How does Place fall into Place?

The lexicon and emergent constraints in children's developing phonological grammar[*]

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In this paper we address the acquisition of place of articulation (PoA) features in words by Dutch children. We show that there is a particular developmental pattern, repeated across children. This pattern can be accounted for by (a) assuming that the child's underlying phonological representation in the lexicon becomes gradually more specified, (b) the emergence of segmental markedness constraints, and (c) referring to the distribution of PoA patterns in the target language. Consonant harmony is an epiphenomenon of this general developmental pattern of PoA organization in words. Generalizations that the child makes over his or her own productive lexicon are grammaticalized as high-ranking markedness constraints, which force PoA features to be linked to certain positions in the word.

1. Introduction

There are two salient aspects to Consonant Harmony (CH) data that previous analyses have not accounted for in a satisfactory way. First, harmony between non-adjacent consonants remains a rather peculiar phenomenon, which is specific to child phonologies. In accounts of CH within the framework of Optimality Theory (Prince & Smolensky 1993-2004), CH forms are treated as unmarked forms. These forms are

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triggered by some high-ranked markedness constraint, which at some point is either demoted to regions where its presence can no longer be felt (Levelt 1994, 1995; Goad 1998, 2001, 2003), or the constraint undergoes a change in the domain of application (Bernhardt & Stemberger 1998; Pater & Werle 2001, 2003; Pater 2002). These measures have to be taken since CH of primary PoA features does not appear in adult language at all. In contrast, other unmarked aspects of children's initial productions, like a CV syllable structure or a minimal Prosodic Word shape, either remain in force in some languages, or emerge under certain circumstances in the adult grammar (The Emergence of The Unmarked, McCarthy & Prince 1994). The child-language-specificity, either of the constraint or of the domain of application of the constraint is a problem if we want the substance of grammars, including child grammars, to be stable, and if we want child grammars to mirror cross-linguistic adult grammars (see Pater 2002 for similar reflections).

The second salient fact is that CH is an emerging phenomenon in children's productions. In initial vocabularies there are no CH forms, and children are in fact surprisingly faithful to the PoA structure of the adult target words they are attempting. In the case of CH, target forms that at later stages lead to CH productions are simply not attempted in the early stages. This initial faithfulness is not expected in a grammar where markedness constraints outrank faithfulness constraints - the accepted view of an initial developmental grammar in Optimality Theory today (see Boersma & Levelt 2003 and references therein; Gnanadesikan 1995/2004). Also, it would be expected that the subsequent demotion of Markedness constraints in the grammar would give rise to more faithful productions, rather than less faithful ones.

A neglected issue concerning CH data is how CH forms relate to other forms in the vocabulary. CH forms have been treated as an isolated set of data in most accounts. However, here we will show that they are an epi-phenomenon of the way children handle Place of Articulation in their vocabulary as a whole.

In the remainder of this paper we will elaborate on the above facts and issues, and show how they can be dealt with. We propose, specifically, that the nature of the initial phonological system is different from the system in more advanced stages of development because it is closely tied to the developing lexicon. In the initial stages, the development of lexical representations and the acquisition of a phonological system go hand in hand. We argue that constraints can emerge in the grammar, as grammaticalized generalizations over the child's early productive lexicon. It remains to be seen whether these constraints are transient, or will form a more permanent part of the grammar. At least, traces of the effect of these constraints can be found in the adult target language (Fikkert *et al*. 2004). Furthermore, we present evidence from production for initial 'holistic' and un(der)specified phonological representations. In the course of development these representations become segmentalized and more specified.

A constructionist or emergentist view of the child's grammar and of the child's lexical forms is of course not new (a.o. Ferguson & Farwell 1975; Macken 1978; Menn 1983; Moskowitz 1973; Vihman 1996, Vihman & Velleman 2000; Waterson 1971). Our aim here is to reconcile this view with a generative approach (in casu OT-based research) on acquisition (see also Pater 2002) by pointing out where, when and how a developing grammar is supplied with 'constructionist' elements. However, our primary goal here is to determine the exact nature of the data.

2. Materials and Methods

Since our claim is that CH is a consequence of emerging constraints, which are built on the structure of the initial lexicon, our interest lies in the development of the distribution of PoA features over words. With that objective we studied the PoA structure of every single word in the utterances of five children acquiring Dutch as their first language. In addition, we studied the PoA structure of words in both the language intake of the children, and in child directed language input (the Van de Weijer (1998) corpus). By intake we mean the adult target words that children attempt to produce, which is a selection from the adult input.

We studied longitudinal, developmental data from 5 children acquiring Dutch as their first language:[1] Tom (1;0-2;22), Jarmo (1;4.18-2;4.1), Robin (1;4.14-2;4.28), Eva (1;4.12-1;11.8) and Noortje (1;7.14-2;11). We recorded data of these children every other week for a period of about one year. These children were selected out of the original group of 12 children from the CLPF database (Fikkert 1994, Levelt 1994) because they were recorded from the earliest stages of meaningful speech production. A total of 8407 spontaneous utterances were analyzed (onomatopaic forms, and

[1] These data can be found in CHILDES (MacWhinney 2000).

immediate repetitions were excluded from the analysis). All the words in these utterances were coded for their PoA structure in the following way: labial consonants were represented by P, coronal consonants by T and dorsal consonants by K. Round (labial and dorsal) vowels were represented by O, coronal (front) vowels by I and low vowels by A (see Pater & Werle 2001 for a similar method). In addition, front rounded vowels were coded as IO. However, as these vowels occurred infrequently and only at more advanced stages of development, they did not influence the main pattern. In words of more than one syllable only the stressed syllable was coded. Thus, a CVCV form with stress on the initial syllable (where V stands for either a long or a short vowel) was coded CVC-: a word like *baby* being coded as PIP-. As there was no difference in the developmental patterns of PIP versus PIP- words,[2] we collapsed both types in our further analyses. In the case of consonant clusters, the PoA feature of the least sonorant consonant in obstruent-sonorant clusters was taken as the basis for coding, as in most instances this is the consonant that survives in children's cluster reduction patterns (Fikkert 1994, Barlow 1997, Jongstra 2003). For similar reasons, in the case of /sC/-clusters the PoA feature of the /C/ was coded. /h/ was coded as placeless H. In (1) we provide some examples of our coding of children's utterances:

(1) Child Utterance Coding

Target	*Child Production*	*Coding*	*Result*
brood *bread* /brot/	[bop]	b= P o= O p = P	POP
snoep *candy* /snup/	[fup]	f = P u = O p = P	POP
paard *horse* /part/	[pat]	p= P a = A t = T	PAT
trein *train* /trɛin/	[tɛin]	t = T ɛi = I n = T	TIT
lachen *laugh* /lɑχə/	[lɑχə]	l =T ɑ = A	TAK-

[2] This is itself an interesting finding, as it strengthens the claim that there is a *word*-pattern, rather than a syllable-based pattern. Codas and onsets of second unstressed syllables behave similarly with respect to PoA.

$\chi = K$

We coded the adult target words in a similar way, as exemplified in (2):

(2) Adult Target Coding

Target	*Coding*	*Result*
brood /brot/	br = P	POT
	o = O	
	t = T	
snoep /snup/	sn = T	TOP
	u = O	
	p = P	
paard /part/	p = P	PAT
	a = A	
	rt = T	
trein /trɛin/	tr = T	TIT
	ɛi = I	
	n = T	

In addition to the adult targets we also coded 914 words from a list of words that 6-year olds are supposed to know and use. This so-called ‘Streefwoordenlijst’ (Schaerlaekens, Kohnstamm & Lejaegere 1999; Zink 2001) is comparable to the McArthur’s CDI list. Furthermore, the utterances in the child directed speech database of Joost van de Weijer were coded (van de Weijer 1998).[3] These were the sources we used to gain information about the PoA structure of the input and intake of language learners.

