sonority scale

Sonorants							Obstruents		
Vowels	>	Glides	>	Liquids	>	Nasals	>	Fricatives	>	Stops

As Clements notes, there is a cross-linguistic tendency to prefer a maximal rise in sonority toward the peak (i.e. onset-to-nucleus), and a minimal fall toward the end (nucleus-to-coda). This is best achieved by low sonority onsets and high sonority codas.

In the analysis of the role of sonority in truncation, Pater (1997) shows that the selection of onset consonants for preservation is directly influenced by their relative sonority, such that high sonority onsets were replaced by onsets of lower sonority, according to the scale. The preference for low sonority onsets is also evident in cluster reduction patterns (e.g. Gnanadesikan 1995/2004; Pater & Barlow 2003), thus yielding the following onset markedness hierarchy:[7]

(12) Onset markedness hierarchy based on the scale of sonority (marked » unmarked)

Glides » Liquids » Nasals » Obstruents

The lower omission rate of obstruents compared to sonorants, exhibited in the productions of all three children, is naturally predicted in this context. Furthermore, R and S follow the universal hierarchy by exhibiting higher omission rates for higher sonority consonants (glides and liquids):

(13) Sonorant omission rates

R					
Consonant	ʁ	l	j	m	n
Omission %	11/29 **38%**	11/36 **31%**	10/36 **28%**	15/81 **19%**	5/35 **14%**
S					
Consonant	j	ʁ	l	n	m
Omission %	24/44 **55%**	30/56 **54%**	17/42 **40%**	12/32 **38%**	18/85 **21%**
Y					
Consonant	l	m	ʁ	n	j
Omission %	16/21 **76%**	68/92 **74%**	17/24 **71%**	15/32 **47%**	6/28 **21%**

In R and S's productions the omission rate is higher for approximant consonants (glides and liquids) compared to nasals. Fisher's exact test showed significant distinctions (p=0.016 for R and p=0.0006 for S). Although there is some variation between R and S's patterns, evident in the slightly higher omission rates for liquids shown by R, the figures are relatively close. Even in S's productions the difference

[7] It is generally agreed upon that glides are non-syllabic vowels (i.e. the only difference between them is their position within the syllable), therefore it is unnecessary to include vowels in the hierarchy since their status would be the same as glides.

between [j] and [ʁ] omission is very small, indicating a clearer cut between the class of approximants and nasals, and a less significant difference within approximants.

In contrast, despite the fact that Y omits sonorants more than any other class and at an even higher rate (62%) compared to R (24%) and S (39%), his pattern deviates from the universal sonority scale, exhibiting the lowest omission rate for the most sonorous consonant. Fisher's exact test did not show a significant distinction between approximant and nasal omission in Y's productions (p=0.069).

Another way to examine evidence of the role of sonority is to look at the selection of targets made by the children:

(14) Number of targets with word-initial sonorant vs. obstruent consonants

Child	Target			
	Sonorant		Obstruent	
R	217/725	**30%**	508/725	**70%**
S	259/1023	**25%**	764/1023	**75%**
Y	197/720	**27%**	523/720	**73%**

The figures in (14) reflect the selection of target words with sonorant versus obstruent consonants in word-initial position. Targets with word-initial obstruents are much more prevalent in the children's speech compared to targets with word-initial sonorants.

Selectivity plays an important role in language acquisition (Ferguson and Farwell 1975; Schwartz 1988). In their study of the acquisition of Hebrew stress, Adam & Bat-El (2009) refer to the *target factor*, reporting more attempts to produce trochaic polysyllabic words than iambic ones during the early stages, thus showing preference for the unmarked structure. This preference gradually decreases while the preference for words with final stress (iambic) increases to conform to the frequency of these structures in the target language, as most Hebrew prosodic words are finally-stressed (Ben-David 2001; Graf & Ussishkin 2003; Bolozky & Becker 2006; Adam & Bat-El 2008b). In another study on the interaction between phonological and morphological development (Bat-El 2010), the child was shown to selectively avoid production of a codaed verb inflectional suffix until she reached about 90% faithful coda productions. Adam & Bat-El (2008c) present a morphological stage characterized by productions of only bare stem verb forms by Hebrew speaking children. According to the authors, this is unexpected since the type-frequency of such forms is much lower in adult language compared to affixed forms. Moreover, the affixes often appear in prominent positions, which should facilitate their production. Importantly, the children do produce nouns that are prosodically identical to the affixed verbal forms. Adam & Bat-El take this to be an indication of morphological knowledge rather than the absence of it.

In her account of productivity and selectivity in the acquisition of early verb morphology in Hebrew, Lustigman (2007) suggests the evident selectivity reflects different stages along the path of acquisition. She shows that even when inflectional affixes begin to be produced productively, this is done in a gradual manner as the child systematically selects for a certain subset of affixes at first (the present-tense, *benoni* forms).

Becker (2007) claims selectivity serves as a means of reducing the processing load. Children can choose a strategy of avoidance over amendment if the latter is too costly in terms of input-output discrepancy.

In this instance, the distribution of word-initial obstruents and sonorants in the children's targets matches the distribution of these consonants in word-initial position in the language. Based on the database of Bolozky & Becker (2006), out of a total of 8,084 target words of $_{w}$[CV structure (excluding word-initial glottal fricative [h]) the frequency of word-initial obstruents is 62% (4,996/8,084) while that of word-initial sonorants is 38% (3,093/8,084). Therefore, in this case the children's selectivity does not provide evidence of the effect of universality as opposed to language specific phonotactics (cf. Adam & Bat-El 2009).

