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When Do Universal Preferences Emerge in Language Development? The Acquisition of Hebrew Stress*

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Abstract
When children have to select one of two structures, do they start with the universally unmarked structure or with the one preferred by the ambient language? This question is directly relevant to metrical systems, which often employ either iambs or the universally unmarked trochees. We argue that children start with the universally unmarked trochaic foot, unless their ambient language provides them with sufficient data to arrive at the language-specific preferred foot prior to the onset of speech. We show that Hebrew-acquiring children, unlike French ones, are exposed to ambiguous data, which do not allow them to determine the type of foot the language's stress system employs. Our quantitative data provide evidence that in such a case, children adhere to the trochaic foot during the very early stage of acquisition (in the case study presented here, the early stage of acquisition refers to the first 100 cumulative target words). Later on, children follow the frequency-based preference in Hebrew, where final stress, and thus the iambic foot is employed in about 75% of the nouns.

Keywords
language acquisition, phonology, foot, the trochaic bias, markedness, stress, truncation, Hebrew

1. Introduction

It is well known that children acquire the unmarked structure before the marked one, as is the case with syllable structure (where a CV syllable is acquired before CVC) as well as segmental inventory (where stops are acquired before fricatives). The gradual development, where both the unmarked and the marked structures are eventually acquired, cannot be employed in the acquisition of stress, where children have to select one out of two structures, the trochaic or iambic foot.

On the basis of data from English, Allen and Hawkins (1978) argued for the "trochaic bias", according to which "the natural metric form of children's words is trochaic" (p. 176). This suggests that the acquisition of stress, like the acquisition

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of other phonological structures, begins with the universally unmarked structure. However, later studies questioned the validity of this claim, given that English is a trochaic language, and data from a trochaic language cannot tease apart the universal bias from language-specific effects. Moreover, studies of the acquisition of French (Rose 2000), Brazilian Portuguese (Santos 2001, 2006), and English (Rose and Champdoizeau 2008) do not support the trochaic bias, and thus provide further grounds for dismissing the universal trochaic bias.

In the present paper, we support the trochaic bias, providing data from the early speech of a typically developing Hebrew-speaking child, which show preference for the trochaic foot. We argue that this preference cannot be attributed to language-specific effects, since the Hebrew stress system employs both iambic and trochaic feet, where the iambic foot enjoys higher frequency.

We begin the discussion (§2) with a review of Hebrew noun stress. We first show that Hebrew-acquiring children are exposed to nouns with both final and non-final (mostly penultimate) stress, where the frequency of final stress is much higher (§2.1). Then we turn to the stress system, arguing that words with final stress are parsed with an iambic foot at the right edge, and words with non-final stress are parsed with a trochaic foot (§2.2). We proceed by introducing our research method and principles (§3), including the criteria for identifying the first word (§3.1), the division of the data into periods exhibiting the gradual lexical development (§3.2), and the three factors considered for the quantitative data (§3.3): the target factor (the attempted target words), the production factor (the produced words), and the truncation factor (the polysyllabic targets truncated into monosyllabic words). At this juncture, we provide our quantitative data (§4), which show that during the early periods of speech production (up to 100 cumulative attempted target words), the child prefers the trochaic foot, i.e. penultimate stress under all three factors (§4.1-§4.3). This preference gradually fades during the later periods. These results are supported by earlier studies of the acquisition of Hebrew, demonstrating in various ways that the trochee is the preferred foot in the early acquisition of Hebrew (§4.4).

At this point we turn to the general discussion on the trochaic bias (§5). First, we lay out our argument that the preference for trochees is universal (§5.1), clarifying the notion of "universal" by distinguishing between innate and grounded principles. Then we submit our view that the preference for trochees is grounded (§5.2). We emphasize, however, that the grounding factors must be mediated via universal grammar, and that they are specific to language, though not language-specific. Although we attribute in this paper a great deal of the early language development to universal grammar, the role of frequency, which has gained support in numerous recent studies, is not denied (§6). Rather, we show that it emerges gradually in later periods, after universal grammar gets to show its effect.

2. Stress in Hebrew Nouns

Since most of the children's early productions are nouns, our discussion of Hebrew stress is limited to nouns. In the ensuing discussion, we start with descriptive generalizations regarding the stress patterns in Hebrew nouns (§2.1), and then turn to the assignment of foot structure (§2.2). Following Graf and Ussishkin (2003), we assign a right-aligned iambic foot to words with final stress and a right-aligned trochaic foot to words with penultimate stress. The quantitative data, which show the high frequency of final stress in Hebrew, together with the assigned foot structure, lead to the conclusion that the iambic foot is the dominant foot in Hebrew. As will be shown in subsequent sections, the iambic foot is not the first foot adopted by the child.

2.1 StressP atterns

Stress in Hebrew noun stems may reside on any one of the last three syllables (known as the "trisyllabic window"), though antepenultimate stress is relatively rare, found mostly in borrowed nouns. Crucially, the position of stress is not phonologically conditioned, as it does not distinguish between CV and CVC syllables.[1] That is, Hebrew stress is quantity-insensitive, as expected in languages with no contrastive vowel length.[2]

(1) Stressi nnounst ems

σ́	**Final**		**Penultimate**		**Antepenultimate**	
	mispó	'fodder'	kélev	'dog'	télefon	'phone'
CV	kitá	'class'	tíras	'corn'	ʃókolad	'chocolate'
	xatuná	'wedding'	rakévet	'train'	brókoli	'broccoli'
	ʃulxán	'table'	tráktor	'tractor'	ámbulans	'ambulance'
CVC	kadúr	'ball'	sáfta	'grandma'	ámburger	'hamburger'
	avirón	'airplane'	mástik	'gum'	béjgale	'pretzel'

[1] Also the templatic morphology of Hebrew does not distinguish between the different types of syllable (unlike that of Arabic and Tiberian Hebrew). For example, the prosodic structure of the verbs *gidel* 'to grow', *tirgem* 'to translate', and *kimpleks* 'to make complex' is assigned by a disyllabic template, not specified for sub-syllable structure (McCarthy 1984, Bat-El 1994, Ussishkin 2000).

[2] Vowels in stressed syllables are phonetically twice as long as vowels in unstressed syllables (Becker 2003, Cohen 2009). In addition, the stressed syllable has a higher pitch when in phrase final position. Otherwise, the high pitch falls on the posttonic syllable (Becker 2003). These phonetic characteristics of Hebrew stress are found in both adult and children's speech.

The forms in (1) suggest that stress in Hebrew nouns is contrastive, as it is impossible to provide a generalization as to which of the three rightmost syllables of the stem will be stressed. The nominal inflectional paradigm (here we consider the plural paradigm) further illustrates the contrastive status of Hebrew stress (Bat-El 1993, Melčuk and Podolsky 1996, Graf 1999, Bolozky 2000). Stems with identical stress patterns may have different patterns in the suffixed form, and vice versa. In some nouns, stress is mobile, thus appearing on the suffix, while in others, it is immobile, thus staying on the stem.