We coded all words in both the children’s utterances and their corresponding targets. However, here we limit the discussion to those words that have at least two consonants, i.e. words with a CVC(-) coding, since we are particularly interested in how PoA in words with two consonants develops in children’s outputs. We will only illustrate the very first stage with the PoA structure of CV and VC(-) words.

In order to see whether a developmental pattern could be found for the distribution of PoA features over words, the PoA patterns of the child utterances and those of the adult targets were aligned on separate Guttman scales, as will be shown below. Guttman scaling is a procedure for obtaining an order in data, and for checking to what extent an order is followed (Torgerson 1963). As the data could be aligned

[3] We want to express our thanks to Joost van de Weijer for generously sharing his data with us.

quite nicely, we concluded that the PoA structures were acquired in a particular order over time. We assumed a pattern to have been acquired if it occurred at least three times during one session, even if the child produced three similar PoA forms of one target word.

For every child the data were aligned on three scales: one showing the order of appearance of the different PoA patterns in the child's production data, one showing the order of appearance of attempted target PoA structures, and one showing the order of faithful productions of attempted adult targets. Finally, we calculated the distribution of the different PoA patterns in the coded list of 914 words from the 'streefwoordenlijst', as well as in the set of attempted adult targets and in the child directed input database. We did this in order to check whether frequency in the input, or intake, influences the order of development in production.

3. Results: PoA patterns in children's utterances, intake and input

In the subsequent sections, we first discuss the PoA patterns found in the production data of the children, and those found in the attempted targets (the intake). Subsequently, we investigate how faithful productions of adult targets develop, and when unfaithful productions appear. Finally we present the distribution of PoA patterns in the language intake and input.

3.1 Development of PoA patterns in children's production data

In this section we provide the developmental patterns of PoA structures from two children, Jarmo and Robin. The patterns of the other children are remarkably similar. In table (I) and (II) below, we have summarized the results from the Guttman scaling procedure for Jarmo and Robin.

Table I: PoA patterns in production (Jarmo)

Stage	Produced forms by Jarmo								
	PVP	TVT	KVK	PVT	PVK	TVK	KVT	TVP	KVP
I 1;4.18 –1;5.28	PA PO	TA TI	KA KO						
II 1;5.28 – 1;6.14	PI	TO	KI						
II/III 1;6.14 - 1;10;23	PAP POP PIP	TIT TAT TOT		POT PAT					
III/IV 1;10;23 1;11.21			KIK KOK	PIT	POK	TIK			
IV/V 1;11.21 – 2;2.6			KAK		PIK	TOK TAK	KIT KAT KOT	TAP TIP TOP	
V 2;2.6									KOP KIP KAP

Table II: PoA patterns in production (Robin)

Stage	**Produced forms by Robin**										
			PVP	TVT	PVT	TVK	PVK	KVK	TVP	KVT	KVP
I 1;5.11 – 1;6.22	PA PO	TA TI	PAP	TAT TIT							
II/III 1;6.22 – 1;8.10	PI		POP		POT			KAK[4]			
II/III 1;8.10 – 1;9.22		TO		TOT	PAT PIT						
IV 1;9.22 – 2;2.27			PIP			TIK TAK TOK	PIK PAK POK	KIK KOK			
V 2;2.27 – 2;3.17									TIP TAP TOP	KIT KAT KOT	KOP KAP KIP

Five general stages emerge from the data:

[4] The only early forms of the shape KAK are onomatopoeic forms like *kwak* 'quack'.

Stage I

At the first stage, both consonants (C_1 and C_2) in the words are labial (P), Coronal (T) or Dorsal (K). In other words, C_1 equals C_2 with respect to PoA features. In addition, the vowel either carries the same PoA feature as the consonants (V = C, that is POP, TIT and KOK) or it is A, a low vowel.[5] Not all children have dorsal initial words, though. For instance, one child, Tom, only has POP, TIT, PAP and TAT words in the earliest stages of production (1;2.14–1;3.24). It seems that all words are harmonic; i.e. words are completely coronal (TIT), labial (POP) or dorsal (KOK). Low vowels in Dutch seem to be neither front nor back, nor round. In short, they seem to lack primary PoA features, and are solely distinguished by features under the Tongue Height Node (Lahiri & Evers 1991, Levelt 1994; see also section 5.2.1). Therefore they do not interfere with the PoA structure of the word.

Stage II

At the second stage, both consonants still share their place of articulation. However, the vowel can now be different from the consonant(s): we find PI(P), TO(T) and KI(K) patterns. Between 1;5.27 and 1;6.13 Jarmo, for instance, starts producing PI, TO and KI word forms, in addition to the forms mentioned above. From the next stage on we represent vowels as ‘v’, as their nature is no longer restricted and can freely combine with all consonant patterns that are allowed in the child’s system.

Stage III

At stage III, C_1 and C_2 can carry different PoA features for the first time, but in a very restricted way. At first, the only pattern with two consonants that differ in PoA is PvT: C_1 is labial, C_2 is coronal.

Stage IV

Here PvK and TvK appear in the children’s data. In other words, C_2 can be realized as dorsal.

Stage V

Finally, at stage V, we find P-final and K-initial combinations: TvP, KvT and KvP.

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[5] Often, words in the initial stage are mostly of the structure CV. In that case, we also find that V = C (PO, TI or KO) or V= A (PA, TA, KA).

It is clear that the term 'stage' is used here in a loosely defined way. It refers to 'reconstructed' stages; in reality, stages can overlap in time, as can be seen above in the data of Jarmo and Robin. However, taking the patterns of all children together, it is the five proposed stages that stand out. Moreover, the data of each individual child may not necessarily show evidence for all five stages, but, importantly, they are never in conflict with the proposed stages either.

3.2 Development of PoA patterns in children's intake

The results for PoA patterns in the intake, i.e. the targets that the child aims to produce, are in fact very similar to the results for the PoA patterns in production, as can be seen in Table III, although they are somewhat less transparent.

Table III Attempted targets by Robin

Period	**ATTEMPTED targets by Robin**								
1;5.13-1;5.27	POP PAP PIP	TIT	TIK*[6] TAK*						
1;5.27-1;6.22				PIT					
1;6.22-1;7.29		TAT TOT		PAT POT	KOT KAT				
1;7.29-1;8.10							TAP	KIK	
1;8.10-1;9.22						POK PIK			KOP
1;9.22-1;11.9						PAK	TOP TIP		KIP
From 1;11.9			TOK		KIT				KAP

The general pattern is that:

I An initial preference for $C_1 = C_2 = V$ (or V = A) structures is also found in the language intake.

II The first combination of different consonants in the intake is PvT, like in production.

[6] TIK and TAK only occur in the onomatopoeic expression *tik tak* 'tick tock'.

III P-final adult targets are attempted relatively late.

The development of target selection thus resembles the development of production forms, but it also shows more variation between children. Naturally, the set of attempted target forms should be larger than the set of produced forms to guarantee a learning effect.

3.3. Development of faithfully produced adult targets

An interesting result comes from the development of faithful productions. With a faithful production we mean a word-production that has the same PoA structure as the target adult word. What we find is that at the early stages all words are produced faithfully and that unfaithful productions appear only later. This is best illustrated with the Guttman scale for the child Robin, in Figure 1. The faithful productions are shaded. In the first set of recordings there are no productions outside of the shaded area, i.e., all the productions are faithful. The forms without shading are the unfaithful productions.

