SEGMENTAL EFFECTS ON SYLLABLE SELECTION: EVIDENCE FROM HEBREW

GALIT ADAM AND OUTI BAT-EL

1. Introduction

The selection of the syllable from the target word is governed by two prosodic constraints: PROMINENCE for the selection of the stressed syllable, and POSITION, for the selection of the final syllable. As shown in Ben-David (2001) and Adam (2002), the preference is evident during the stage at which the children produce monosyllabic forms for targets with final stress (e.g. *ka* for *kadúr* 'ball') and disyllabic forms for targets with non-final stress (e.g. *táta* for *sáfta* 'grandma' and *úka* for *múzika* 'music'). The stressed and the final syllables are perceptually more accessible than unstressed and/or non-final syllables (Echols and Newport 1992, Kehoe 2000).

Studies of monolingual Hebrew-speaking children (Ben-David 2001, Adam 2002), including the present study, support the claim that the prosodic constraints play a major role in the target-production correspondence. In this paper, however, we show that segmental effects may interact with the prosodic constraints, in particular, that the syllable is selected on the basis of the preference for the vowel *a*. The effect of *a* on syllable selection is evident mostly, but not exclusively, during the initial prosodic stage, known as the sub-minimal word stage (Demuth 1995). However, based on a comparison between two children with different developmental pace, it appears that evidence for such an effect can be found only in slow development.

2. Details of the study

Our data are drawn from a longitudinal study of the early speech of two Hebrew-speaking children, where one child (S) exhibited a faster developmental pace than the other (Y). As shown in the table below, although the two children produced the first word at a similar age, S reached 254 cumulative attempted target words 8 months before Y.

Child	Pace of development	First recording	First word	Last recording	Cumulative attempts
S	Faster	0;08.04	1;02.00	1;06.26	254
Y	Slower	1;00.05	1;02.29	2;02.28	260

Table 1: Children's information

The children were recorded on a weekly basis, in their natural environment, and the data were transcribed and coded in CHILDES. The speech sample is drawn from spontaneous speech and picture/object naming.

In order to display the gradual development, we divided the data into periods, which were determined on the basis of cumulative attempted target words. The scale starts with up to 10 words for the first period, 50 for the second period, and then additional 50 words for every subsequent period.

Period	I	II	III	IV	V	VI
Scale by # of words	~10	~50	~100	~150	~200	~250

Table 2: Periods of quantitative examination

3. Prosodic effects on syllable selection

In the acquisition of Hebrew (Ben-David 2001, Adam 2002, Tubul-Lavy 2005, Adi-Bensaid 2006), as well as languages such as Dutch (Fikkert 1994), English (Pater 1997), and Catalan (Prieto 2006), there is a stage, during which the children produce the stressed and/or the final syllable. As shown in the Hebrew examples below, the prosodically-governed target-production correspondence allows monosyllabic productions for targets with final stress and disyllabic productions for targets with non-final stress.

Target	Child		
Target words with final stress: Target $\sigma_2\sigma_1$ – Child σ_1			
bakbúk	bu	'bottle'	S 1;04.24
dolfín	fin	'dolphin'	S 1;05.04
agás	gaθ	'pear'	S 1;05.08
Target words with penultimate stress: Target $\acute{\sigma}_2\sigma_1$ – Child $\acute{\sigma}_2\sigma_1$			
kóva	kóa	'hat'	S 1;04.24
écba	éba	'finger'	S 1;05.04
glída	díla	'ice cream'	S 1;05.08

Target words with antepenultimate stress: Target σ$_3$σ$_2$σ$_1$ – Child σ$_3$σ$_1$			
tapúax	púax	'apple'	S 1;04.24
goríla	gíla	'gorilla'	S 1;05.04
yaréax	éax	'moon'	S 1;05.08

Table 3: Prosodically-governed syllable selection in Hebrew

4. Segmental effects on syllable selection

Based on data drawn form Y, we argue that segmental constraints may interact with the prosodic constraints, in the task of syllable selection. We concentrate on the preference for the vowel *a*, referred here as TAKE-*a*.

The sub-minimal word stage, at which most polysyllabic targets are produced as monosyllabic, was rather long for Y, in comparison with S as well as other children (Ben-David 2001). Y thus provided us with quite a few monosyllabic forms supporting the effect of TAKE-*a*.

4.1. Deciding between PROMINENCE and POSITION

In monosyllabic productions for targets with non-final stress, the child has to determine whether to respect PROMINENCE and select the stressed syllable, or respect POSITION and select the final syllable.