(2) Stressm obility

a. Mobilest ress:st ressonsuffi x

Final stem's stress			**Penultimate stem's stress**		
xút	xut-ím	'string'	nékev	nekav-ím	'hole'
tavlín	tavlin-ím	'spices'	xéder	xadar-ím	'room'
melafefón	melafefon-ím	'cucumber'	ʃóreʃ	ʃoraʃ-ím	'root'

b. Immobilest ress:st ressont hest em

Final stem's stress			**Penultimate stem's stress**		
tút	tút-im	'strawberry'	méter	métr-im	'meter'
xamsín	xamsín-im	'heat wave'	tíras	tíras-im	'corn'
hipopotám	hipopotám-im	'hippopotamus'	tráktor	tráktor-im	'tractor'

Given the paradigms in (2), nouns with an identical stress pattern in the stem may have different stress patterns in their suffixed forms (e.g. *zamár – zamar-ím* 'singer(s)' vs. *salát – salát-im* 'salad(s)'), and nouns with an identical stress pattern in their suffixed forms may have different stress patterns in the stems (e.g. *gamál – gmal-ím* 'camel(s)' vs. *kéter – ktar-ím* 'crown(s)'). That is, like the position of stress in stems, stress mobility is a lexical property.

The conclusion that stress in Hebrew nouns is lexical does not imply that all nouns are lexically marked for stress. Following Bat-El (1993) and Graf (1999), we assume that only nouns with immobile stress (2b) are lexically marked. Nouns with mobile stress are free of lexical marking of stress, though there must be some lexical distinction between noun stems with penultimate stress and final stress (2a).

Descriptions of Hebrew stress, such as Bolozky (1978), indicate that stress is usually final, with the exception of a few groups of words. This generalization is consistent with the frequency data in (3), which indicate a higher priority for the final stress in Hebrew nouns.

(3) The frequency of finalst ressi ncor pora

	Types	**Tokens**
Nouns in a dictionary (Bolozky andB ecker 2006)	75% (N=11,920)	
3 hours of SR's CDS (Child Directed Speech)	73% (N=386)	71% (N=983)
CDS – disyllabic words (Segal et al. 2009)[3]	72.2% (N=8075)	75.5% (N=228,946)

2.2 StressS ystem

Given the lexical status of stress in Hebrew nouns, it is not surprising that linguists do not agree as to what type of foot the stress system employs. Some argue for the iambic foot, attributing non-final stress to lexical stress or extrametricality (Bat-El 1993). Others argue for the trochaic foot (Graf 1999, Becker 2003), which is binary in words with penultimate stress (e.g. *[kélev]*$_F$ 'dog') but degenerate in words with final stress (e.g. *xa[túl]*$_F$ 'cat'). All analyses agree that there is no weight distinction between CV and CVC, and thus a monosyllabic foot is not binary.

Contrary to these studies, Graf and Ussishkin (2003), argue that the Hebrew stress system does not employ a particular foot-type. They propose that the type of foot emerges from constraint interaction, and can be either iambic (e.g. *[xatúl]*$_F$ 'cat') or trochaic (e.g. *[kélev]*$_F$ 'dog'). Crucially, there are two independent constraints, one assigning final stress, and another assigning a binary foot not specified for prominence at the right edge of the prosodic word (it is not relevant here whether footing is exhaustive). Consequently, there is no direct reference to either trochees or iambs. Graf and Ussishkin's paper focuses on verbs, which do not have lexical stress, but as shown below, their analysis can be extended to nouns.

In nouns without lexical stress (4a), as in verb stems, an iambic foot (final stress) emerges, since the foot is right-aligned and stress is final. In nouns with lexical stress (4b), the foot is right-aligned as long as it includes the lexically stressed syllable, since lexical stress must be surface true.[4] Thus,

[3] Segal et al. (2009) note that younger children are exposed to a higher proportion of trochaic words than older ones. However, iambs are also in the majority in the youngest group (0;9–2;0), 69.5% tokens and 72.1% types.

[4] Antepenultimate stress may optionally shift two syllables to the right (Bat-El 1993), as in *ámbulans – ámbulansim ~ ambulánsim* 'ambulance(s)'. In a few lexical items, stress shift is contrastive (for some speakers), as in *télefon – télefonim* 'phone calls' vs. *telefónim* 'phones (instrument)'.

when one of the last two syllables is marked for lexical stress, the assigned binary foot is either iambic (if the final syllable is lexically marked) or trochaic (if the penultimate syllable is lexically marked). If the antepenultimate syllable is marked for lexical stress, the foot cannot be at the right edge of the prosodic word, since the lexical stress must be surface true. Therefore, the foot is minimally removed from the right edge, yielding a trochaic foot (*[trákto]r-im*).

(4) Stressa ssignment

a. Wordsw ithoutl exicalst ress

Input	**Footing**	**Stress**	**Emerging foot**
sipur	[sipur]	[sipúr]	Iamb
sipur-im	si[pur-im]	si[purím]	Iamb
xut	[xut]	[xút]	Degenerate
xut-im	[xut-im]	[xut-ím]	Iamb

b. Wordsw ithl exicalst ress

Input	**Footing**	**Stress**	**Emerging foot**
galón	[galón]	N/A	Iamb
galón-im	ga[lón-im]	N/A	Trochee
tráktor	[tráktor]	N/A	Trochee
tráktor-im	[trákto]r-im	N/A	Trochee
tút	[tút]	N/A	Degenerate
tút-im	[tút-im]	N/A	Trochee

Following the discussion above, neither the frequency of the stress patterns nor the stress system facilitates the selection of a foot type. The stress system does not employ a particular foot, and frequency gives priority to the iambic foot, but not totally. We argue that when the ambient language does not allow the children to reach a conclusion right away, they adhere to a universal preference. The quantitative data in §4 support this argument.

3. Research Method

Our data are drawn from the early speech of a typically developed Hebrew-speaking boy. We assume, with Rose (2000), that in a language like Hebrew, which does not support the trochaic foot (see §2), evidence for the trochaic bias should appear at the onset of speech production. Therefore, we started the recording sessions during the babbling period, in order to detect the emergence of the very first word. The upper limit of the data presented here is drawn by the period during which the frequency of the child's stress patterns is close to that in the adult's language.

(5) Relevanti nformationa boutt hest udy

a. Subject: SR, a boy (two years younger than his sister)	
b. Age of first recording session	0;08.04
c. Age of first word production (see §3.1 below)	1;02.00
d. Age of last session relevant to the present study	1;07.09
e. Number of speech recording sessions (1;02.00-1;7.09)	24
f. Cumulative number of attempted target types	323
g. Number of produced tokens	1988

The data were collected during weekly one-hour sessions in the child's natural environment. All data are naturalistic, obtained from spontaneous speech, and picture/object naming. Recording, transcription, and encoding, were done by trained linguists.