INSERT FIGURE 1 about HERE

An examination of these unfaithful productions reveals that every single pattern that is used as an unfaithful substitute has previously (or simultaneously) been used faithfully.[7] This is shown in Table IV:

[7] The only exception is TOK (marked with *), which appears very late.

Table IV. Faithful vs. unfaithful use of PoA pattern

PoA pattern in production	First Faithful use	First Unfaithful use for Targets:	
TIT	1;5.13	1;5.27 1;7.15 1;8.26 2;0.20	PIT TOT KAT KIT
PAP	1;5.13	1;6.22 1;8.26 1;11.9	PAT TAP KAP
TI	1;5.13	1;7.15 1;7.15 1;7.29	TIK PIK KIK
TA	1;5.13	1;5.13	TAK
POP	1;5.27	1;7.15 1;7.15 1;8.10 1;9.22	TOT KOT KOP TOP
POT	1;7.15	1;8.10 1;9.8	TOT KOT
TAT	1;7.15	1;7.15	KAT
PAT	1;7.29	1;7.29	TAP
TOT	1;8.26	1;9.8	KOT
TIK	1;9.22	1;10.9	KIK
PIP	1;10.9	1;10.9 1;10.9	TIP KIP
TOK	1;11.9*	1.10.23	KOK

For every PoA pattern that is used as a substitute at some point, the date of its first faithful use is in the 'First Faithful use' column, and the date of its first unfaithful use is in the next column. It is also indicated for which target pattern the production pattern is used as a substitute. This same pattern is found for the other children in our study: faithful productions of a specific PoA pattern appear before this pattern is used unfaithfully – or in some cases they appear simultaneously – in the recorded data.

3.4. Distribution in intake and input

Our final results come from the distribution of the different PoA patterns in the intake and input. The distribution was calculated in three sets of data: (a) in a list of 914 ‘required’ vocabulary[8] items for 4-year-olds (a rough estimation of the input), (b) in the set of adult targets that were attempted by the children (intake over all children), and (c) the Child Directed Speech corpus of van de Weijer (1998).

(3) Distribution of the different PoA patterns in intake

(a) ‘required’ vocabulary		(b) Attempts at adult targets		(c) Child Directed Speech	
KK	2,74%	KP	3,13%	PP	0,8%
PP	5,14%	KK	3,95%	KK	1,8%
KP	5,14%	PP	5,69%	TP	1,9%
TP	10,5%	TP	6,00%	PK	3%
KT	10,83%	PK	8,52%	KP	4,5%
PK	11,27%	KT	9,45%	KT	9,1%
TK	13,24%	TK	9,78%	TK	7,8%
TT	15,65%	TT	25,72%	PT	19,8%
PT	25,49%	PT	27,76%	TT	24,1%

The low-to-high order of frequencies is quite similar in the three lists: KK, PP, TP and KP have the lowest frequencies, KT, PK and TK are in the middle-range, and TT and PT occur in the data most frequently.

3.5 Summary of results

From the longitudinal data of language learners of Dutch, a clear developmental pattern emerges in the PoA structure of their productions. Generalizing over the entire set of data, we find the following stages:

(4) Stages in the development of PoA structures in production

Stage	*Development*	*Production patterns (cumulative)*
I	$C_1 = C_2 = V$ (or V=A)	POP, PAP, TIT, TAT, KOK, KAK
II	$C_1 = C_2$	PIP, TOT, KIK
III	$C_1 = P$, $C_2 = T$	PVT

[8] This refers to the target vocabulary that Dutch children are supposed to have at the age of six, according to Schaerlaekens *et al*. (1999) and Zink (2001).

IV	$C_2 = K$	PVK, TVK
V	$C_2 = P$, $C_1 = K$	TVP, KVT, KVP

The development of selected adult targets for production shows a similar pattern. These developmental patterns are related because of the salient finding that a PoA pattern is produced faithfully before it is used as a substitute.

4. Discussion

4.1. Generalizations over developmental patterns

For a satisfactory and comprehensive explanation of the results presented in section 3 we need to take into account at least the following factors: (a) the developing representation of phonological units, (b) the developing lexicon, and (c) the specific input. Below we formulate five generalizations over the developmental patterns that relate to these factors:

1. Whole Word Stage: PoA contrast is initially defined on the entire word, and in this sense the word is not analyzed into separately targetable segments yet (Waterson 1987, Menn 1983, Levelt 1994).
2. Staged Segmentation: After the whole-word stage, words become segmentalized. First, consonants become separate from vowels. Subsequently, PoA contrast becomes defined over different consonant positions: C_1 is the dedicated position for labial, C_2 is the dedicated position for dorsal (Moskowitz 1973; Vihman *et al.* 1993).
3. Emerging Constraints: Language learners are constrained by their own lexicon: lexical patterns are overgeneralized, i.e. the structure of the lexicon builds constraints into the grammar. This accounts for the pattern of initial faithfulness and emerging unfaithfulness in the data (Ferguson & Farwell 1975, Menn 1983).
4. Unspecified Coronals. Compared to Labial and Dorsal, the position of Coronal segments is not restricted to a specific position. We hypothesize that

this is because Coronal is unspecified in the lexical representation (Paradis & Prunet 1991).

5. Input Frequency effect: There is a correlation between input-frequency and order of development as soon as segments in words are separately specifiable. Inter- or intra-language input-specific distribution of PoA features can thus lead to different orders of development (Moskowitz 1973).

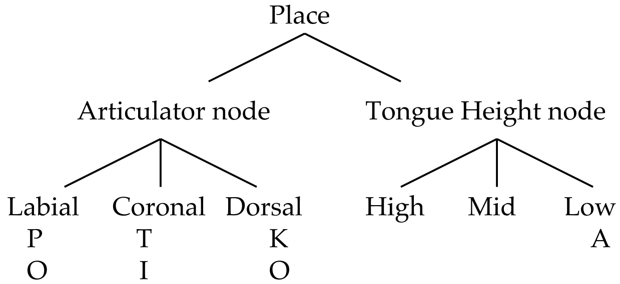
These points will feature in the remainder of the discussion, where we will elaborate on the different developmental stages.

4.2 Stage I

4.2.1 One word, one feature

As a generalized initial stage it was found that in production words have a very restricted PoA pattern, namely TIT, TAT, POP, PAP and for some children also KOK, KAK.[9] Translating these patterns back to features, the patterns TIT, POP and KOK represent structures that can be captured by referring to a single PoA feature, Coronal (i.e., unspecified), Labial, or Dorsal, respectively. The A stands for a low vowel /a/ or /ɑ/, and we will contend that a low vowel has no PoA specification, only the tongue height specification Low, as shown in (5) (Lahiri & Evers 1991). This is why the low vowels can appear together with either Coronal, Labial or Dorsal consonants in the TAT, PAP and KAK patterns.

(5)



In the initial stage, then, every produced word contains a single PoA characterization. It thus appears that with respect to PoA, the entire unsegmented word forms the

[9] For children with only CV-syllables the patterns are TI, TA, PO, PA and KO, KA.

representational unit of specification (Waterson 1987, de Boysson-Bardies & Vihman 1991). If the specification is Labial, and the vowel is non-low, the result is POP; if the vowel is low the result is PAP. No PoA specification (i.e., Coronal) leads to TIT, or TAT in case the vowel is low, and a Dorsal specification leads to KOK, or KAK in case the vowel is low.