2.2.4 Monosyllabic vs. polysyllabic words

In order to establish whether the underlying motivation for omission is prosodic or articulatory, the realization of onsets in monosyllabic productions was examined as well. The omission rate in monosyllabic compared to polysyllabic productions is given in (15):

(15) Omission rate in monosyllabic vs. polysyllabic productions

		ʁ	l	j	m	n
R	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%**
		j	ʁ	l	n	m
S	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%**
		l	m	ʁ	n	j
Y	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%**

These figures indicate a significant difference in the rate of omission between polysyllabic to monosyllabic productions. Although there is a higher rate of [j] omission in R'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 Y 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 Y's productions as well.

The lower rate of omission in monosyllabic productions is consistent with our expectations. Since coda consonants are often absent from children's early productions, omission of the onset in monosyllabic productions will result in consonant-free words (Adi-Bensaid and Tubul-Lavy 2009), i.e. words consisting of vowels only. Such productions minimize lexical contrast and are therefore usually avoided in typical development (see Grijzenhaut and Joppen 1999 for discussion of minimal contrast in children's early productions). In the present study, some consonant-free words were found in Y's productions.

A study of hearing impaired Hebrew speaking children (Adi-Bensaid 2006) reports the production of onsetless words for both monosyllabic and polysyllabic targets. Adi-Bensaid and Tubul-Lavy (2009) maintain that the resulting consonant-free words are not limited to atypically developing children, but rather characterize the transition stage between babbling and speech. They claim 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 R and S went through the same stages of development as Y, including the production of onsetless monosyllabic words, but due to their relative quick progress (recall Y's prolonged monosyllabic stage, discussed in section 2.1), combined with the motivation to preserve minimal contrast, the overlap is very small. In this particular instance, what may seem at first glance as an idiosyncratic property of Y's atypical development could in fact reflect what we might achieve if we could examine typical development in slow motion. The examination of onset clusters, discussed in the next section, provides a similar picture.

It is important to note that even if typically developing children do go through a stage where they produce onsetless monosyllables, we would still expect to see a difference between monosyllabic and polysyllabic words. This is evident in Y's productions, where the omission rate in monosyllables is significantly lower compared to polysyllabic words.

Addressing the question of articulatory restrictions, the involvement of such restrictions is especially relevant in Y's case, where the production rate of sonorant onset consonants is very low. For one, it seems Y had not acquired liquids in onset position yet, based on his low production rate of [l] (8% [2/26] in monosyllables; 5% [1/21] in polysyllabic words) and [ʁ] (0% [0/43] in monosyllables; 0% [0/24] in polysyllabic words).

Recall however that all three children omit obstruents as well as sonorants, though to a smaller extent. The consonant [t], for example, is realized faithfully in 80% (59/74) of Y's monosyllabic productions. Out of the remaining 20%, 16% (12/74) are substitutions and only 4% (3/74) are omissions. This distribution indicates Y has acquired this consonant in onset position. Nevertheless, [t] is still omitted at a rate of 20% (11/55) in his polysyllabic productions. To state more clearly, the generalization is that although Y has already acquired this consonant in onset position, he continues to omit it in polysyllabic words at a rate of 20%. The context for omission can thus be attributed to a higher level of prosodic complexity rather than an articulatory restriction.

2.3 CHAIN SHIFT EFFECT IN THE ACQUISITION OF COMPLEX ONSETS

While all three children produced onsetless words at a rate of 14%-23% for target words with word-initial simple onset (see section 2.2.1), their productions corresponding to targets with word-initial clusters reveal a different pattern. The table in (16) compares the realization of simple onsets with that of complex onsets:

(16) Rate of faithful and onsetless polysyllabic productions – simple vs. complex onsets

Child	Period	Age	Target		Production					
			Structure	Total	$_{w}$[CCV		$_{w}$[CV		$_{w}$[V	
R	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%**
S	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%**
Y	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 clusters is significantly lower. In other words, the children omit the onset entirely in word-initial simple onset targets but not in word-initial complex onset targets, where they only omit one consonant.

As the minimal and near-minimal pairs in (17) show, the same segments that are omitted in productions of simple-onset targets are realized faithfully in productions of onset clusters:

(17) Omission of simple and complex onset – (near) minimal pairs

Child name & Age	Child output	Target	Gloss
R (1;10.28-2;03.01)	ixá	mixál	'Michal'(a proper name)
R (2;00.16)	mixá	smixá	'blanket'
S (1;09.00)	améʁ	naméʁ	'tiger'
S (1;07.09)	naí	snaí	'squirrel'
Y (2;05.21)	azén	gaʁzén	'ax'
Y (2;05.00)	gadím	bgadím	'clothes'

This observation 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. For example, 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 & 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 discussed by Dinnsen and Barlow

(1998) and the famous “puzzle-puddle-pickle” chain of Amahl (Smith 1973; see also Dinnsen et al. 2001 and Jesney 2005 on chain shifts in acquisition).