3.1 The First Word

The detection of the first word was based on the following two criteria:

(6) Criteriafor i dentifyingt hefi rstw ord

a. The child's production is identified as the phonological correspondence of the target word.

b. There is a consistent continuation of word productions in the ensuing sessions.

Criterion (6a) excludes onomatopoeic words, as well as phonetically inconsistent forms (Dore et al. 1976), where the latter ones, appearing during the transition from babbling to speech, only look like words.

As shown in (7) below, the first two forms produced by the child, *dídi* and *dída*, remotely resemble the target *kadúr* 'ball', thus considered phonetically inconsistent forms (criterion (6a)). Moreover, continuation of speech (criterion (6b)), does not grant these words the title of the first words, given that the subsequent sessions consisted of pure babbling. Therefore, 1;02.00 is clearly the age of the first word, under the two criteria given in (6). The three words produced during this session are phonologically related to their targets, and during the ensuing session, the child produced five words. From that session onwards, there were no more sessions consisting only of babbling.

(7) The emergence of SR's firstw ord

Age	Child	Target	
0;10.00	dídi	kadúr	'ball'
1;00.01	dída	kadúr	'ball'
1;00.06	babbling	no target	
1;00.13	babbling	no target	
1;00.22	babbling	no target	
1;00.26	babbling	no target	
1;01.02	síkta, títa, tíki	síktak	onomatopoeia for 'clock'
1;01.10	babbling	no target	
1;01.23	babbling	no target	
1;02.00 First word	dah	todá	'thanks'
	búax, púax, péax	tapúax	'apple'
	pápa, papá	parpár	'butterfly'
	ába	ába	'father'
	ta	sáfta	'grandmother'
1;02.07	íma	íma	'mother'
	da	todá	'thanks'
	púax	tapúax	'apple'

3.2 Periodsf orQ uantitativeE xamination

In order to display the gradual development, we divided the data into periods, on the basis of cumulative target words attempted by the child. The scale starts with about 10 words for the first period, 50 for the second period, and then an additional 50 words for every subsequent period. We selected the number of the child's productions closest to the numbers in the scale.

(8) Periods for quantitative examination based on cumulative attempted targets

Period	Age	No. of attempted target types	
		Scale	Child
I	1;02.00–1;03.05	10	9
II	1;03.14–1;04.24	50	49
III	1;05.04–1;05.08	100	96
IV	1;05.15–1;05.29	150	147
V	1;06.02–1;06.20	200	207
VI	1;06.26	250	254
VII	1;07.02–1;07.09	300	323

It should be emphasized that these periods do not imply stages. They serve as a methodological tool, which allows us to provide a quantitatively-based development of the distribution of the stress patterns, as well as a baseline for a cross-subject comparison in our subsequent studies.

3.3 The Factors

In order to evaluate the child's preferred foot, we examined the data on the basis of three factors:

(9) Thefa ctors

a. The target factor
The percentage of polysyllabic trochaic vs. iambic target types attempted by the child (regardless of the structure of the corresponding produced forms).

b. The production factor
The percentage of polysyllabic trochaic vs. iambic types produced by the child (regardless of the structure of the corresponding target forms).

c. The truncation factor
The percentage of polysyllabic trochaic vs. iambic target types truncatedt om onosyllabicf orms.

It should be noted that we counted "prosodically distinct types per session". By "prosodically distinct", we mean productions with a different number of syllables and/or different stress patterns. For example, *púax* and *búax* for *tapúax* 'apple' were counted as one type, since both are disyllabic with penultimate stress, but *púax* and *bux* were counted as two types, since they differ in the number of syllables. By "types per session" we mean that *púax*/*búax* was counted as one type, regardless of the number of times it was produced in one session, but it was counted again when it appeared in another session.

We counted only major lexical items, thus excluding the following sorts of words: (i) Non-major lexical items, such as *íne* 'here it is', *éfo* 'where', and *et-zé* 'this Acc.'; (ii) Onomatopoeic words, such as *gága* 'duck sound' and *tíktak* 'clock sound'; (iii) Others, such as *álo* 'hello', *ópa* 'oops-a-daisy'. We also excluded the words for 'father' *ába* and 'mother' *íma*, which the child produced with a large variety of stress and intonational patterns (partially due to the variation in the input). Notice that these words are mostly trochaic, and their inclusion in the counting would have significantly added to the quantitative preference of trochees.

A few examples of the child's productions are presented below (note that adjacent vowels in Hebrew are heterosyllabic, thus *tapúax*, for example, is trisyllabic).

(10) The child's productions (3σ = 3 or more syllables; Tσ = number of syllables in the target)

a. PeriodI :1;02.00–1;03.05

Tσ	**Penultimate (trochee)**			**Final (iamb)**		
	Child	**Target**		**Child**	**Target**	
2σ	ta	sáfta	'grandma'	da	todá	'thanks'
	das	dási	'Name'	bu ~ bábú	bakbúk	'bottle'
3σ	pax ~ púax	tapúax	'apple'			

b. PeriodI I:1;03.14–1;04.024

Tσ	**Penultimate (trochee)**			**Final (iamb)**		
	Child	**Target**		**Child**	**Target**	
2σ	táta	sáfta	'grandma'	tik	kapít	'spoon'
	kúki	túki	'parrot'	babú	bakbúk	'bottle'
3σ	púax	tapúax	'apple'	igjá	agalá	'pram'
	nána	banána	'banana'	máta ~ tatá	ipopotám	'hippopotamus'

c. PeriodI II:1; 05.04–1;05.08

Tσ	**Penultimate (trochee)**			**Final (iamb)**		
	Child	**Target**		**Child**	**Target**	
2σ	géθem	géʃem	'rain'	búk ~ bakbúk	bakbúk	'bottle'
	péax	pérax	'flower'	tanín	tanín	'crocodile'
3σ	ʒijája	ʤiráfa	'giraffe'	aón ~ anión	avirón	'airplane'
	gíla	goríla	'gorilla'	ijá	kubijá	'building block'

d. PeriodI V:1;05.15–1;05.29

Tσ	**Penultimate (trochee)**			**Final (iamb)**		
	Child	**Target**		**Child**	**Target**	
2σ	díla	glída	'ice cream'	gaθ ~ agáθ	agás	'pear'
	kákel	tráktor	'tractor'	sa ~ kísa ~ kisá	kivsá	'sheep'
3σ	póax	efróax	'chick'	ka	neʃiká	'kiss'
	giléle	tarnególet	'hen'	tíja ~ tijá	mitrijá	'umbrella'