We will illustrate this stage with the initial recorded vocabularies of two children, Robin and Eva. These children differ in one respect: Robin is almost entirely faithful to the PoA structure of the adult target, except for some syllable-structure induced dissimilarities (6e, g, i), while Eva's productions can have a PoA structure that is fairly unfaithful to the adult target structure.

(6) Initial vocabulary of Robin (1;5.11)

	adult target	*gloss*	*child's production*	*target structure*	*production structure*
a.	die	that one	ti	TI	TI
b.	huis	house	hœys	HIT	HIT
c.	thuis	home	tœs	TIT	TIT
d.	zes	six	sɛs	TIT	TIT
e.	tik tak	tick-tock	tita	TIK TAK	TIT
f.	aan	on	an	AT	AT
g.	daar	there	da	TA	TA
h.	niet	not	nt	TIT	TT
i.	pop	doll	pɔ	POP	PO
j.	mamma	mommy	mɑma	PAP	PAP
k.	aap	monkey	ap	AP	AP

(7) Initial vocabulary of Eva (1;4.12)

	adult target	*gloss*	*child's production*	*target structure*	*production structure*
a.	dicht	closed	dɪə	TIT	TI
b.	eend	duck	ein	IT	IT
c.	eten	eat	eitɪ	IT	IT

d.	trein	train	tæin	TIT	TIT
e.	neus	nose	nɛs	TIT	TIT
f.	konijn	rabbit	tɛin	TIT	TIT
g.	teen	toe	ten	TIT	TIT
h.	patat	french fries	tɑt	TAT	TAT
i.	staart	tail	tat	TAT	TAT
j.	daar	there	da	TA	TA
k.	bed	bed	dɛt	**PIT**	**TIT**
l.	prik	injection	tɪt	**PIK**	**TIT**
m.	kijk	look	tɛit	**KIK**	**TIT**
n.	beer	bear	dɛ	**PI**	**TI**
o.	oma	granny	oma	OP-	OP-
p.	op	on	ɔp	OP	OP
q.	open	open	opə	OP	OP
r.	aap	monkey	ap	AP	AP
s.	buik	tummy	bœyp	**PO/IK**	**POP**
t.	brood	bread	mop	**POT**	**POP**
u.	sloffen	slippers	pɔfə	**TOP**	**POP**
v.	poes	cat	puf	**POT**	**POP**
w.	schoenen	shoes	umə	**KOT**	**OP**

As can be judged from the types of words that are attempted, the initial *recorded* vocabulary of Robin reflects the actual initial set of words in his active vocabulary, while Eva's initial recorded vocabulary reflects a more advanced stage of lexical development. However, her unfaithful productions all fit the initial stage of 'One word, one PoA feature.'

The data in (7k, l) and in (7s, t, u, v) could easily be mistaken for cases of CH. However, two aspects show that this is the wrong analysis. First of all, there would be both labial harmony and coronal harmony, and second, both types of harmony would apply to the same sequence of consonants, namely labial-coronal (7k, t, v). In (7l), an apparent case of coronal harmony – given markedness, coronal harmony is curious in itself – there is actually no coronal consonant in the target adult word that could trigger harmony. However, there is a coronal (front) vowel. The data in (7n) and (7w) confirm that it is the vowel that determines the PoA structure for the entire word: in *beer* (7n) the vowel is coronal, there are no coronal consonants in the target, and labial /b/ is substituted with coronal /d/. In *schoenen* (7w) we find the opposite: the vowel is labial, there are no labial consonants present in the target, and coronal /n/ is substituted with labial /m/. Since the vowel is a salient segment in perception, it is not surprising that the PoA value of this segment should attract the highest amount of attention and feature as the PoA specification for the entire word in production.

Faithfulness to the underlying PoA specification of a vowel outranks faithfulness to the underlying PoA specification of a consonant, and apparently only one specification (or no specification at all) is possible. The surface form therefore carries only the PoA feature of the target adult vowel.

4.2.2 Origin of One Word, One feature stage

What is the origin of this initial PoA pattern? It is unlikely that the pattern results directly from a high-ranking markedness constraint in the grammar. Harmonic forms, i.e. forms with consonant harmony, are usually dispreferred in the languages of the world (Frisch *et al.* 2004). An account in terms of an innate and universal markedness constraint requiring such harmonic forms is therefore not the most obvious solution.

MacNeilage and Davis (2000) give a biomechanical explanation for a similar pattern in babbling and early words. They found the following fixed patterns of CV productions: Coronal C + front V (i.e, TI), Labial C +central V (i.e. PA) and Dorsal C + back V (i.e. KO). According to MacNeilage and Davis these patterns result from mandibular oscillation – an opening-closing movement of the jaw which forms the CV *frame* – in combination with a tongue that remains fixed in either front, central or back position during that oscillation, the *content*.

Waterson (1971) states that the child initially has difficulty in the planning and production of rapid articulatory movements. Limiting the number of PoA features to one per word leads to a reduction of the processing and production load.

Both explanations are pragmatic, accounting for the ‘One word, One PoA feature’ stage by means of either a physical constraint or a constraint on planning and processing. A grammatical account of this developmental stage requires that a constraint such as ‘One word, one PoA feature’ be active in the grammar. As this is a pragmatic constraint based on difficulties with performance, it is part of E-language. Some E-language constraints ultimately receive the status of I-language constraints, and it has been claimed that emerging markedness constraints of this type can cause language change (Haspelmath 1999). However, since both the biomechanical restrictions and the planning and production difficulties of the early stages will disappear over time with experience and maturation, it is very unlikely that this particular E-language constraint will receive the status of an I-language constraint and remain in the grammar. It would thus be a transient aspect of the grammar. As these biomechanical or processing difficulties are highly unlikely to re-appear, no adult language will have this constraint actively participating in the grammar. We return to the issue of transient constraints in 4.3.

4.2.3 Perception

An alternative to a ‘One word, One PoA feature’ constraint in the grammar arises from considering the role of perception at this particular stage of development. From numerous studies it has become firmly established that infants are able to discriminate speech sounds at high levels of accuracy (for an overview see Jusczyk 1997). The fact that children specifically select words for production that conform to a certain pattern illustrates this ability. In contrast, it turns out that as soon as children start to learn word meanings, they are no longer such accurate perceivers (Stager &Werker 1997, Werker *et al*. 2002, Pater *et al*. 2004, and Fikkert, Levelt & Zamuner 2005). Sound sequences like /bɪ/ and /dɪ/, which young infants can discriminate, cannot be discriminated by older infants – 14 months old – when word meanings are involved. Stager & Werker found that it is not until the age of 17 months that infants can discriminate minimal pairs like /bɪ/ and /dɪ/ that have semantic referents.

In the initial stage in our study, the children are between 14 and 17 months old, i.e., precisely the period during which children cannot discriminate /bɪ/ and /dɪ/ if word meaning is involved, and where they have just set out to build a lexicon. Nonaccurate perception, or rather, an incomplete storage in the lexicon of what is perceived, can thus be expected, leading to incompletely specified lexical representations. We expect vowels to be perceived quite accurately as they are the perceptually salient segments (see Kuhl 2000 for an overview). The perceived PoA characteristic of the vowel is thus mapped successfully onto the lexical representation. The consonants, however, are less accurately identified, and leave gaps in their lexical representation. The word *prik*, for example, could be lexically represented as in (8). As in Stager & Werker's /bɪ/ versus /dɪ/ case, the child is not sure about the PoA feature of the consonants, and their PoA is therefore left unspecified.