Once again, Y’s pattern of development sets him apart, providing evidence of a stage that is not observable in the other children’s development. While R and S tend to reduce clusters to a single onset but do not omit them entirely, Y’s productions include both omissions and reductions, implying the existence of an initial stage in which onset clusters are not produced at all. This is exemplified in (18):

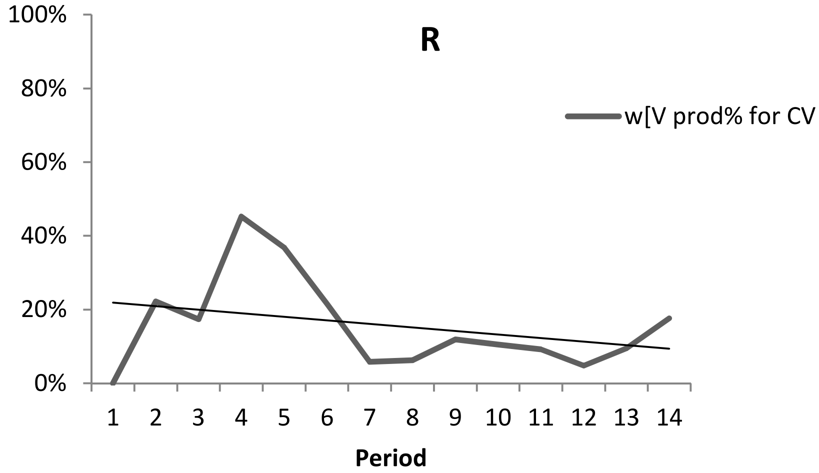
(18) Omission of simple vs. complex onset- evidence of initial stage

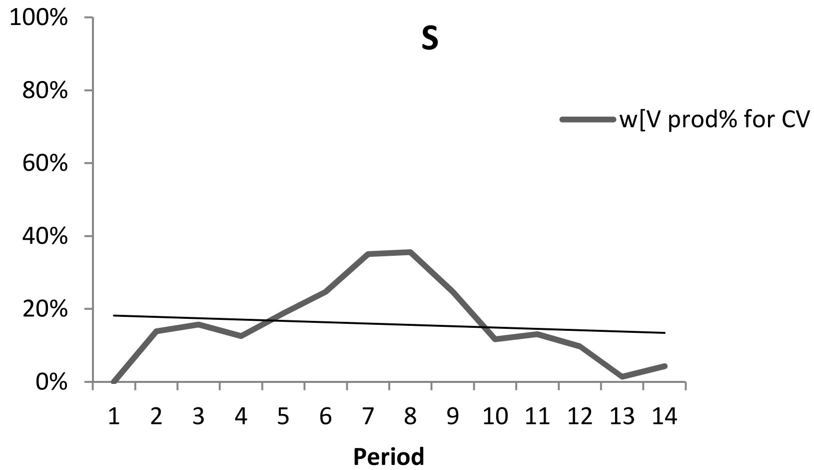
Child name & Age	Child output	Target	Gloss
R (1;10.28-2;03.01)	ixá	mixál	‘Michal’(proper name)
R (2;00.16)	mixá	smixá	‘blanket’
Y (2;02.28-2;05.28)	ixá	mixál	‘Michal’(proper name)
Y (1;10.09)	exá	smixá	‘blanket’

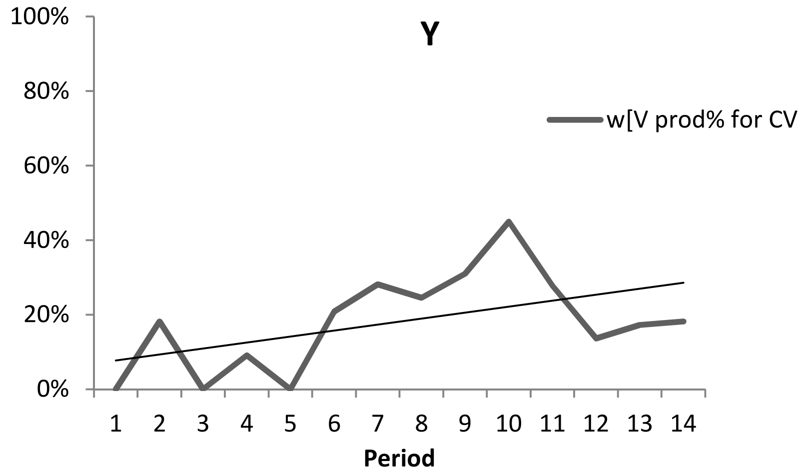
This pathway of development supports the observations of Ben-David (2001) and Greenlee (1974) regarding the acquisition of clusters. Y’s development stretches over a longer period of time compared to R and S, enabling us to observe in more detail the processes that take place, some of which we might otherwise miss.

The charts in (19) and (20) show the omission of onsets in the children’s productions over time:

(19) Simple onset omission over time

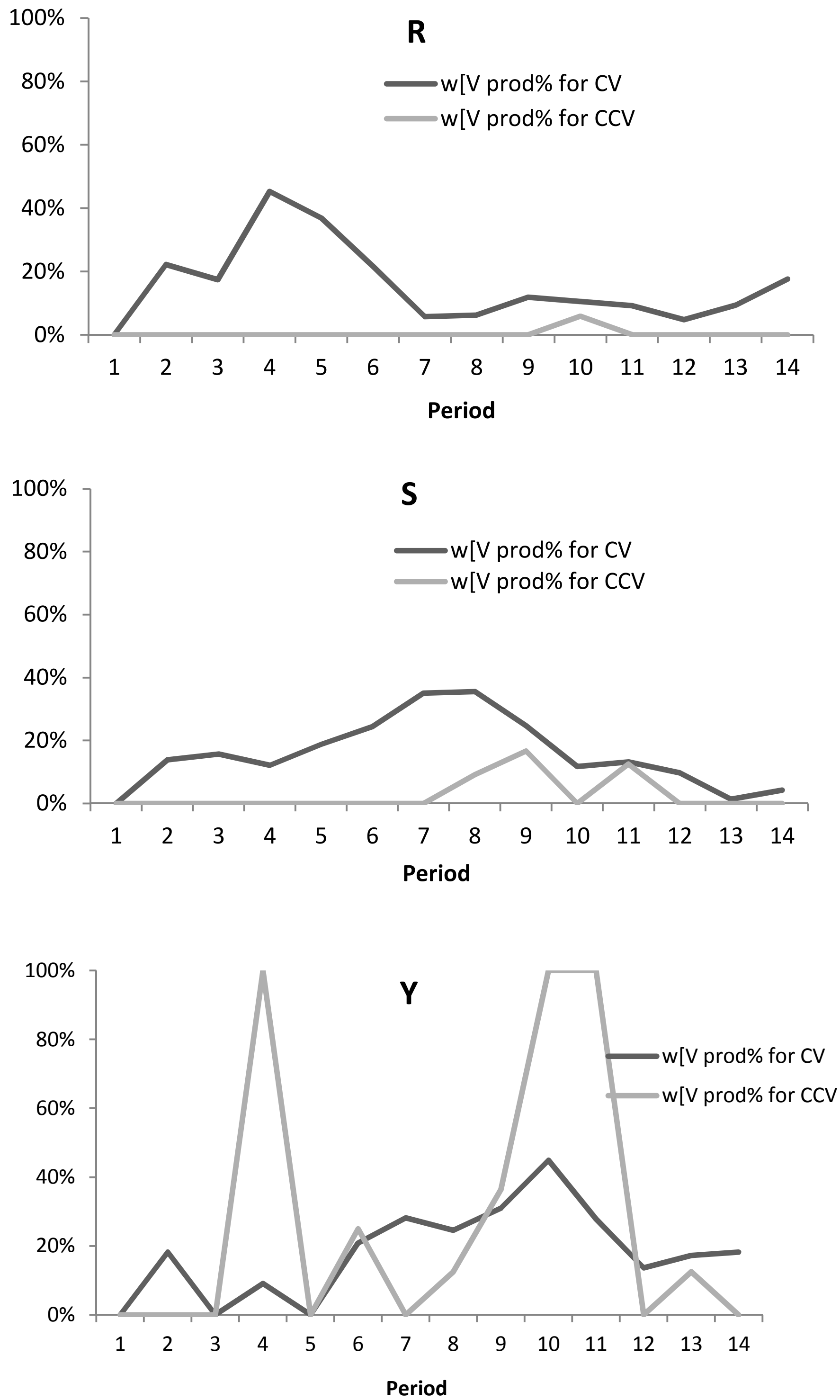






The charts above show the omission rate of simple onsets throughout the periods of development. As indicated by the trend line, omission rates seem to decrease over time for R and S, but increase for Y. The gap in development is further illustrated in the charts in (20), where the omission of simple onsets over time is compared with that of complex onsets:

(20) Simple vs. complex onset omission over time



While there is no evidence of the initial stage (total omission of onsets for both $_{w}$[CCV and $_{w}$[CV targets) in R and S's data (recall the scarcity of complex onset omissions in their productions), Y's data provides us with the missing piece. Furthermore, it seems that at this point in development Y can provide us with evidence for the initial stage only. Unlike Y's chart, R and S's charts demonstrate similar, visible trends that indicate transition between stages (summarized in (21) below). This difference suggests that Y has not yet made the transition to the second stage.

The stages of onset acquisition that emerge from this analysis are summarized in (21):

(21) Stages of onset acquisition

Target		$_{w}$[CCV	gviná 'cheese'	$_{w}$[CV	giná 'garden'	Periods		
						R	S	Y
Production	I	$_{w}$[V	iná	$_{w}$[V	iná	---	---	1-14
	II	$_{w}$[CV	giná	$_{w}$[V	iná	1-7	1-10	---
	III	$_{w}$[CV	giná	$_{w}$[CV	giná	7-14	10-14	---
	IV	$_{w}$[CCV	gviná	$_{w}$[CV	giná	---	---	---

Y's prolonged development demonstrates the initial stage - No onset (I), while R and S provide evidence of the next two stages – One C deletion (II) and Simple onset (III). By the end of period 14 (the last period) the children have not reached the final stage of faithful productions yet.

In the next section I will incorporate the stages of onset acquisition based on the observations discussed above into an Optimality Theory based analysis. The stage that is most relevant to the present study is stage II, where a chain shift effect is observed.

3 OPTIMALITY THEORETIC ACCOUNT

In the constraint based framework of Optimality Theory (Prince & Smolensky 1993/2004, henceforth OT) the grammar is comprised of 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 this chapter I present the principles of OT and discuss the nature of constraint interaction in acquisition, with regard to the pattern of development described in the previous chapter.

3.1 CLASSIC OPTIMALITY THEORY

As established by Prince & Smolensky (1993/2004), surface forms are selected according to a language specific constraint ranking. There are two major types of constraints: **MARKEDNESS** constraints, representing conditions on the well-formedness of surface structures, and **FAITHFULNESS** constraints, which act to preserve lexical contrast through correspondence between input and output forms (McCarthy & Prince 1995). All constraints are violable by definition and as markedness constraints are in constant conflict with faithfulness constraints as well as other markedness constraints, there is no grammar that satisfies all the constraints. Cross-linguistic variation is represented through different rankings of these universal constraints.