e. Period V:1;06.02–1;06.20

Tσ	Penultimate (trochee)			Final (iamb)		
	Child	**Target**		**Child**	**Target**	
2σ	délet	délet	'door'	bánaθ ~ pasás	panás	'torch'
	kóva	kóva	'hat'	gadér	gadér	'fence'
3σ	áfa	ʤiráfa	'giraffe'	tan ~ itán	livjatán	'whale'
	jadájim	jadáim	'hands'	keará	keará	'bowl'

f. Period VI:1;06.26

Tσ	Penultimate (trochee)			Final (iamb)		
	Child	**Target**		**Child**	**Target**	
2σ	xáxal	záxal	'caterpillar'	abár	axbár	'mouse'
	lájla	lájla	'night'	kifsá	kifsá	'sheep'
3σ	dúθa	medúza	'jelly fish'	izón	xilazón	'snail'
	anána	banána	'banana'	kavíθ	akavíʃ	'spider'

g. Period VII:1;0 7.02–1;07.09

Tσ	Penultimate (trochee)			Final (iamb)		
	Child	**Target**		**Child**	**Target**	
2σ	pílpel	pílpel	'pepper'	ajé	arjé	'lion'
	táktor	tráktor	'tractor'	namér	namér	'tiger'
3σ	abáti	spagéti	'spaghetti'	galím	igulím	'circles'
	jadáim	jadáim	'hands'	agalá	agalá	'pram'

The representative examples above show that polysyllabic targets with penultimate stress were produced as minimally disyllabic earlier than those with final stress. Targets with final stress were produced mostly as monosyllabic for quite a while, and in a few cases, with penultimate stress, or with level stress. In addition, there was a greater degree of variation in the production of targets with final stress than with non-final stress. The priority of the penultimate stress, thus the trochaic foot, reflected in the data above is given quantitative affirmation in the following section.

4. Research Results

In this section, we provide the quantitative data, with reference to the factors provided in (9). The data is divided into periods, as outlined in (8) above.

4.1 *The Target Factor*

Under the target factor, we examined the percentage of trochaic vs. iambic polysyllabic targets attempted by the child, out of the total number of attempted targets (regardless of the stress pattern of the corresponding producedfor ms).

(11) Thet argetf actor

Period	Age	Attempted polysyllabic targets				
		Total	Trochee		Iamb	
I	1;02.00-1;03.05	16	9	56%	7	44%
II	1;03.14-1;04.24	72	43	60%	29	40%
III	1;05.04-1;05.08	68	39	57%	29	43%
IV	1;05.15-1;05.29	92	35	38%	57	62%
V	1;06.02-1;06.20	104	49	47%	55	53%
VI	1;06.26	79	26	33%	53	67%
VII	1;07.02-1;07.09	150	51	34%	99	66%

Schema: trochaic targets/total polysyllabic targets vs. iambic targets/total polysyllabic targets

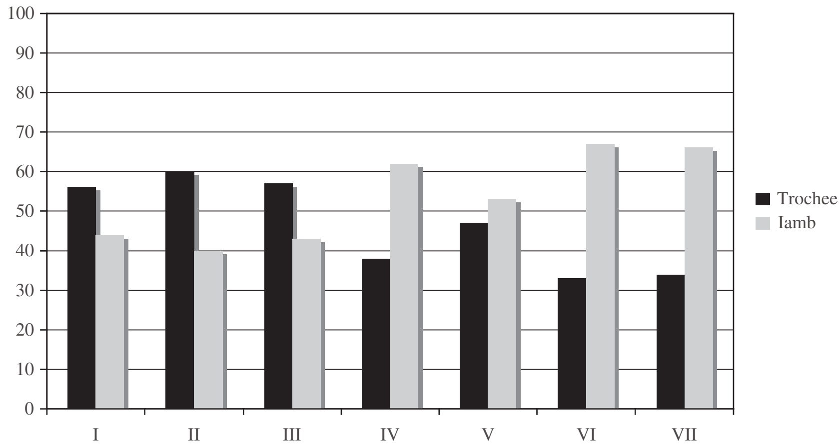

Figure 1. Percentage of attempted trochaic vs. iambic target types (per session) in periodsI- VII.

As the data above suggest, the child attempted more trochaic polysyllabic words than iambic ones through period III. The preference for words with an iambic foot becomes closer to that of their distribution in Hebrew (about 73%) only during period VII (see (3) above for the distribution of the stress patterns in adult Hebrew). A chi-square test for expected 25% trochees and 75% iambs provided significant distinctions ($p<0.05$) for all periods, with the exception of period V ($p=0.10$), when the child slipped back to trochees, after already showing a significant preference for iambs in period IV.

4.2 The Production Factor

Under the production factor, we examined the percentage of trochaic vs. iambic polysyllabic productions (types and tokens) out of the total number of polysyllabic productions (regardless of the stress pattern of the corresponding target forms).

(12) Thep roductionf actor

Period	**Age**	**Polysyllabic productions – types**				
		Total	**Trochee**		**Iamb**	
I	1;02.00-1;03.05	11	8	73%	3	27%
II	1;03.14-1;04.24	65	38	58%	27	42%
III	1;05.04-1;05.08	65	38	58%	27	42%
IV	1;05.15-1;05.29	87	39	45%	48	55%
V	1;06.02-1;06.20	102	54	53%	49	47%
VI	1;06.26	71	27	38%	44	62%
VII	1;07.02-1;07.09	176	72	41%	104	59%

Period	**Age**	**Polysyllabic productions – tokens**				
		Total	**Trochee**		**Iamb**	
I	1;02.00-1;03.05	41	37	90%	4	10%
II	1;03.14-1;04.24	175	107	61%	68	39%
III	1;05.04-1;05.08	119	81	68%	38	32%
IV	1;05.15-1;05.29	175	69	39%	106	61%
V	1;06.02-1;06.20	246	141	57%	105	43%
VI	1;06.26	110	53	48%	57	52%
VII	1;07.02-1;07.09	503	233	46%	270	54%

Schema: monosyllabic targets/total targets vs. monosyllabic productions/total productions

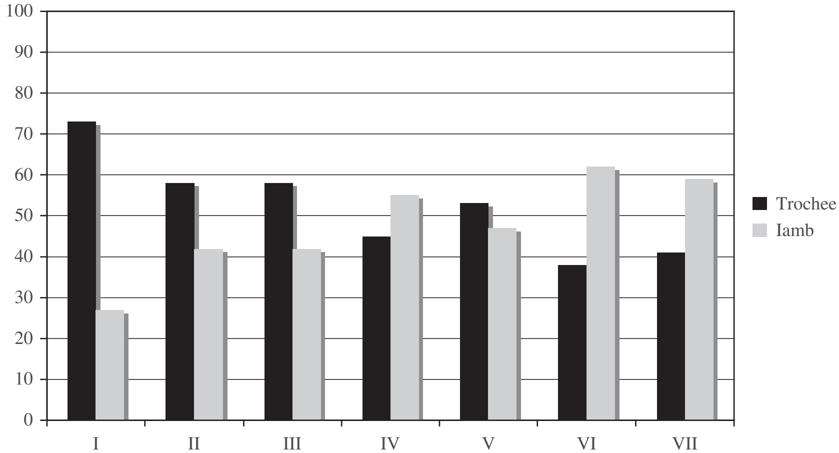

Figure 2a. Percentage of trochaic vs. iambic types (per session) produced in periods I-VII.