(8) Incomplete lexical representation

prik (injection)

Adult output:	[pr ɪ k]
Child's Lexical representation:	C ɪ C
	Cor[10]

In production, the PoA feature that is available from the lexical representation is used to fill out the unspecified segments. The child is therefore faithful to the underlying representation, and the discrepancy between adult target and child production results from an incomplete representation, which in turn results from the incomplete storage of perceptual features in the phonological representation.

What still needs to be explained is the difference between children that appear to select specific words (Robin, in (6) above) and those that do not (Eva, in (7) above). We offer a preliminary hypothesis here. The 'labiality', 'coronality' or 'dorsality' characteristic of the salient vowel is not disturbed by dissimilar "noise" from surrounding consonants in words that are harmonic across vowels and consonants. Some children, like Robin, only represent (or only attempt to produce) words with a 'pure' PoA characteristic, while other children, like Eva, represent words on the basis of PoA information of the vowel alone. Some children play safe,

[10] We will assume that coronal is underspecified and therefore not present in the underlying representation. The strongest evidence for this claim comes from the fact that coronal often appears when other sounds are disallowed, as in the case of the U-shaped pattern of development to be discussed below in (13).

phonologically speaking, while others trade phonological security for more expressive power.

How can we decide between the two accounts, a grammatical constraint versus incomplete storage in the lexical representation, for the initial stage? We opt for the incomplete storage account for the following reasons. First, it is indicative that the period in which the children in Stager &Werker's studies had problems with linguistic perception coincides exactly with the period in which children produce the completely harmonic forms. Furthermore, the data are cross-linguistically uncommon, and very different from the data from subsequent developmental stages. Assuming a detailed phonological representation for the initial stage renders the developments in the next stage unexpected and hard to account for. Below we discuss how subsequent developments follow from the growing phonological awareness of the learner: segmentalization of the word-unit and the discovery of segmental patterns in both the surrounding language and the child's own lexicon.

4.3 Stages II-IV: Staged segmentation

Segmentation of the unit 'word' can be seen as an instance of developing phonological awareness: the ability to deal explicitly with phonological elements (Ferguson & Farwell 1975). In the data of some of the children we saw that as a first step in word segmentation, the category vowel is separated from the category consonant. Where in the initial stage we found predominantly POP and TIT and some KOK patterns, in the second stage we also find TOT, PIP, and for some children also KIK, patterns. From now on we will focus on the consonants.

4.3.1 Labial Left

As soon as consonants in a word can be separately specified, severe limitations on features in combination with certain positions in the word become apparent. The first non-identical, in terms of PoA, combination of consonants is, for every child in our study, PT. The same observation has been made in the early words of children from five different language communities (MacNeilage & Davis 2000), and has been referred to as fronting: a sequencing of consonants proceeding from more forward to more backward places of articulation across the word (Ingram 1974).

According to MacNeilage and Davis (2000) this pattern is so basic because it reflects the young child's tendency to start a word in an easy way – a labial consonant only requires a jaw movement, no additional tongue movement.

Another likely reason for this specific distribution of PoA features within a word to emerge early is the frequency with which it occurs in words from the target language, the input. Words with an initial Labial consonant are highly frequent in Child Directed Speech: Joost van de Weijer (p.c.) reports that 26.19% of the CVC(V) words directed to a child have a labial segment at C_1, and 19.8% of the CVC(V) words have an initial labial consonant and a coronal segment at C_2. PT is the most frequent pattern in the input after TT in his database. In (3) above, we saw that the PT intake of children is of a similar magnitude: PT words form 25.49% of the words in the required vocabulary, and 27.76% of the attempted adult targets. Among others, Juczyck, Luce and Charles-Luce (1994) demonstrated that infants are aware of the relative frequency of occurrence of different phonotactic patterns: infants prefer to listen to words with frequently occurring phonotactic patterns. Zamuner, Gerken & Hammond (2004) present similar results for older children.

The child starts adding words to his/her lexicon that have this PT pattern, like *bad* (bath), *bed* (bed), *pet* (cap) and *poes* (cat), and these targets are faithfully produced by the child, i.e. with a PT pattern. Subsequently, the learner analyses his or her vocabulary and deduces a pattern: labial is connected to C_1. This generalization over the child's production lexicon gives rise to a preference: Labial should be at the left edge. At this point the lexical pattern 'Labial Left' becomes part of the grammar, as a constraint [LABIAL, and can be 'overgeneralized'. This is illustrated in the tableaux in (9). In order to show the interaction of [LABIAL with Faithfulness, we have supplied the grammar in the tableaux in (14) with the Faithfulness constraints MAX(LAB), DEP(LAB) and LINEARITY.

(9) OT grammar I: [LABIAL

a. *poes* (cat) /pus/

/pus/	[LABIAL	MAX(LAB)	LINEARITY	DEP(LAB)
☞pus				
puf				*
sup	*!		*	

b. *soep* (soup) /sup/

/sup/	[LABIAL	MAX(LAB)	LINEARITY	DEP(LAB)
sup	*!			
pus			*!	
☞fup				*
sus		*!		

c. klimmen (climb) /klɪmə/

/klɪmə/	[LABIAL	MAX(LAB)	LINEARITY	DEP(LAB)
kɪmə	*!			
mɪkə			*!	
☞ pɪmə				*
kɪkə		*!		

While targets like *poes* can be faithfully produced without violating [LABIAL, the faithful candidates for targets like *soep* and *klimmen* are not the optimal candidates. The optimal candidate for *soep* (9b) is [fup], and the optimal candidate for *klimmen* (9c) is [pɪmə] in this particular grammar: they satisfy [LABIAL, and in addition they satisfy the higher ranked faithfulness constraints MAX(LAB) and LINEARITY.

Again, forms like [fup] and [pɪmə] can be mistaken for cases of CH. In our analysis, however, they result from the interaction of the requirement that Labial should be linked to C_1, and the faithfulness constraints MAX(LAB), LINEARITY and DEP(LAB). To illustrate this with chronology, around the age of 1;7.15 Robin starts to attempt more and more adult target words with a PvT structure. As discussed earlier, these targets are produced faithfully. One month later, in the recording at 1;8.12 the first cases of Labial CH appear. Except for TvT and PvP and a quickly disappearing KvK, no other patterns are produced, or even attempted with any frequency. According to us, then, there is no pressure in the grammar for two consonants to share a PoA feature. Additional support for a non-harmonic approach comes from metathesis in child language and from cases where the to-be-aligned feature Labial does not come from an input labial consonant, but from a vowel. In the literature we find the observation that some children metathesize T/KvP forms to PvT/K forms (Menn 1983, Velleman 1995). It is clear that these metathesized forms result from the same [LABIAL constraint in combination with a slightly different ordering of the faithfulness constraints. In the grammar of metathesizing children, LINEARITY, which controls the sequence of segments, is ordered below DEP(LAB), as in (10):

(10) Metathesis of *kip* (chicken) /kɪp/

/kɪp/	[LABIAL	MAX(LABIAL)	DEP(LAB)	LINEARITY
kɪp	*!			
☞pɪk				*
pɪp			*!	

In (11), data from Robin and Eva show a [LABIAL effect originating with a target labial vowel:

(11) VC 'harmony' resulting from [LABIAL

a. doen 'do'	/dun/	[bun]	Eva (1;7.15)
b. schoenen 'shoes'	/sxunə/	[bunə]	
c. schoen 'shoe'	/sxun/	[pun]	Robin (1;8.10)
d. goed 'good'	/xut/	[fut]	

As shown in (12) these data result from the same (partial) grammar as the CH and metathesis data above:

(12) VC Harmony of *doen* (do) /dun/

/dun/	[LABIAL	FAITH(LABIAL)
dun	*!	
☞bun		
din		*!