Target		Production				
		POSITION		PROMINENCE		
'water'	máim			ma	<i>	Y 1;03.27
'tractor'	tráktor			ka	<o>	Y 1;04.03
'Shira'	ʃíra	ta	<i>			Y 1;04.03
'ice cream'	glída	da	<i>			Y 1;04.24
name	nóa	na	<o>			Y 1;06.12
'hat'	kóva	ba	<o>			Y 1;06.26
'two'	ʃtáim			ta	<i>	Y 1;09.18
'zebra'	zébra	ba	<e>			Y 1;08.14
'pita bread'	píta	ta	<i>			Y 1;10.09
'flower'	pérax	xa	<e>			Y 2;00.03

Table 4: Monosyllabic productions corresponding to targets with one *a*

As shown above, when either the stressed or the final syllable had an *a*, the syllable with the *a* is selected.[1]

The small number of penultimate stressed syllable with *a* (PROMINENCE) correlates with the distribution of the stress patterns in the language. Based on the Hebrew dictionary (compiled by Shmuel Bolozky and coded by Michael Backer), the distribution of *a* (stressed and unstressed) in final syllables of disyllabic words is 39% (2212/5667), while the distribution of stressed *a* in penultimate syllables is only 5.5% (313/5667).[2] The penultimate stressed *a* comprises of 17% (313/1842) of the penultimate *a*'s in disyllabic words. Even if we look only at the words with at least one *a* (counting twice those with two *a*'s), the distribution of penultimate stressed *a* is only 8% (313/4014), compared with 54% (2172/4014) of final *a*. This distinction is reflected in the child's selection of syllables in his monosyllabic productions.

As shown in the quantitative data below, the child selected the final syllable with *a* more often than the penultimate syllable, 62% (133/214) vs. 38% (81/214) respectively. However, this distinction is not to be attributed to the preference of POSITION, but rather to what the language provides, given the low distribution of penultimate stressed *a*. Crucially, in most of his productions (average of 97%), the child selected the syllable with *a*.

Period	Age	Total	Final unstressed			Non-final stress		
			Total		with *a*	Total		with *a*
I	1;02.29-1;04.03	4	1	25%	**100%**	3	75%	**100%**
II	1;04.10-1;7.12	24	16	67%	**100%**	8	33%	**86%**
III	1;7.23-1;9.18	97	82	85%	**100%**	15	15%	**87%**
IV	1;10.02-1;11.13	62	23	37%	**100%**	39	63%	**92%**
V	1;11.25- 2;01.03	20	7	35%	**100%**	13	65%	**100%**
VI	2;01.22-2;02.28	7	4	57%	**100%**	3	33%	**100%**
	Total	214	133	62%	**100%**	81	38%	**94%**

Table 5: Monosyllabic productions corresponding to targets with penultimate stress

The data above clearly suggest the effect of TAKE-*a* on syllable selection, in cases where the child had to determine whether to respect PROMINENCE (stressed syllable) or POSITION (final syllable).

It should be noted that the child had all the five vowels of Hebrew in his inventory (with the exception of period I), though, as shown below, *a* is by far the most frequent vowel in both targets and productions.

	a	**i**	**o**	**e**	**u**
Targets	**53.5%**	18.1%	15.1%	8.2%	5.1%
Productions	**64.4%**	7.7%	16.4%	8.2%	3.3%

Table 6: The distribution of vowels in Y's data

The high frequency of *a* in Y's data reflects its high frequency in the language. In the 5667 disyllabic words (the most common word size of Hebrew stems), the frequency of *a* is 36%, while of the rest of the vowels is 22.5% for *i*, 17% for *e*, 14.5% for *u*, and 10.5% for *o*. Not only that *a* enjoys the highest frequency in Hebrew, it is also the most salient vowel; it is longer than the other vowels (Most et al. 2000), and also more sonorous.[3] Thus, Y, like other children, reflects the preference for *a* in both attempts and productions. However, Y's preference for *a* is higher than that in the language. While the distribution of *a* in Hebrew is 36%, its distribution in Y's speech is 53.5% in attempted targets and 64.4% in productions.

4.2. Violating PROMINENCE/POSITION

There were also a few instances, where TAKE-*a* overpowered the prosodic constraints PROMINENCE or POSITION. In such forms (presented in the right column below), Y produced a syllable with *a*, which does not correspond to the stressed/final syllable. In all these forms, the target was a word with final stress, where PROMINENCE and POSITION converge.

