*First Steps in the Acquisition of German Phonology: A Case Study**

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1 INTRODUCTION

This paper examines the acquisition of prosodic words by one German child, Naomi, between age 1;2.06 and 1;7.27. In the literature on the early acquisition of English and Dutch (e.g., Ingram 1978, Smith 1973, and Fikkert 1994a,b, respectively), it is usually assumed that the first words in child speech consist of a plosive followed by a vowel, i.e., the first words that children produce supposedly have a CV-structure. In this paper, we will challenge this assumption. We will show that the first words in German child speech consist of at least one consonant and one vowel and the consonant may either precede or follow the vowel at the earliest word-stage. Also, initial fricatives are avoided at this stage and they are not replaced by any other consonant. We conclude from our findings that there is no stage in the development of German child speech where a CV-structure is preferred. Rather, German children respect the linear order of segments of the adult target from the onset of speech.

A further aim of this paper is to provide an account of the observed stages in the acquisition of place of articulation and manner of articulation, respectively. With respect to place of articulation, we will account for the fact that even at the stage where labials are realised as such in words in which only labial consonants occur, there is a bias in child speech for alveolars in words which have a labial and an alveolar consonant in the adult form. We will also elaborate on a proposal made by Rice & Avery (1995) to explain the fact that velars are acquired relatively late. With respect to manner of articulation, we will show how an optimality-based account can explain the fact that word-initial fricatives are first omitted by Naomi, then realised as stops, subsequently as stops or approximants, and finally as fricatives.

The paper is structured as follows. Section 2 describes the method used to elicit and store the child data. Section 3 introduces the German consonant inventory and briefly discusses German syllable structure. Section 4 discusses the acquisition of syllable structure of Naomi. Sections 5 and 6 consider the development of consonantal places of articulation and manner of articulation, respectively, of the same child. Section 7 concludes.

2 METHOD

The material on which this article is based was compiled in the following way. From age 1;2.06, the mother took detailed notes about Naomi's speech in everyday situations. At this time, the child has an active vocabulary of about 20 words. From age 1;4.26, audiotape recordings of the child were made on a weekly basis at the child's home. Naomi grows up near Düsseldorf and both parents speak modern standard German. She has no brothers or sisters. The first three taped sessions lasted approximately 15 minutes, later sessions lasted 30 minutes. The first session took place on 19 September 1997 and the last one that we will consider in this paper took place on 21 December 1997. All recordings were transcribed by Sandra Joppen - Naomi's mother - the same day as the recordings took place. All sounds that Naomi produced during the sessions were transcribed. However, for the analysis, only utterances that were intended to be real words and that were understood by the transcriber are

counted as an utterance. Thus, babbling and uninterpretable utterances are ignored. Immediate repetitions of identical forms are counted as a single utterance. The transcriptions are stored in a database system (Excel). It contains a list of the German words that Naomi attempted to say and a list of her actual utterances in IPA font.

3 GERMAN CONSONANTS AND SYLLABLE STRUCTURE

3.1 Onset Consonants

The German consonant system includes the consonants in Figure 1 (based on Ramers & Vater 1995 and Wiese 1996):

Figure 1: The German Consonant System

	LABIAL	CORONAL			DORSAL		LAR.
	labial	alveolar	postalveolar	palatal	velar	uvular	glottal
-son	p, b, (p^f), f, v	t, d, t^s, s, z	$t^ʃ$, ʃ, ʒ	ç	k, g		h
+son	m	n, l		j	ŋ	R^1	

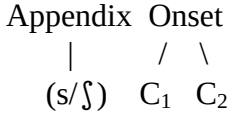
All consonants except the velar nasal /ŋ/ may occur in word-initial position in adult speech. Syllable-initially, the affricate /p^f/ is realised as [f] in most German dialects and this is also the case in the speech of the parents of the child we examined. We will therefore ignore this sound in what follows. Also note that the strident fricative /s/ is rare in word-initial position. It occurs in certain loan words, e.g., *Sphäre* ['sfɛ:ʀə], *Smog* [smɔk] and before /k/ in, e.g., *Skandal* [skan'da:l] ‘scandal’. In our corpus, initial /s/ is not attested at all.