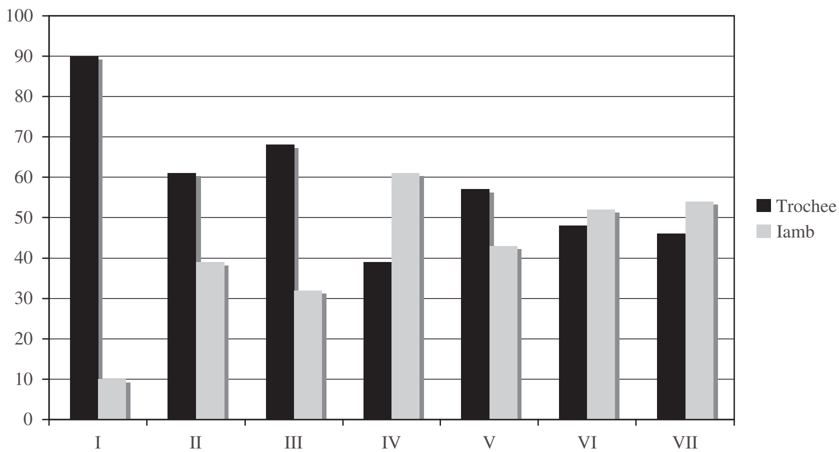

Figure 2b. Percentage of trochaic vs. iambic tokens (per session) produced in periods I-VII.

Under the production factor, period III is also the switch point, as up to this period the child produced more trochaic types and tokens than iambic. Period IV seems like a change in the inclination, but in period V, the inclination towards a trochaic foot rises again. Distinctions were significant (p<0.05) for all the periods, for both types and tokens, with an expected 25% trochees and

75% iambs for productions and 29% trochees and 71% iambs for tokens (based on Bolozky and Becker 2006).

4.3 The Truncation Factor

Under the truncation factor, we examined the percentage of monosyllabic truncated productions from polysyllabic trochaic vs. iambic targets, out of the total number of polysyllabic trochaic vs. iambic targets respectively.

(13) Thet runcationf actor

Period	**Age**	**Truncated monosyllabic productions**					
		Trochee			**Iamb**		
		Total	**Monosyllabic**		**Total**	**Monosyllabic**	
I	1;02.00-1;03.05	9	5	56%	7	6	86%
II	1;03.14-1;04.24	43	6	14%	29	14	48%
III	1;05.04-1;05.08	39	4	10%	29	8	28%
IV	1;05.15-1;05.29	35	4	11%	57	16	28%
V	1;06.02-1;06.20	49	1	2%	55	16	29%
VI	1;06.26	26	0	0%	53	6	11%
VII	1;07.02-1;07.09	51	2	4%	99	4	4%

Schema: monosyllabic productions of trochaic targets/total polysyllabic trochaic targets vs. monosyllabic productions of iambic targets/total polysyllabic iambic targets.

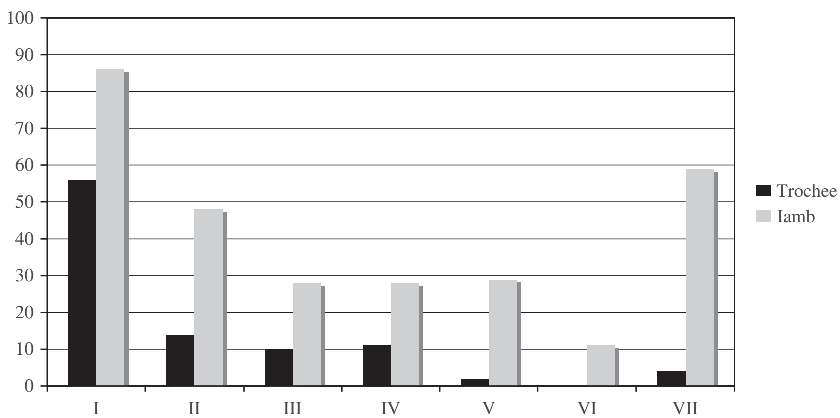

Figure 3. Percentage of trochaic vs. iambic target types (per session) truncated to monosyllabic forms in periods I-VII.

There were more cases of truncation to monosyllabic forms in iambic targets than in trochaic targets. Truncation in trochaic targets dropped below 15% after period I, and reached a very low percentage (2-4%) after period IV. This in contrast with truncation in iambic targets, which dropped below 20% only during period VI. Distinctions were significant (p<0.05) only for period II and V, due to the small number of examples, but note that there is a significant distinction in a late period (period V).

It should be emphasized that truncation to monosyllabic forms cannot be attributed to the frequency of monosyllabic words in Hebrew (cf. Prieto 2006). The distribution of monosyllabic words in the Hebrew dictionary (Bolozky and Becker 2006) is 0.5% (590/125,190). The percentage is higher in child directed speech (three hours of S's CDS), rising to 9% types (18/200) and 23% tokens (109/476).

(14) Monosyllabict argetsa ndp roductions

Period	**Age**	**Target**			**Production**		
		Total	**Monosyllabic**		**Total**	**Monosyllabic**	
I	1;02.00-1;03.05	18	2	11%	23	12	52%
II	1;03.14-1;04.24	93	21	23%	105	40	38%
III	1;05.04-1;05.08	82	14	17%	90	25	28%
IV	1;05.15-1;05.29	110	18	16%	126	39	31%
V	1;06.02-1;06.20	122	18	15%	136	34	25%
VI	1;06.26	96	17	18%	95	24	25%
VII	1;07.02-1;07.09	185	35	19%	220	44	20%

Schema: monosyllabic targets/total targets vs. monosyllabic productions/total productions

The data above show that the distribution of monosyllabic words in the child's speech is above that in the Hebrew dictionary. The percentage of the child's monosyllabic productions almost reaches that of the tokens in CDS during period V (child 25% – CDS 23%), but the percentage of the child's targets does not reach the types in CDS (9%). As expected, there is a decrease in monosyllabic productions towards later periods.