The question is whether this emergent constraint [LABIAL is a transient constraint, or whether it establishes itself firmly in the grammar as an I-language constraint. If it is part of the I-language grammar, we should find evidence for [LABIAL cross-linguistically. It certainly leaves a trace: the cross-linguistic high frequency of labial initial words (Davis, McNeilage & Matyear 2002). Grammaticalization of the 'Labial Left' lexical pattern in the learner's grammar could re-establish the high frequency of PT/K words in vocabularies. We need to be on the look-out for cases of 'The Emergence of The Unmarked' (McCarthy & Prince 1994) that possibly refer to [LABIAL. A first attempt to experimentally test this claim was a rhyming experiment in which subjects were found to supply rhyme-words more often with an initial labial consonant than with other places of articulation. This suggests that both older children and adults have a preference for initial labials (Fikkert *et al.* 2004).

*4.3.2 *[DORSAL*

Labial and dorsal are considered to be marked PoA features. During development it appears that labial and dorsal segments are in complementary distribution for a while: Labial becomes specifically linked with C_1, while dorsal is banned from this position. In the data of some children, like Eva, we find evidence for both a general ban on dorsal and, later, the more specific constraint banning dorsal from initial position. In the data of most children, however, target words containing dorsal in C_2 position, like *dragen* (carry), *drinken* (drink) and *pakken* (catch), appear, and are faithfully produced. Moreover, target words containing Dorsal in C_1 position, which were produced faithfully in the initial 'holistic' stage, e.g., *koek* /kuk/ (cookie), all of a sudden are produced unfaithfully, faithful [kuk] becomes unfaithful [tuk]. This U-shaped developmental pattern is especially salient in the data of Noortje.

(13) U-shaped development (data from Noortje)

a. Stage I

KOK	koek 'cookie'	→	[kuk]	(2;3.7)
	klok 'clock'	→	[kɔk]	(2;5.23)
KIK	kikker 'frog'	→	[kɪk]	(2;2.21)
	kijk 'look'	→	[kɛik]	(2;5.23)

b. Stage III

KOK	koek 'cookie'	→	[touk]	(2;8.17)
	klok 'clock'	→	[tɔk]	(2;8.17)
KIK	kijk 'look'	→	[tɛik]	(2;8.17)
	kikker 'frog'	→	[tikɑ]	(2;9.1)

c. Later stage

KOK	kruk 'stool'	→	[kyk]	(2;9.29)
	kuiken 'chicken'	→	[kœyk]	(2;10.12)

In (13a) we see that dorsal-initial target words are faithfully produced in the early stages in which the word is not, or hardly, segmentalized. The data in (13b) show a sudden dislike for dorsal: the exact same target words from the earlier stage are no longer produced faithfully. U-shaped patterns are not uncommon in acquisition data (Stemberger, Bernhardt & Johnson 1999), but are hard to account for in a traditional OT account where the initial state is Markedness >> Faithfulness. We cannot account for the development from (13a) to (13b) by referring to changes in the ranking between an innate markedness constraint of the type *[DORSAL (No initial Dorsals) and FAITH(DORS), since the demotion of *[DORSAL would give rise to more faithful productions, rather than less faithful ones. We assume, then, that *[DORSAL has emerged in the grammar, in a high-ranked position. In (13c), finally, the constraint against dorsal in initial position has lost its force, and target initial dorsals can be produced faithfully again. In (14), we provide examples of other dorsal-initial targets that appear simultaneously with the data in (13b) and have no initial dorsal in the child's production.

(14) Initial K > T elsewhere (data from Noortje)

a. KIT > TIT

kleine 'little'	→	[tɛinə]	(2;8.17)
kind 'child'	→	[tɪnts]	(2;9.15)
kers 'cherry'	→	[tɛs]	(2;9.29)

b. KAT > TAT

koud 'cold'	→	[tɑuts]	(2;7.2)

kan ‘can’ → [tɑnə] (2;9.1)

d. KOT > TOT

grote ‘big’ → [dotə] (2;9.1)

kousen ‘stockings’ → [tɑusa] (2;10.26)

e. KIP > PIP > TIP

kip ‘chicken’ → [pɪp] (2;6.5)

[tɪp] (2.10.12)

The example in (14e) merits some additional information. Because of the two constraints [LABIAL and *[DORSAL, discussed above, both TP and KP targets cannot be produced faithfully for some time. As long as [LABIAL is high-ranked, both TP and KP targets will be produced PP, hence [pɪp] for *kip* (chicken). The force of [LABIAL is the first to wane. This results in faithful productions of TP targets. KP targets still provide difficulties because of *[DORSAL. The production of KP targets does, however, evolve, namely from PP to TP: target *kip* now being produced [tɪp].

What happens to *[DORSAL in the grammar? Again we could say that it leaves a frequency trace in the language: Dorsal-initial words have a relatively low frequency compared to labial-initial and coronal-initial words. Its effect can also be seen in the nasal stop series: the dorsal nasal is banned from C_1 position in Dutch, as well as in many other languages.

4.3.3 Input/intake and order of development

Why do the Dutch children have the particular order of development of PoA patterns that is observed and not some different order? Why are PvT words so early and TvP words so late? It turns out that as soon as consonants with different PoA features can be combined in production, at Stage III, the order of acquisition correlates very well with the distribution of the different PoA patterns in the surrounding language, in this case Dutch. This is shown in (15) for the list of required words:

(15) Correlation intake-development I

List of required words			*Development*	
PvT	**233**	**25,49%**	Stage III	PvT
TvT	143	15,65%		
TvK	**121**	**13,24%**	Stage IV	TvK
PvK	**103**	**11,27%**		PvK
KvT	**99**	**10,83%**	Stage V	KvT
TvP	**96**	**10,5%**		TvP
PvP	47	5,14%		KvP
KvP	**47**	**5,14%**		
KvK	25	2,74%		

As can be seen, PvT is the most frequent PoA pattern in the set of 914 Dutch input words, and PvT is also the first pattern that is produced after the initial two 'whole word' stages. The K-final patterns TvK and PvK have the next highest frequencies, and also occur next in production. This is followed by the K-initial pattern KvT, both in frequency and in appearance. The P-final patterns TvP and KvP have the lowest frequencies and are also produced last. If attempted adult targets are also an indication of adult input (de Boysson-Bardies & Vihman 1991), then almost the same correlation is found, with a slight discrepancy between the KvT and PvK (italicized):

(16) Correlation intake-development II

Attempted adult targets		*Development*	
PvT	**27,8%**	Stage III	PvT
TvT	25,7%		
TvK	**9,8%**	Stage IV	TvK
KvT	***9,5%***		*PvK*
PvK	***8,5%***	Stage V	*KvT*
TvP	**6%**		TvP
PvP	5,7%		KvP
KvK	4%		
KvP	**3,1%**		

The distribution of PoA patterns in the Child Directed Speech data correlates less well for the KvT and PvK patterns (italicized in (17)): KvT has a relatively high frequency in this set of data, and PvK a relatively low frequency. However, it does correlate for the PvT pattern and the P-final patterns.