PROMINENCE/POSITION Final/stressed syllable				**TAKE-*a* Non-final unstressed syllable**				
Target		**Child**		**Target**		**Child**		
'tower'	migdál	da	<i>	'donkey'	xamór	xam	<o>	1;05.01
'star'	koxáv	xa	<o>	'orange'	katóm	ka	<o>	1;07.23
'egg'	bejcá	ta	<e, i>	'other'	axér	xa	<e>	1;09.18
				'hen'	tarnegól	ta	<e, o>	1;10.02
'thanks'	todá	da	<o>	'balloon'	balón	ba	<o>	1;11.05
				'hello'	ʃalóm	ʃa	<o>	1;11.13
				'costume'	taxpóset	ta	<o, e>	2;00.03

Table 7: Selection of unstressed non-final syllable with *a*

As shown below, in 90% of the cases, Y produced the final stressed syllable. However, the 10% of the cases where he produced the non-final unstressed syllable were due to TAKE-*a*, given that in 96% of these production there was an *a*. Moreover, the productions respecting PROMINENCE and POSITION are also indicative, since in 75% of them there was an *a* (cf. 39% of final *a* in Hebrew):

Period	Age	Total	Final stressed			Non-final unstressed		
			Total		with *a*	Total		with *a*
I	1;02.29-1;04.03	0						
II	1;04.10-1;07.12	54	53	98%	**100%**	1	2%	**100%**
III	1;07.23-1;09.18	326	276	85%	**83%**	50	15%	**96%**
IV	1;10.02-1;11.13	166	142	86%	**61%**	24	14%	**83%**
V	1;11.25-2;01.03	176	168	95%	**55%**	8	5%	**100%**
VI	2;01.22-2;02.28	95	93	98%	**75%**	2	2%	**100%**
	Total	817	732	90%	**75%**	85	10%	**96%**

Table 8: Monosyllabic productions corresponding to targets with final stress

5. Developmental Criteria

The effect of TAKE-*a* appeared in Y's speech but not in S's. We suggest that TAKE-*a* can serve as an indicator for slow development, as it correlates with other criteria pointing out that Y's development is not typical.

5.1. Cumulative attempted targets

Base on the period scale presented in §2, the table below shows that the age gap between the two children increases throughout the periods. Y produced his first word at 1;02.29, only 29 days after S, whose first word appeared at 1;02.00 (see Adam and Bat-El this volume for criteria identifying the first word). While the gap in the starting point is negligible, its increase in the following periods is overwhelming. The children reached period VI, of 250 cumulative target words (254 for S and 260 for Y), with 8 months gap in favor of S.

Pr.	Scale: # of words	S Age (# of sessions)	S # of words	Y Age (# of sessions)	Y # of words	Age gap
	1st word	1;02.00		1;02.29		**0.29**
I	~ 10	1;02.00–1;03.05 (6)	9	1;02;29-1;04.03 (6)	10	**0.28**
II	~ 50	1;03.14–1;04.24 (13)	49	1;04.10-1;07.12 (18)	47	**2.29**
III	~ 100	1;05.04–1;05.08 (15)	96	1;07.23-1;09.18 (26)	97	**4.10**
IV	~ 150	1;05.15–1;05.29 (18)	147	1;10.02-1;11.13 (31)	145	**5.15**
V	~ 200	1;06.02–1;06.20 (21)	207	1;11.25-2;01.03 (35)	188	**6.14**
VI	~ 250	1;06.26 (22)	254	2;01.22-2;02.28 (38)	260	**8.02**

Table 9: Cumulative attempted targets in relation to age

The gap in the cumulative target words indicates a considerable difference in the developmental pace, where Y is identified as the slower developing child.

5.2. Truncated monosyllabic productions

As noted in Ben-David's (2001) longitudinal (non-quantitative) study of 10 typically developing Hebrew-speaking children, the sub-minimal word stage, characterized by monosyllabic productions, is rather short. Actually, there was no child whose first ten words consisted of only monosyllabic productions.

This could be due to language specific as well as universal effects, given the low distribution of monosyllabic words in Hebrew and their sub-minimal status (cf. Demuth 1995). The frequency of monosyllabic nouns is 0.5% (590/125,190) in the Hebrew dictionary (Bolozky and Becker), and 9% types (18/200) and 23% tokens (109/476) in child directed speech (3 hours). Monosyllabic verbs are even less frequent.

As shown below, both Y and S have a high percentage of truncated monosyllabic productions in period I (the first 10 cumulative attempted targets). However, while S shows a considerable decrease in monosyllabic productions already in period II (from 68% to 28%), Y persists with a high percentage until period VI.