Surface forms are selected as a result of the operation of the two functions of grammar, GEN and EVAL. For every underlying input the function GEN generates a set of possible outputs, or *candidates,* for evaluation by the function EVAL. EVAL selects the most harmonic candidate according to the language specific constraint hierarchy. The optimal candidate is the form that best satisfies the system of constraints by minimal violation of the lower ranked constraints (see Prince & Smolensky 1993/2004 for an elaborate discussion).

It is important to note that in classic OT, the generation and evaluation of candidates is performed in parallel, i.e. without intermediate derivational steps.[8]

3.1.1 Acquisition in OT

In this constraint-based model, language acquisition involves gradual reranking of constraints in order to achieve the ranking in the target language (Tesar & Smolensky 1996).[9]

As children's early productions are characterized by unmarked structures, it has been suggested that in the initial stages of acquisition markedness constraints outrank faithfulness constraints (Demuth 1995; Gnanadesikan 1995/2004; Tesar & Smolensky 1996; Levelt & Van de Vijver 1998/2004; Hayes 1999/2004; Levelt et al. 2000, among others). Over time, more faithfulness constraints are reranked above markedness constraints (according to the constraint hierarchy of the target language), leading to the production of more marked structures.[10]

With regard to the syllable, the interaction between the structural constraints (i.e. markedness constraints) relating to syllable well-formedness and conflicting faithfulness constraints will determine the possible syllable structures in a language (or an intermediate grammar in a specific stage of acquisition).

---

[8] The notion of gradual evaluation is captured in a derivational version of OT called *Harmonic Serialism*, in which GEN performs only one change at a time. The output of EVAL is fed back into GEN, which in turn generates another limited set of candidates for evaluation and so on until no further improvement can be made (Prince & Smolensky 1993/2004; McCarthy 2000, 2008).

[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). This theoretical discussion will not be addressed in this paper.

[10] Although many unmarked forms also happen to be structurally simple, the relationship between markedness and complexity is not always straight-forward. For example, the syllable type that is considered to be universally unmarked is CV, and this is despite the fact that it is more structurally complex than a syllable of the structure V. In spite of the relative complexity of CV structure, all known languages that allow V syllables also allow CV syllables, but not vice versa.

The relevant structural constraints, based on Prince & Smolensky (1993/2004), are provided in (22):

(22) Structural constraints

ONSET	A syllable must have an onset (e.g. no V syllables)
NOCODA	A syllable must not have a coda (e.g. no CVC syllables)
*COMPLEX	No more than one C or V may associate to any syllable position node (e.g. no CCV syllables)

Different ranking of the faithfulness constraints in relation to these markedness constraints will result in the emergence of different syllable types. For example, a grammar in which all structural constraints dominate faithfulness constraints will only allow CV syllables – the universally unmarked syllable structure. Adopting the view of initial dominance of markedness over faithfulness, this is the only syllable type permitted by the child grammar in the initial state. This is exemplified in the tableau in (23), taken from Adam (2002):

(23) Initial ranking: MARKEDNESS » FAITHFULNESS

Input: CCVC	MARKEDNESS			FAITHFULNESS
	*COMPLEX	NOCODA	ONSET	FAITH
a. CCVC	*!	*		
b. CVC		*!		*
c. CCV	*!			*
d. V			*!	***
e. VC		*!	*	**
f. ☞CV				**

The faithfulness constraints are represented here as FAITH. In this case, a violation of FAITH is incurred when a consonant in the input does not have a correspondent in the output (i.e. whenever a consonant is deleted). As long as all three markedness constraints are ranked above FAITH, the only possible output is candidate (23f).[11] Any violation of either *COMPLEX, NOCODA or ONSET will result in the elimination of the candidate. At this point, there is no evidence for crucial ranking between the markedness constraints (represented by a dotted line in the tableau). As pointed out by Adam (2002), the ranking above represents three pairs of conflicting constraints:

i. *COMPLEX » FAITH

ii. NOCODA » FAITH

iii. ONSET » FAITH

During the course of acquisition, the constraints are reranked with respect to each other according to the hierarchy in the target language. For example, if the target language allows syllable codas, the reranking of NOCODA below FAITH will enable CVC syllables to surface:

(24) Reranking: NOCODA » FAITH → FAITH » NOCODA

Input: CVC	FAITH	NOCODA
a. CV	*!	
b. ☞CVC		*

In the initial state, candidate (24b) would be eliminated due to violation of NOCODA, resulting in the selection of (24a) as optimal. In this stage, only CV syllables are expected to surface. The reranking of NOCODA below FAITH enables the selection of the faithful candidate as optimal, thus increasing contrast. In languages that allow

[11] The example in (23) is only partial, as there are other possible candidates that do not appear in the tableau, such as the candidate CVCV. Like candidate (23f), this candidate does not violate any of the markedness constraints. The difference lies in the nature of faithfulness violation and the resulting prosodic structure. While CV violates faithfulness twice by omitting two consonants, CVCV violates faithfulness by omitting one consonant and inserting a vowel. As a result, another syllable is added to the word. Regardless, the syllable structure in both outputs is the same.

clusters, codas and onsetless syllables, all three constraints will eventually be reranked below conflicting faithfulness constraints, but not necessarily in the same order by all children. Some generalizations can be made, though. In a study of 12 children acquiring Dutch, Levelt et al. (2000) observed that all children produced codas and onsetless syllables prior to clusters, with variation observed mainly in the order of the acquisition of more complex syllable structures (onset clusters, coda clusters and various combinations; see also Levelt & Van de Vijver 1998/2004 for discussion of typology and acquisition with regard to syllable types).