4.4 Summarya ndA dditionalS upport

All the factors considered above indicate that the child's early speech exhibits a preference for penultimate stress, which, as argued in §2, indicates a trochaic foot. He produced more trochaic than iambic words (§4.2), and in parallel, truncated to monosyllabic more iambic words than trochaic (§4.3). Moreover, the child attempted more trochaic targets (§4.1), reflecting phonological

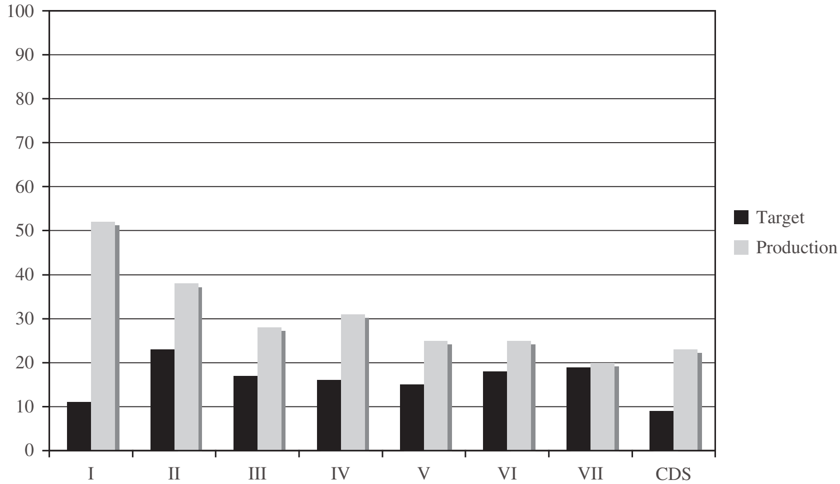

Figure 4. The percentage of monosyllabic targets and productions in period I-VII and in CDS[5].

selectivity (Schwartz 1988). As claimed in Becker (2007), such selectivity aims at reducing the processing load, in our case truncation, which is required for iambic targets in a production grammar with a preference for trochees. The quantitative data also show that the preference for trochees gradually fades in the course of development, towards the frequency of the stress patterns in Hebrew.

The results conform to those of earlier studies, all emphasizing the preference for non-final stress in the early acquisition of Hebrew. Ben-David's (2001) study of ten typically developing children reveals that disyllabic productions of target words with penultimate stress appear before disyllabic productions of target words with final stress. That is, when trochaic targets are produced as disyllabic (e.g. *dída* for *glída* 'ice cream') iambic targets are still truncated to monosyllabic (e.g. *du* for *kadúr* 'ball'). Similarly, Adi-Bensaid's (2006) study of ten hearing-impaired children shows that during the minimal word stage, where most words are maximally disyllabic, there were still more attempts of disyllabic words with penultimate stress (53.3% – 867/1659) than with final stress (47.7% – 792/1659), as well as a higher rate of disyllabic productions of disyllabic targets with penultimate stress (94.8% – 822/867) than with final stress (83.5% – 661/792).

[5] In child directed speech (CDS) the grey column refers to types and the black to tokens.

Inclination towards non-final stress is also found at the onset of a new morphological category. SR produced his first verbs at period II, where his iambic noun production was at 42% for types and 39% for tokens. Although 95% of Hebrew verb stems are iambic, none of SR's first verbs was iambic (Bat-El 2006). Similarly, although 77% of the plural nouns are iambic (Bolozky and Becker 2006), the girl studied in Levinger (2007) showed an early preference for trochees (see also Berman 1981 and Levy 1983). During the first stage of the development of plural nouns (1;05.29-2;00.02), she attempted 59% (20/34) trochaic plural forms and produced 65% (24/37).

Hebrew is not learner-friendly when it comes to stress. The high frequency of iambic stress is not sufficient to lead the children to a systematic stress pattern, and therefore they learn stress lexically, as evident by the rarity of stress shift (Ben-David 2001, Ben-David and Berman 2007). In this case, one should ask whether the child assigns footing to begin with; he could just as well assume lexical stress as yet another structural feature of the syllable (Demuth 1996). However, lexical stress without reference to a foot predicts arbitrary stress patterns, and thus cannot explain the consistent preference for penultimate stress in early speech. Moreover, there is evidence from English (Demuth and Fee 1995) and Dutch (Fikkert 1994) suggesting the effect of a foot-size upper limit on the children's productions, given that the production of CVCV words is followed by CVV/CVC rather than CVCVCV. In Hebrew too, there is a rather long period of a disyllabic maximal limit on the children's productions (Ben-David 2001, Adam 2002), attributed to the binarity of the foot.

5. The Trochaic Bias

Now that we have established the fact that the Hebrew-speaking child in our study, like the children in the above-mentioned studies, prefers the trochaic foot during the very early stage of development, we must inquire into the source of this preference. The discussion in §2 of Hebrew stress eliminates the possibility that the source is the ambient language, and we must thus adhere to a universal preference (Adam and Bat-El 2008b). First, we lay out our argument that the preference for trochees is universal (§5.1), clarifying the notion of "universal" by distinguishing between innate and grounded principles. Then we submit our view that the preference for trochees is grounded (§5.2).

5.1 The Trochaic Bias is Universal

In (15) below, we present the results of various studies with regard to the preferred foot type in children's speech. Unfortunately, for two of the languages in the list, there are disagreements, which are probably due to methodological differences.

(15) Foot preferencei nd ifferentl anguages[6]

a. Languagesw here **trocheesa** rem oref requent

Language	**Children's preference**	
English	Trochee	(Allena ndH awkins 1978, 1980, Gerken 1994,
Dutch	Trochee	(Fikkert 1994)
Greek	Trochee	(Tzakosta 2004)
Spanish	Trochee	(Lléo 2002)
	Trochee	(Rapp 1994,i nS antos 2001)
Brazilian Portuguese	**Iamb**	(Santos 2001, 2006,F ikkerta nd Santos 2006)

b. Languagesw here **iambsa** rem oref requent

Language	**Children's preference**	
Catalan	Trochee	(Prieto 2006)
Hebrew	Trochee	(Ben-David 2001,A dam 2002, Adi-Bensaid 2006, this study)
French	Trochee	(Allen 1983, Archibald and Carson 2000)
	Iamb	(Rose 2000, Rose and Champdoizeau 2008)

Children whose ambient language has a higher frequency of trochees (15a), prefer the trochaic foot. The exception is Brazilian Portuguese, where the results are conflicting (see §6). In the languages with a higher frequency of iambs (15b), trochees are still preferred, with the exception of French, where the results, again, are conflicting. In addition, there is also a preference for trochees in the tonal language Sesotho (Demuth 1993) and the pitch-accent language Japanese (Ota 2003). So roughly speaking, there seems to be a general tendency towards the trochaic foot, crucially in the languages where iambs are more frequent (15b).