(17) Correlation input-development

Child Directed Speech		*Development*	
TvT	**24,1%**		
PvT	**19,8%**	Stage III	PvT
KvT	*9,1%*		
TvK	**7,8%**	Stage IV	TvK *PvK*
KvP	**4,5%**	Stage V	*KvT* TvP KvP
PvK	*3%*		
TvP	**1,9%**		
KvK	1,8%		
PvP	0,8%		

As can be seen in (15), (16) and (17), intake frequency does not correlate particularly well with PoA development in the earliest stages, Stage I and Stage II; specifically, KK and PP are of very low frequency, yet are produced very early. This is consistent with the claim that in the initial two stages the language learner has a different, less detailed, lexical representation. However, input frequency does correlate with PoA development as soon as consonants can receive separate PoA feature specifications. Given that differences in frequency can be very minor, a perfect correlation between input/intake frequency and developmental order can hardly be expected. On linguistic grounds we expect to find generalizations over these patterns, in terms of Dorsal-initial patterns, Labial-initial patterns, etc. This is worked out in detail in Fikkert, Levelt & van de Weijer (2002, *submitted*).

We proposed that the constraint underlying the apparent cases of Labial consonant harmony, [LABIAL, emerged in the grammar based on the child's lexicon. The word patterns in the early lexicon correlate with high-frequency word patterns in the input/intake. Indirectly, then, Labial harmony in Dutch child language can be traced back to the high frequency of Labial-initial words in the adult input.

5. Summary and Conclusions

In this paper we provided evidence that there is a fixed order of development of PoA contrast in words, both in production and in the selected targets. At the first stage, the word is an unanalyzed whole and we find only a single PoA in a word. We thus find words with the POP, TIT, and for some children KOK patterns, in addition to PAP, TAT and sometimes KAK patterns. Although these words are harmonic, they are clearly not the result of an assimilatory process between consonants, but show that PoA is not yet contrastively used within words

At stage two, segmentalization of words starts. For most children the vowel becomes separately specifiable from the rest of the word, i.e. the consonants, and we often find a separate PoA for the vowel and consonants; i.e. vowels and consonants can now contrast in PoA within a word. Here we find patterns such as TOT, PIP and KIK but combinations of different consonants have yet to appear.

At stage three, further segmentalization takes place and this development follows a strict pattern; first, we find that labial consonants are preferred at the left edge of the word, and subsequently we find that dorsal consonants are preferred at the right edge but banned from the left edge. At this third stage, the lexicon is first rapidly expanded with words from the target language that have the PoA structure PvT. Words with this structure are highly frequent in the target language. These labial-initial words are faithfully produced. Based on these forms, the generalization 'Labial is at the left edge of the word' is made, and this generalization becomes grammaticalized as a high-ranking constraint in the child's grammar. It is the constraint [Labial that is responsible for apparent cases of Labial consonant harmony. In a similar fashion, *[Dorsal emerges in the grammar. This constraint is consistent with the target language lexicon where a dorsal specification is relatively infrequent at C_1 and relatively frequent at C_2. PvK and TvK words are added to the lexicon, and are produced faithfully. Subsequently, *[Dorsal emerges high-ranked in the grammar.

The presence of these constraints in the grammar is reflected in unfaithful productions that promote labials and ban dorsals in initial position in the production data. U-shaped developmental patterns are a consequence of these emerging markedness constraints. As soon as, for example, *[Dorsal emerges, *koek* is realized as [tuk] rather than the earlier, faithful production [kuk]. It seems that at this point in development, the child builds constraints into the grammar based on the structure of the his or her own lexicon or intake. A question that arises is whether we should regard all markedness constraints as emergent constraints (p.e. Boersma 1998). Is it possible to find a principled difference between an innate set of constant, stable markedness constraints and these emergent markedness constraints that reflect the learner's focus on word-sized units. If there is such a division, it might well lie between prosodic markedness constraints, which are relatively uncontroversial in phonological theory, and the more elusive segmental markedness constraints.

With regard to the role of input frequency we can say that when children have segmentalized the words in their lexical representation, input frequency appears to determine the learner's choice for certain lexical patterns. Input frequency does not affect the first 'holistic' stage as PP and KK patterns are not very frequent but are produced early. However, when words are segmentalized, the most frequent patterns in the input appear first (i.e., PT). Less frequent patterns (i.e., KP) appear late. The frequencies of the intermediate input patterns lie quite close together and children vary in how they expand their lexicons with respect to these patterns. It thus seems that early production patterns and input frequency conspire towards the emergence of markedness constraints in the grammar.

We have demonstrated that children start out with faithful productions of targets, and thus, that Faithfulness – at least with respect to the underlying PoA structure – rather than just Markedness is active in the early states of the grammar. The generally assumed Markedness >> Faithfulness initial state of the grammar cannot account for emerging markedness in development. We might thus need to differentiate between universal markedness constraints and emergent markedness constraints that are based on the lexicon. This problem requires careful and detailed studies of developmental data, particularly of languages that have a different distributions of PoA patterns in words, as these are predicted to show different emerging constraints.

To conclude, our analysis departs from the classical OT accounts in two respects. First, lexical representations are not adult-like from the start; words need to be segmentalized. Segmentalization leads to the emergence of position-specific constraints in the grammar. Second, not all constraints are innate; constraints may emerge as children generalize over their lexicons. A challenge for future work is to come to an understanding of why in some languages labial harmony is prevalent, while in others, notably English, dorsal harmony is more common, if indeed both labial and dorsal harmony are the result of emergent constraints. Our prediction is that different constraints emerge in different languages (see Fikkert, Levelt and van de Weijer, 2002, subm.).

Finally, CH-like forms must be viewed as an epiphenomenon of the state of the lexicon. The developmental lexicon is child-specific, therefore CH is child-language specific. There is no need to account for the fact that CH of primary place features does not occur in adult language.

References

Barlow, Jessica (1997). *A constraint-based account of syllable onsets: Evidence from developing systems*. PhD Dissertation, Indiana University.

Bernhard, Barbara & Joseph Stemberger (1998). *Handbook of phonological development: From the perspective of constraint-based nonlinear phonology.* San Diego, CA: Academic Press.

Boersma, Paul (1998). *Functional phonology: Formalizing the interactions between articulatory and perceptual drives.* PhD Thesis, University of Amsterdam.

Boersma, Paul & Clara C. Levelt (2003). Optimality Theory and phonological acquisition. *Annual Review of Language Acquisition* 3: 1–50.

Boysson-Bardies, Bénédicte de & Marilyn Vihman (1991). Adaption to language: Evidence from babbling and first words in four languages. *Language* **67**: 297–319.

Davis, Barbara L, Peter F. MacNeilage & Christine L. Matyear (2002). Acquisition of serial complexity in speech production: A comparison of phonetic and phonological approaches to first word production. *Phonetica* **59**: 75–109.

Ferguson, Charles A. & Carol Farwell (1975). Words and sounds in early language acquisition. *Language* **51**: 419–439.

Fikkert, Paula (1994). *On the acquisition of prosodic structure*. Doctoral dissertation, HIL, University of Leiden.

Fikkert, Paula, Marieke van Heugten, Philo Offermans & Tania S. Zamuner (2004). Rhymes as a window into grammar. *Proceedings of the 29th Annual Boston University Conference on Language Development.* Somerville, Mass: Cascadilla Press. 204–215.

Fikkert, Paula, Clara C. Levelt & Joost van de Weijer (2002, subm.). Input, intake and phonological development; The case of consonant harmony. Paper presented at GALA, Utrecht.

Fikkert, Paula , Clara C. Levelt & Tania Zamuner (2005). Learning underlying forms: Evidence from child perception and production. Paper presented at NELS 36: the Northeastern Linguistic Society. University of Massachusetts, Amherst, 28–30 September 2005.