In the context of the present study, the reduction of clusters during the course of acquisition is naturally predicted by OT (as they are marked structures). However, the same thing could not be said about the production of onsetless syllables for target words with an onset, as the omission of onsets violates both ONSET and the faithfulness constraint MAX, demanding that every segment in the input have a correspondent in the output (McCarthy & Prince 1995). The result is the substitution of the unmarked CV syllable with the relatively marked V structure, an unexpected outcome given the typology of syllable structure, and a pattern that is unattested in fully developed languages. Consonant harmony (the assimilation of one consonant to another across vowels) is another example of a child-specific phenomenon (e.g. Grunwell 1982; Pater 1997; Pater & Werle 2003; Gafni 2011, among others). Such disparities between child and adult language pose a problem to the strong identity hypothesis (Jakobson 1941/1968), or the continuity assumption (Pinker 1984). Under this notion, child grammar does not differ qualitatively from adult grammar. The same laws govern child language and the fully developed languages of the world, and both systems are subject to the same processes (Stampe 1969). In OT terms, this applies to the set of universal constraints. To avoid assigning child-specific constraints, the assumption would be that a constraint whose effect is absent in adult language must be ranked low in the hierarchy. However, this is in conflict with factorial typology (Prince & Smolensky 1993/2004) that predicts the effect of this constraint should emerge in some language, and also with the assumption that intermediate child grammars should correspond to some existing adult language. Following this assumption, we would expect to see evidence of such a pattern in fully developed languages as well.

3.1.2 Prominent positions in child vs. adult grammar

The omission of onsets is even more unexpected considering contextual strength relations. This notion refers to the asymmetry in the behavior of phonological elements in different positions, specifically prominent vs. non-prominent positions (Beckman 1998; Casali 1996; Lombardi 1999; Smith 2000). Cross linguistically, phonological units in some positions tend to maintain contrast and resist processes of neutralization. Such positions include roots, syllable/foot/word initial position and stressed positions, and are perceived as more salient. In contrast, units in perceptually or psycholinguistically 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.

Nevertheless, a closer look at child phonology reveals more 'unnatural' processes. Dinnsen & 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 & Rose (2008) discuss velar fronting and lateral gliding in word-initial and/or stressed onsets - instances of neutralization in prosodically strong positions that are 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 & Farris-Trimble 2009, and references therein). This leads us to conclude there must be an underlying motivation for the children's production of word-initial onsetless syllables.

This motivation could relate to something other than the well-formedness of syllable structure. In section 2.2.4, the omission of onsets was shown to occur in polysyllabic, but not monosyllabic productions.[12] As argued, this implies 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 here: Where markedness and complexity do not conform, complexity prevails. Thus children produce sub-Minimal Words before producing the universally unmarked binary foot (Demuth 1995; Demuth & Fee 1995; Ben-David 2001; Adam 2002). As Ben-David (2001) 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

[12] As discussed in section 2.2.4, there are differences between typical and atypical development with respect to the production of monosyllabic onsetless words, however even if such words are produced, the rate of production compared to polysyllabic words is significantly lower, indicating a clear trend.

target words of 3 and 4 syllables, observed by Ben-David (2001) as well as in the present study:[13]

(25) Productions of tri- and quadrisyllabic targets

Child	Age	Output	Target	Gloss
R	1;08.27	edáim	jadáim	'hands'
R	1;09.18	abáim	garbáim	'socks'
R	1;09.27	emíma	jemíma	'Yemima' (proper name)
R	2;01.27	átatsim	nátsnatsim	'sparkles'
R	2;02.04	avaním	levaním	'white ms. pl.'
S	1;06.12	ipaʁáim	mispaʁáim	'scissors'
S	1;06.26	anána	banána	'banana'
S	1;07.17	itijá	mitʁijá	'umbrella'
S	1;07.23	ókolad	ʃókolad	'chocolate'
S	1;10.26	agafáim	magafáim	'boots'
Y	2;04.09	ekuká	mekulkál	'out of order'
Y	2;05.00	efúax	tapúax	'apple'
Y	2;06.04	ifétset	miflétset	'monster'
Y	2;08.27	atosím	metosím	'airplanes'
Y	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 & Edwards 1977; Bernhardt & Stemberger 1998; Stemberger et al. 1999; Bat-El 2010). In this case, prosodic complexity increases (words consisting of more syllables) at the expense of segmental faithfulness (onset omission).[14]

[13] 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.

[14] 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 (e.g. R 2;00.16 *ʃeʃéʁet* for *ʃaʁʃéʁet* 'necklace' (word-initial onset is produced while word-medial coda is omitted); R 1;11.18 *əʁbáim* for *gaʁbáim* 'socks' (word-initial onset omitted while word-medial coda is produced).

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

Dinnsen & 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 (e.g. Echols & Newport 1992). In a picture naming experiment combining phonological priming, Brooks & MacWhinney (2000) determine 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 & 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, thus giving priority to perceptually prominent positions.