[6] It should be noted that some of the listed studies attribute the quantitative foot preference to the trochaic bias, while others assign it to frequency (e.g. Tzakosta 2004), or the language's metrical system (e.g. Prieto 2005). Here, we ignore the "no bias" results obtained for English (Kehoe and Stoel-Gammon 1997, Vihman et al. 1998), Spanish (Hochberg 1988), and French (Vihmanet a l. 1998).

It should be noted that a high frequency of a particular foot type usually implies that this foot is employed by the stress system of the language. However, this is not always the case. In Hebrew, following the analysis adopted here (§2), the system does not promote a particular foot type, and in Brazilian Portuguese, according to Santos (2005), the stress system assigns an iambic foot, while the more frequent non-final stress is due to lexical or morphological extrametricality.

For Hebrew, we have established the following facts above:

a. The child's early speech exhibits a preference for the trochaic foot (§4).
b. The preference for trochees cannot be attributed to their frequency, or to their role in the stress system of Hebrew (§2).

Since the preerence for trochees in Hebrew is not language-specific, we must conclude that it comes from somewhere else (Anderson and Lightfoot 2002), that is, universal grammar. However, the term "universal" must be clarified.

We suspect that much of the objection to the universality of the trochaic bias is due to a misinterpretation of Allen and Hawkins' (1978) terms "natural" and "universal" as synonymous to "innate". These terms, however, only partially overlap, given the following two types of universal principles:

(16) Two types of universal principles

a. **Innate** principles of linguistic knowledge are not functionally grounded or promoted by external factors (Chomsky 1986); they constitute "shared knowledge that appears to have no shaping stimulation – knowledge without grounds …" (Chomsky 1980:41).
b. **Grounded** principles of linguistic knowledge correlate with some phonetic or perceptual property (Archangeli and Pulleyblank 1994, Hayes 1998).

That is, innate principles are universal, but not natural, while grounded principles are both natural and universal.

We argue in the ensuing section, following Vihman et al. (1998), that the trochaic bias is grounded, agreeing with Bernhardt and Stemberger's (1998) claim that there is "little reason to posit that phonetic grounding is innate" (p.63). However, we admit the role of universal grammar in associating a particular external property with a particular grammatical property. As emphasized in Hayes' (1998) study of inductive grounding, relations between external and grammatical properties are not direct, as they must be mediated via grammar. Universal grammar thus has a dynamic function in the course of language development, in establishing correlations between external and grammatical properties.

5.2 The Trochaic Bias is Grounded

Various independent factors converge towards the trochaic foot. First, there is a phonetic basis for trochees, which is the decline in the fundamental frequency at the end of a breath group (mostly in declarative intonation), due to a fall in the subglottal air pressure (Lieberman and Blumstein 1998). This is a natural physiological property, and thus expected to be found in children's speech too, regardless of their ambient language (Vihman et al. 1998).

The role of universal grammar is to associate this particular phonetic property with the trochaic foot. Indeed, the decline in the fundamental frequency at the end of the breath group maps directly to the final weak element in the trochaic foot. However, children could just as well prefer the uneven iambic foot ($[\breve{\sigma}\bar{\sigma}_s]_F$), given that many languages exhibit phrase final lengthening (Lieberman and Blumstein 1998).

Trochees also allow children to maximize their prosodic word while remaining faithful to the target stress. As noted earlier, studies on the acquisition of Hebrew (Ben-David 2001, Adam 2002, Adi-Bensaid 2006) report that in early stage of acquisition, children only produce the stressed and final syllables of the target word, refraining from stress shift. During this stage, target words with final stress are produced as monosyllabic (e.g. *du* for *kadúr* 'ball') and target words with non-final stress are produced as disyllabic (e.g. *kévet* for *rakévet* 'train'). This pattern of syllable selection is attributed to perceptual saliency (Echols and Newport 1992), where children respect the constraints PROMINENCE for the stressed syllable and POSITION for the final syllable (Adam and Bat-El 2008c). The trochaic foot, but not the iambic one, allows them to respect both PROMINENCE and POSITION, as well as the universal constraint FOOT BINARITY.

The selection of the trochaic foot allows the children to produce a binary foot without producing non-final unstressed syllables. In choosing an iambic foot, the child's output is restricted to monosyllabic forms.

(17) Onlyt rocheesca ny ielda d isyllabicf ootw hiler espectinga llc onstraints

Target stress patterns		**Child's options**	**Constraint violation**
Non-final	… $\acute{\sigma}\sigma\}_{PrWd}$	$\{[\acute{\sigma}\sigma]F\}_{PrWd}$	No violation
Final	… $\sigma\acute{\sigma}\}_{PrWd}$	$\{[\sigma\acute{\sigma}]F\}_{PrWd}$	Violationo f PROMINENCE and POSITION
		$\{[\acute{\sigma}]F\}_{PrWd}$	Violation of FOOT BINARITY

Principles of universal grammar as well, lead the child to trochees. We assume that children take a quantity-insensitive system as their starting point, given that Dutch children do not exhibit weight contrast in their early productions, although the language is quantity-sensitive (Fikkert 1994). Given this property in their early language, universal grammar leads them to trochees, following Hayes' (1995) proposal that "the syllabic trochee is the basic mechanism available for quantity-insensitive alternation" (p. 73). That is, the moment the child selects a quantity-insensitive system, the choice of trochee comes from universal grammar (Dresher and van der Hulst 1995). Therefore, all children start with a trochaic quantity-insensitive system, which persists until they accumulate sufficient evidence to the contrary.

Finally, from an evolutionary point of view, trochees are the "natural selection". They have a better chance of surviving beyond the onset of speech, since there are more trochaic languages than iambic.[7] Also, trochees are common in languages with or without weight contrast, while iambs survive better in languages with weight contrast (Hayes 1995).

6. The Emergence of Frequency

The role of frequency in language acquisition has gained much support (Levelt et al. 2000, Stites et al. 2000, Roark and Demuth 2000, Zamuner et al. 2005, Prieto 2006, among others). Prieto (2006), for example, argues that Catalan-speaking children produce CVC words for a significantly longer time than Spanish-speaking children, because CVC words enjoy higher frequency in Catalan than in Spanish. Paradis' (2000) study shows that French-English bilingual two-years-olds have fewer trochaic truncated forms (55%) than monolingual English-speaking ones (89%), due to the high frequency of iambs in French. That is, frequency may play a role across languages in bilingual children, when the structures are shared by both languages (Target: $\sigma_1\sigma_{2S}\sigma_3\sigma_{4S}$ – Truncated trochaic forms: $\sigma_{2S}\sigma_3$).

Our study does not deny the role of frequency in language acquisition; on the contrary, it supports it. However, it argues that before the children start figuring out the frequency in their ambient language, they appeal to universal grammar, relying on one or more of the sources for trochees provided in §5.2. This development can be illustrated with a comparison between early and late periods in the child's speech, which shows how the frequency gap between the child's speech and the adults' language decreases in the late period.