Frisch Stefan A., Janet Pierrehumbert & Michael Broe (2004). Similarity Avoidance and the OCP. *Natural Language and Linguistic Theory* **22**: 179–228.

Gnanadesikan, Amalia (1995/2004). Markedness and faithfulness constraints in child phonology. In R. Kager, J. Pater & W. Zonneveld (Eds.), *Constraints in phonological acquisition*. Cambridge: Cambridge University Press. [ROA-67]

Goad, Heather (1998). Consonant harmony in child language: An optimality-theoretic account. In: S. J. Hannahs & Martha Young-Scholten (Eds.), *Focus on phonological acquisition*. Amsterdam: John Benjamins. 113–142.

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

Goad, Heather (2003). Licencing and directional asymmetries in Consonant Harmony. Poster presented at the Child Phonology Conference, Vancouver, B.C. July 1–4, 2003.

Haspelmath, Martin (1999). Why is grammaticalization irreversible? *Linguistics* **37**: 1044–1068.

Ingram, David (1974). Phonological rules in young children. *Journal of Child Language* **1**: 29–64.

Jongstra, Wenckje (2003). *Variation in reduction strategies in Dutch word-initial consonant clusters*. PhD Dissertation, University of Toronto.
Jusczyk, Peter W. (1997). *The discovery of spoken language.* Cambridge MA: The MIT Press.
Jusczyk, Peter W., Paul Luce & Jan Charles-Luce (1994). Infants' sensitivity to phonotactic patterns in the native language. *Journal of Memory and Language* **33**: 630–645.
Kuhl, Patricia K. (2000). A new view of language acquisition. *PNAS* **97**: 11850–11857.
Lahiri, Aditi & Vincent Evers (1991). Palatalization and Coronality. In: C. Paradis & J.-F. Prunet (Eds.), *The special status of coronals: Internal and external evidence*. (Phonology and Phonetics 2.), San Diego, California: Academic Press.
Levelt, Clara C. (1994). *On the acquisition of a place*. Doctoral Dissertation 8, Holland Institute of Generative Linguistics, Leiden University.
Levelt, Clara C. (1995). The segmental structure of early words: Articulatory frames or phonological constraints. In E. Clark (Ed.), *Proceedings of the 27th Child Language Research Forum,* Stanford, CA: CSLI: 19–27.
Macken, Marlys (1978). Permitted complexity in phonological development: one child's acquisition of Spanish consonants. *Lingua* **44**: 219–253.
MacNeilage, Peter F. & Barbara L. Davis (2000). Origin of the internal structure of word forms. *Science* **288**: 527–531.
MacWhinney, Brian (2000). *The CHILDES project: Tools for analyzing talk. 3rd Ed. Vol. 2: The databases*. Mahwah, NJ: Lawrence Erlbaum.
McCarthy, John & Alan Prince (1994). The emergence of the unmarked. In: Mercè Gonzàlez (Ed.). *NELS 24: Proceedings of the Northeastern Linguistic Society, Vol. 2*. GSLA: Amherst, MA. 333–379.
Menn, Lise (1983). Development of articulatory, phonetic, and phonological capabilities. In B. Butterworth (Ed.), *Language production, 2* London: Academic Press.
Moskowitz, Arlene J. (1973). The acquisition of phonology and syntax: A preliminary study. In: Hintikka, Jaakko *et al*. (Eds.), *Approaches to natural language : proceedings of the 1970 Stanford Workshop on Grammar and Semantics*. Dordrecht : Reidel Publ. 48–84.
Paradis, Carol & Jean-F. Prunet (Eds.) (1991). *Phonetics and phonology: Vol 2. The special status of coronals*. San Diego, CA: Academic Press.
Pater, Joe (2002). Form and Substance in Phonological Development. In: Line Mikkelson & Chris Potts (Eds.), *WCCFL 21 Proceedings*. Somerville, MA: Cascadilla Press. 348–372.
Pater, Joe & Adam Werle (2001). Typology and variation in child consonant harmony. In: Caroline Féry, Antony Dubach Green & Ruben van de Vijver (Eds.), *Proceedings of HILP5*, University of Potsdam. 119–139.
Pater, Joe & Adam Werle (2003). Direction of Assimilation in Child Consonant Harmony. *Canadian Journal of Linguistics* **48** (3/4): 385–408.
Pater, Joe, Christine Stager & Janet Werker (2004). The Perceptual Acquisition of Phonological Contrasts. *Language* 80: 384–402.
Prince, Alan & Paul Smolensky (1993, 2004). *Optimality Theory: Constraint interaction in generative grammar.* Blackwell. As Technical Report CU-CS-696-93, Department of Computer Science, University of Colorado at Boulder,

and Technical Report TR-2, Rutgers Center for Cognitive Science, Rutgers University, New Brunswick, NJ, April 1993.

Schaerlaekens Annemarie, Dolf Kohnstamm & Maryline Lejaegere (1999). *Streefwoordenschat van zesjarigen: derde herziene versie, gebaseerd op nieuw onderzoek in Nederland en België*. Lisse: Swets en Zeitlinger.

Stager, Christine L. & Janet F. Werker (1997). Infants listen for more phonetic detail in speech perception than in word learning tasks. *Nature* **388**: 381–382.

Stemberger, Joe, Barbara Bernhardt & Carl Johnson (2001). 'Regressions' ("u"-shaped learning) in the acquisition of prosodic structure. *Rutgers Optimality Archive* ROA-471.

Torgerson, W. (1963). *Theory and methods of scaling*. New York: Wiley.

Velleman, Shelley (1995). Metathesis highlights feature-by-position constraints. In B. Bernardt, J. Gilbert & D. Ingram (Eds.), *Proceedings of the UBC International Conference on Phonological Acquisition.* Somerville, MA: Cascadilla Press.

Vihman, Marilyn (1996). *Phonological development. The origins of language in the child*. Oxford: Blackwell.

Vihman, Marilyn & Shelley Velleman (2000). Phonetics and the origins of phonology. In N. Burton-Roberts, P. Carr, & G. Docherty (Eds.), *Phonological knowledge*. Oxford, UK: Oxford University Press. 305–339.

Vihman, Marilyn, Shelley Velleman & Lorraine McCune (1993). How abstract is child phonology? Towards an intergration of linguistic and psychological approaches. In M. Yavas (Ed.), *First and second language phonology.* San Diego: Singular Publishing Group.

Waterson, Natalie. (1971). Child phonology: a prosodic view. *Journal of Linguistics* **7**: 179–211.

Waterson, Natalie. (1987). *Prosodic phonology: the theory and its application to language acquisition and speech processing*. Newcastle upon Tyne: Grevatt & Grevatt.

Weijer, van de Joost (1998). *Language input for word discovery*. Ph.D. thesis. Max Planck Series in Psycholinguistics 9.

Werker, Janet F., Chris Fennell, Kathleen Corcoran & Christine L. Stager (2002). Age and vocabulary size influences on the phonological representation of newly learned words in infants aged 14 to 20 months. *Infancy* **3**: 1–30.

Zamuner, Tania S., Lou-Ann Gerken, & Michael Hammond (2004). Phonotactic probabilities in young children's production of coda consonants. *Journal of Child Language* 31, 515–536.

Zink, Inge (2001). *N-CDIs: Lijsten voor Communicanieve Ontwikkeling. Aanpassing en hernormering van de MacArthur CDI`s*. Leuven: Acco.