3.2 SYNCHRONIC CHAIN SHIFTS AND LOCAL CONJUNCTION OF CONSTRAINTS

This section presents an OT account of the acquisition of onsets based on the data presented in this study. The stages of development as summarized in section 2.3 are given below:

(26) Stages of onset acquisition

Target			$_W$[CCV	gviná 'cheese'	$_W$[CV	giná 'garden'
Production	Stage I	No onset	$_W$[V	iná	$_W$[V	iná
	Stage II	One C deleted	$_W$[CV	giná	$_W$[V	iná
	Stage III	Simple onset	$_W$[CV	giná	$_W$[CV	giná
	Stage IV	Faithful	$_W$[CCV	gviná	$_W$[CV	giná

In stage I, target words with both simple and complex word-initial onsets are produced without an initial onset. In 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 stage III, word-initial simple onsets are produced while word-initial clusters are still reduced to a singleton. In stage IV both simple and complex word-initial onsets are produced.

The relevant constraints are provided in (27):

(27) 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 peak of a syllable

FAITHFULNESS CONSTRAINTS

MAX-SEG		Every segment in the input should have a correspondent in the output

As discussed in 3.1.1, while there are many languages that do not allow clusters or onsetless syllables, there are no languages known to demand onsetless syllables (languages that allow onsetless syllables also allow syllable onsets, but not vice versa). Unlike the constraints *COMPLEX and ONSET that are active in both child and adult language, the constraint $_{W}$[V appears to be child-specific and is in that sense non-universal. This undoubtedly casts a shadow on its legitimacy, however the empirical evidence cannot be ignored. Further consideration is required to resolve the conflict between theoretical restrictiveness and empirical necessity (Ito & Mester 1998).

3.2.1 Stage I: Total omission (MARKEDNESS » FAITHFULNESS)

As evident in Y's productions, in this initial stage the onset is omitted entirely, regardless of the input. The tableaux in (28) demonstrate the constraint ranking at this stage in development:

(28)

i. Target: Simple onset

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

ii. Target: Complex onset

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

Since $_{W}$[V outranks MAX-SEG, the winning candidate is the onsteless form, whether the target-onset is simple (i) or complex (ii). However, there is no evidence at this point for crucial ranking of *COMPLEX with respect to $_{W}$[V, and therefore the constraint ranking in this stage of development is: *COMPLEX, $_{W}$[V » MAX-SEG.

3.2.2 Stage II: Simple onset omission and cluster reduction (MARKEDNESS ~ FAITHFULNESS)

This stage of development is characterized by onsetless productions for input-simple onset targets (*giná → iná*) and simple onset productions for input-complex onset targets (*gviná → giná*). The tableau in (29i) demonstrates the constraint ranking yielding the output for simple onset targets:

(29)

i. Target: Simple onset

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

The selection of candidate (ib) over (ia) is an indication that $_{W}$[V still outranks MAX-SEG. However, this ranking cannot account for the selected output in the case of complex-onset targets, as shown in (29ii):

ii. Target: Complex onset

Input: gvina	*COMPLEX	$_{W}$[V	MAX-SEG
a. gvina	*!	**	
b. gina		*!	*
c. ☛ina			**

Although the expected output is candidate (iic), indicated by the black hand symbol, the actual output is (iib).

It would be possible to claim 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 section 2.3) is not compatible with the pattern of free variation characteristic of transition stages.

This leads to the conclusion there must be another constraint favoring candidate (iib) over (iic). To put simply, there is a constraint preventing (*gviná* → *iná*), thus creating a chain shift effect (see section 2.3).

Kirchner (1995, 1996) proposes the use of local constraint conjunction of two faithfulness constraints in order to account for synchronic chain shifts and argues in favor of an OT analysis.[15] The concept underlying local conjunction of constraints (Green 1993; Smolensky 1993) refers to the combined effect of conjoined constraints

[15] Kirchner (1995) refers to the notion of *Distantial Faithfulness*, later adopted by Dinnsen & 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.

as opposed to the effect of each constraint independently, i.e. simultaneous violation of two conjoined constraints in a certain domain leads to the elimination of a candidate whereas a violation of each constraint alone does not.[16] Self-conjunction is a special case of constraint conjunction, where the conjoined constraints are identical (see for example Ito & Mester 1998). This is the case here. The tableaux in (31) demonstrate the constraint interaction under the approach of constraint conjunction, introducing the self-conjunction of MAX-SEG, as defined in (30):

(30) 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.

(31)

i. Target: Simple onset

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

ii. Target: Complex onset

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

The violation of $_W$[V by the winning candidate (iib) provides evidence for the crucial ranking of this constraint below *COMPLEX and MAX-SEG$^2_{ONS}$. Candidate (iic) violates MAX-SEG$^2_{ONS}$ as both onset consonants are absent and is therefore eliminated. Candidate (iia) violates the undominated *COMPLEX and is ruled out as well. By

[16] See Moreton & Smolensky (2002) for a discussion of typological predictions of local constraint conjunction, as well as Jesney (2005) for a review of alternative accounts for chain shifts and the resulting theoretical implications.

introducing the conjoined constraint we are able to correctly predict the output for both simple and complex onset targets.

The ranking of constraints in this stage of development is: *COMPLEX, MAX-SEG$^2_{ONS}$ » $_W$[V » MAX-SEG. Returning to the initial stage, the hypothesized ranking is: *COMPLEX, $_W$[V >> MAX-SEG$^2_{ONS}$, MAX-SEG (markedness above faithfulness).