Pr.	S				Y			
	Age	Total	Monosyllabic		Age	Total	Monosyllabic	
I	1;02.00–1;03.05	16	11	68%	1;02;29-1;04.03	10	7	70%
II	1;03.14–1;04.24	72	20	28%	1;04.10-1;07.12	79	57	72%
III	1;05.04–1;05.08	68	12	18%	1;07.23-1;09.18	178	168	94%
IV	1;05.15–1;05.29	92	20	22%	1;10.02-1;11.13	184	159	86%
V	1;06.02–1;06.20	104	17	16%	1;11.25-2;01.03	172	123	71%
VI	1;06.26	81	6	7%	2;01.22-2;02.28	228	87	38%

Table 10: Truncated monosyllabic productions

Thus, also the truncated monosyllabic productions, like the cumulative attempted targets (§5.1) indicate that the development of Y is much slower than that of S.

5.3. TAKE-*a* as an indicator of slow development

The data supporting the effect of TAKE-A (§4) were drawn from the speech of Y, the slower developing child; S always respected PROMINENCE/POSITION in targets with final stress (cf. Y in table 7). For example, he produced *tik* (rather than *ka*) for *kapít* 'spoon' (1;04.03) and *buk* (rather than *ba*) for *bakbúk* 'bottle' (1;06.20). Also in Ben-David's (2001) study of 10 typically developing Hebrew-speaking children, the prosodic constraints were always respected, regardless of the vowels. As for targets with non-final stress, S also did not provide sufficient monosyllabic productions to allow determining the role of TAKE-*a* (cf. Y in table 4). Only 15% of such targets were truncated to monosyllabic productions during periods II-IV, which dropped to 2% afterwards. Y, on the other hand, truncated the majority of target forms, 80% with non-final stress and 91% with final stress, thus allowing to observe the effect of TAKE-*a*.

The differences between the two children suggest a strong correlation between segmental effects and developmental pace (though here we provide evidence only for TAKE-*a*). The fewer the cumulative number of attempted targets the higher the frequency of monosyllabic productions, and the productions affected by TAKE-*a*. We thus propose that TAKE-*a* characterizes mostly slow (atypical?) development. This proposal requires, of course, further support from more studies of children with typical and atypical development.

6. Conclusion

We showed that segmental effects, in particular the preference for the vowel *a*, may interact with prosodic constraints in the selection of syllables in truncated forms, and in some cases even take priority over them. We suggested that the effect of TAKE-*a* indicates a slower developmental pace, supported by the frequency of truncations to monosyllabic forms and the cumulative attempted targets. There are, however, a few questions that need to be addressed.

We may wonder why the monosyllabic productions allow the emergence of TAKE-*a* effect, rather than, say, TAKE-*t*? One could imaging consonantal-based target-production correspondence, where a syllable with an oral stop is selected, as in the hypothetical **ki* for *xanukijá* 'Chanukah lamp' and **tu* for *xatuná* 'wedding' (cf. Ota 2003 for the effect of consonants on syllable deletion). However, we have not found such examples in our data, nor in the data provided by other studies. We submit that TAKE-*a*, which gives priority to the most salient vowel, joins forces with the prosodic constraints PROMINENCE and POSITION in enhancing the perceptual saliency of the syllable. Other things being equal, a syllable with *a* is more accessible than a syllable with *i*.

We should also ask why the effect of TAKE-*a* is found mostly in a slow developmental pace? This is due the fact that the effect of TAKE-*a* emerges in truncated monosyllabic forms in conjunction with the relatively great number of monosyllabic productions appearing in the over stretched sub-minimal word stage in slow development. As shown below, this leads to a difference in the distribution of *a* in the early periods (I-IV) in fast and slow development.

		I	II	III	IV	V	VI
Targets:	S (fast)	62%	39%	38%	43%	45%	48%
	Y (slow)	77%	54%	54%	54%	43%	40%
Productions:	S (fast)	62%	40%	42%	48%	47%	45%
	Y (slow)	88%	73%	75%	66%	45%	40%

Table 11: The distribution of *a* in both children (targets and productions)

As Y has been recently diagnosed as an atypically developing child, our results conform with Grunwell's (1987) observation, that disordered phonology exhibits phenomena that are not found in typical phonology.

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[1] In targets with two *a*'s, whether with penultimate or ultimate stress (e.g. *ʃáar* 'gate', *pará* 'cow'), it is often impossible to determine which syllable is selected.

[2] In most targets with penultimate stressed *a*, the final syllable is onsetless, and it is thus possible, as suggested in Adi-Bensaid (2006), that the preference of syllables with onset also plays a role in the selection of syllable (e.g. *ma* for *máim* 'water', *ba* for *báit* 'house', *ta* for *ʃtáim* 'two')..

[3] In terms of typology, according to Maddieson (1984) *i* is a bit more common than *a*, 91.5% vs. 88% respectively (based on a sample of 317 languages).