[7] Rose and Champdoizeau (2008) note that the recent discovery of new iambic languages may change the balance, but we do not know the actual number of trochaic and iambic languages.

(18) Theem ergingr oleof t hef requencyof i ambs

	Target	**Production–type**	**Production–token**
Period I	44%	27%	10%
Period VII	66%	59%	54%
Hebrew	75%	73%	71%

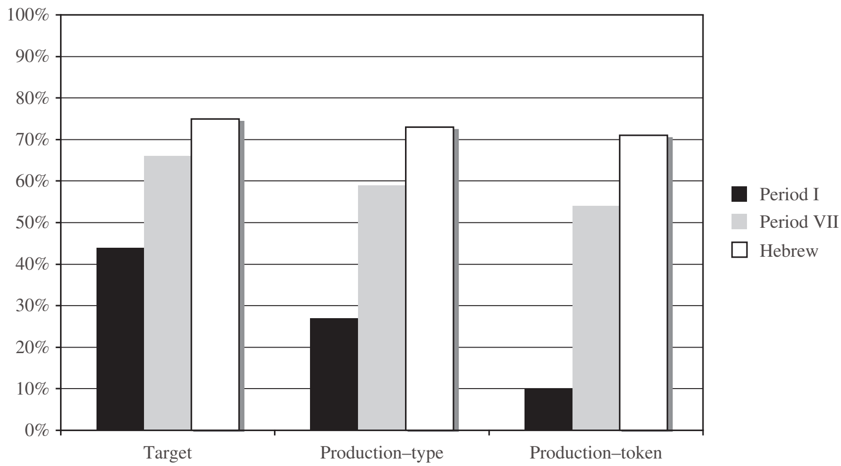

Figure 5. Frequency distribution of iambs under the target and production factors in period II, period VII, and in adults' Hebrew.

Such a development can be observed mostly in languages with lexical stress and inconsistent stress patterns, where it takes the child longer to identify the most frequent foot. In languages with consistent stress patterns, such as French, the children may recognize the most frequent foot, which is the only foot, during the pre-speech period (Peperkamp 2004), such that "at the stage where the first words are produced by the child, the predominant stress pattern of the target language … is already acquired" (Rose 2000:38). In such languages, there is little or no evidence for the trochaic bias. Thus, while the French-speaking children studied in Rose (2000) did not provide evidence for trochees, those studied in Archibald and Carson's (2000) had some productions with level stress and a stress shift towards trochees.

In order to detect the early effect of universal grammar, the data should be drawn from the very first word, as in our study (see §3.1). Therefore, Tzakosta's (2004) argument against the trochaic bias in Greek is not reliable, since it is based on data drawn from children who were not younger than 1;7.05. By this age, and even earlier, the child in our study was already quite close to the language's frequency. Moreover, the oldest child in Tzakosta's study was 3;5.29, by which time children have already acquired some morphology. Indeed, the data from Greek includes some complex forms (stem plus suffix), and it is thus likely that they have also acquired some of the lexical / morphological effects on the stress patterns. It should be noted that Greek is a trochaic language, with a great degree of lexical stress (like Hebrew), and the children did show a preference for trochees. However, Tzakosta's argument against the trochaic bias is based on the production of targets with ambiguous footing, such as σσ́ σ and longer words, which can be footed with either an iambic foot ([σσ́]σ) or a trochaic foot (σ[σ́ σ]). The children produced both trochees [σ́σ] and iambs [σσ], with a higher frequency of trochees. The trochaic bias, according to Tzakosta, predicts that only trochees will appear in the children's speech, and therefore Tzakosta attributes the preference for trochees to their higher frequency in Greek. However, the prediction is wrong: First, as noted above, the children were much too old to provide evidence for universal effects. Second, children's language development does not proceed in discrete stages, and there is always a certain degree of overlap between stages (Adam 2002), or, as Tzakosta (2004) argues, parallel grammars.

Brazilian Portuguese remains a puzzle, since the children prefer the iambic foot (according to Santos 2001, 2006, but not according to Rapp 1994). Santos (2001) argues that what looks like word stress in the children's production is actually phrase stress, as phrase prominence in the language is right-headed. The explanation proposed in Fikkert and Santos (2006), relies on the durational differences between pretonic and posttonic vowels, where the latter are significantly shorter. Children prefer producing the more salient syllables, thus ignoring the final postonic syllable (the one with the shorter vowel) in favor of the stressed syllable and the one preceding it. This results in iambic productions for target words with penultimate stress. This is a perceptual explanation, compatible with that given in Echols (1988) for the preference for trochees in English, where the durational differences are in favor of the unstressed vowel in the word final syllable.

A grammatical explanation is proposed in Santos (2005), according to which children's early speech reflects the stress system of Brazilian Portuguese, where the iambic foot is employed; non-final stress is achieved by lexical or morphosyntactic extrametricality. Crucially, final unstressed vowels are often not part of the stem but rather suffixes or theme vowels.

Adam and Bat-El's (2008a) study of early verbs shows that children tend to produce stem-like forms (Armon-Lotem and Berman 2003), although their prosodic development allows them to produce the suffixes. That is, when children produce the noun *da* or *jadá* for *jaldá* 'girl' they do not produce the verb *xa* or *axá* for *alxá* 'she went' but rather the verb stem *aláx*. It is thus possible that what takes priority in the speech of the Brazilian-Portuguese children is the constraint interaction that does not allow them to produce suffixes (see analysis in Adam and Bat-El 2008a).

As emphasized earlier, data supporting the trochaic bias should meet two preliminary conditions: (a) the data should be drawn from a language with a great degree of lexical stress, with a higher frequency of iambs; and (b) the data should be drawn from the very early speech of the children, starting with the first words. It is possible that the discrepancy among the studies is due to methodological reasons, where the children's data are not always drawn from very early speech.

7. Conclusion

In this paper, we have provided quantitative data, drawn from the naturalistic speech of a Hebrew-speaking child, which show the preference for the trochaic foot in both productions and attempts. We argued that this preference cannot be attributed to frequency, since the iambic foot is predominant in Hebrew, nor to the stress system, which does not employ a specific foot type. We thus concluded that the preference for trochees in the child's speech, supported by other studies of the acquisition of Hebrew, must be attributed to the universal trochaic bias.

Universal phonological principles are usually grounded, and the trochaic bias is no exception. We provided several grounding sources, all converging towards trochees. We emphasized, however, that the external properties that serve for grounding must be mediated via grammar, which is responsible for the correlation between a particular external property and its corresponding grammatical principle.

Our data also showed that the inclination towards the trochaic foot is evident only during the early periods of speech. In later periods, the effect of frequency emerges, and the iambic foot takes over, as is the case in Hebrew. That is, the effect of universal principles that the ambient language does not support, can be detected only in very early speech.

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