*3.2.3 Stage III: Faithful production of simple onsets and cluster reduction (*COMPLEX, MAX-SEG$^2_{ONS}$ » MAX-SEG » $_W$[V)*

In this stage the children produce simple-onset targets faithfully while still reducing clusters to singletons. The tableaux in (32) illustrate the predicted outputs for simple and complex-onset targets:

(32)

i. Target: Simple onset

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

ii. Target: Complex onset

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

The winning candidate (ia) violates $_W$[V, thus providing us with evidence of the reranking of MAX-SEG above $_W$[V. From the selection of candidate (iib) over (iia) we conclude that *COMPLEX still outranks MAX-SEG. Therefore the ranking in this stage of development is: *COMPLEX, MAX-SEG$^2_{ONS}$ » MAX-SEG » $_W$[V.

3.2.4 *Stage IV: Faithful production (FAITHFULNESS » MARKEDNESS)*

In the final stage the children produce all target onsets faithfully, as illustrated in (33):

(33)

i. Target: Simple onset

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

ii. Target: Complex onset

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

The selection of candidate (iia) as optimal is an indication of the reranking of the faithfulness constraints above *COMPLEX. Therefore, the ranking in the final stage is: MAX-SEG$^2_{ONS}$, MAX-SEG » *COMPLEX, $_W$[V.[17]

A summary of the rankings of the four stages of onset acquisition is given below. The reranking of constraints is indicated by arrows.

[17] As discussed in section 1.1.2, triconsonantal clusters are rare in Hebrew, and there are no documented attempts to produce such forms in the data. However, the analysis proposed above raises questions about the prediction regarding target words with triconsonantal clusters, specifically - whether the analysis will require a higher level of conjunction (i.e. MAX-SEG^3).

(34) Stages of simple and complex onset acquisition in Hebrew - summary

Stage		Ranking
I	No onset	*COMPLEX, ${}_{w}$[V >> MAX-SEG$^{2}_{ONS}$, MAX-SEG
II	One C deleted	*COMPLEX, ${}_{w}$[V >> MAX-SEG$^{2}_{ONS}$, MAX-SEG → *COMPLEX, MAX-SEG$^{2}_{ONS}$ » ${}_{w}$[V » MAX-SEG
III	Simple onset	*COMPLEX, MAX-SEG$^{2}_{ONS}$ » ${}_{w}$[V » MAX-SEG → *COMPLEX, MAX-SEG$^{2}_{ONS}$ » MAX-SEG » ${}_{w}$[V
IV	Faithful	*COMPLEX, MAX-SEG$^{2}_{ONS}$ » MAX-SEG » ${}_{w}$[V → MAX-SEG$^{2}_{ONS}$, MAX-SEG » *COMPLEX, ${}_{w}$[V

4 SUMMARY

During the course of simple and complex onset acquisition, children go through a stage in which they omit the word-initial consonant. Quantitative and qualitative data obtained from two typically developing subjects (R and S) and one atypically-developing subject (Y) confirm this observation, previously made by Ben-david (2001).

Data analysis, presented in section 2.2, showed that all three children omitted the onset in polysyllabic target words. Although Y also omitted the onset in monosyllables, the omission rate in these targets was significantly lower. This context-specific omission implies this process is triggered by an increase in prosodic complexity. This is further substantiated by the omission of word-initial onsets in later attempted tri- and quadrisyllabic targets, shown in section 3.1.2. The omission of onsets may seem surprising, considering the prominence of word-initial position, the relative markedness of the resulting V syllable structure compared to CV structure, and the absence of such patterns in adult language. However, the data clearly show 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.

The effect of stressed versus unstressed position on the omission of onsets was examined as well, to reveal a lower rate of omission in stressed positions in the productions of R and Y, but not in S's productions, where the omission rate was higher in stressed positions. A higher omission rate in stressed positions contradicts our expectations since stressed positions are considered to be more prominent than unstressed ones, and are therefore often resistant to neutralization or omission.

Sonority was also shown to have an effect on omission patterns, as the overall omission rate of sonorants (41%; 275/673) was significantly higher than the omission rate of obstruents (10%; 178/1795) in the children's productions. This is consistent with the universal preference for low-sonority onsets, discussed in section 2.2.3.

A developmental account of the acquisition of simple and complex onsets in Hebrew provided an intriguing observation. The data indicate the existence of a stage in which simple onsets are omitted (e.g. *giná* 'garden' → *iná*), while complex onsets are reduced to singletons rather than omitted entirely (e.g. *gviná* 'cheese'→ *giná*). This creates a chain shift of the form $_{w}$[CCV→$_{w}$[CV →$_{w}$[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*). This state of affairs poses a challenge to classic Optimality Theory (Prince & Smolensky 1993/2004), where surface forms are selected according to a language specific constraint ranking. In this non-derivational framework, if the surface form of

$_w[V$ structure is preferred over $_w[CV$ (evident from the omission of word-initial consonants), it should be preferred regardless of the underlying form.

Following Kirchner (1995, 1996), the existence of both forms in the same stage of phonological development can be resolved by using local constraint conjunction (Green 1993; Smolensky 1993), which refers to the combined effect of conjoined constraints as opposed to the effect of each constraint independently (in this instance - the self-conjunction of a faithfulness constraint). As shown in section 3.2.2, ranking the self-conjunction of the faithfulness constraint prohibiting deletion (along with the markedness constraint prohibiting clusters) above the markedness constraint underlying onset omission correctly predicts the omission of one, but not two onset consonants in complex-onset targets. Incorporating the notion of constraint conjunction in the analysis enables a unified Optimality Theoretic account of the acquisition of simple and complex onset in Hebrew.

A full developmental account was made possible by combining data from both typical and atypical development, as Y's prolonged development provided evidence of the initial stage of acquisition where both simple and complex onsets are omitted, while R and S provided evidence of the later stages of development.

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