In syllable-initial positions, consonant clusters involve a stop or a fricative which is followed by a non-homorganic sonorant consonant (e.g., Hall 1992, Vater 1992, and Wiese 1996):

(1)	a. pneumatisch	*tnee	Knie
	b. Plan	*tlee	klug
	c. Prinz	Trend	Kranz
	d. Fleisch	[ʃ]leim	
	e. frank	[ʃ]rank	

Single stops and stop-sonorant clusters may be preceded by a strident fricative, e.g., *springen* ['ʃpʀɪŋən] ‘to jump’ and *Strand* [ʃtʀant] ‘beach’. Also, the strident fricatives /ʃ/ and /s/ are the only fricatives that may precede /m/ word-initially, e.g. *Schmied* [ʃmi:t] ‘smith’ and *Smaragd* [sma'rakt] ‘emerald’. The exceptional distribution of word-initial strident fricatives suggests that they are not part of the core syllable. Following Vennemann (1988), we will assume that there is an extra position at the left edge of words to accommodate /s/ and /ʃ/ before other consonants:

(2)



In Naomi's speech, initial consonant clusters are not produced. We would like to point out that in a stop-sonorant cluster, Naomi selects the first consonant for production, e.g., *Brot* [bʀo:t] 'bread' is realised by her as [bo:] (1;2.06) and later as [bo:tˤ] (1;7.27). In a strident fricative plus stop cluster as in *Stuhl* [ʃtu:l] 'chair', or a strident fricative plus nasal cluster as in *schmeißen* ['ʃmaisən] 'throw', Naomi selects the non-strident consonant: i.e., these words are pronounced as ['tu:ə] (1;5.08) and ['maiçə] (1;7.27), respectively. Assuming the model in (2) in which pre-consonantal strident fricatives are not part of the onset, we may conclude that the child produces the first consonant (C_1) of a syllable.

3.2 The Rhyme

In adult speech, the rhyme of a syllable may consist of a long vowel, as in the word *See* [ze:] 'lake', it may contain a diphthong, as in the word *Frau* [fʀaʊ] 'woman', or it may contain a sequence of a short vowel plus a consonant, as in *Ball* [bal] 'ball' and *mit* [mɪt] 'with'. There are no syllables that contain a full short vowel without a following segment. It may thus be concluded that the rhyme has minimally two positions in German. Apparent counter examples are syllables headed by Schwa (e.g. the final syllable in *Sprache* ['ʃpʀa:χə] 'language') and syllables headed by sonorant consonants (e.g. the final syllables in *sprechen* ['ʃpʀɛçn̩] 'to speak' and *Atem* [a:tm̩] 'breath'). Such syllables do not require an onset and are never stressed. Henceforth, we will refer to them as "degenerate syllables".

In word-final position, a long vowel, a diphthong, or a short vowel plus a sonorant consonant may be followed by another sonorant (see 3), or an obstruent (see 4):

(3)	a.	Bahn	[ba:n]	'railroad, tram'
	b.	Bein	[bain]	'leg'
	c.	Salm	[zalm]	'salmon'

(4)	a.	Bad	[ba:t]	'bathroom'
	b.	seit	[zait]	'since'
	c.	bald	[balt]	'soon'

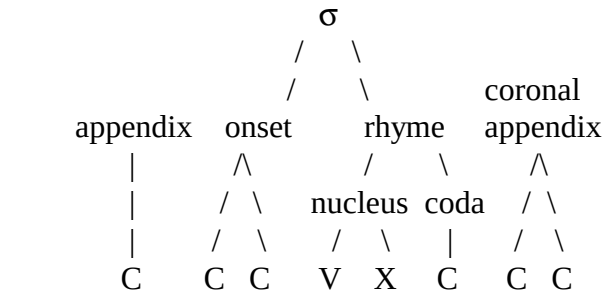
The data presented above are compatible with the so-called "sonority sequencing principle" which requires post-vocalic consonants to fall in sonority (e.g., Jespersen 1904). We assume that the two nucleus-positions may be occupied by a long vowel, or a short vowel plus a sonorant (i.e., a glide, a liquid, or a nasal). The nucleus may be followed by a less sonorant consonant in the coda-position of a rhyme. The proposed structures of the nucleus and the coda, respectively, ensure that the sonority sequencing principle is never violated.

Some post-vocalic sequences have an equal level of sonority. In these clusters, the second member is always an alveolar obstruent:

(5)	a.	Abt	[apt]	'abbot'
	b.	oft	[ɔft]	'often'
	c.	Gips	[gɪps]	'plaster'
	d.	Akt	[akt]	'act'
	e.	nicht	[nɪçt]	'not'
	f.	Keks	[ke:ks]	'biscuit'

If decreasing sonority in the rhyme is a valid condition for syllable-wellformedness in German, examples with final alveolar obstruents pose a potential problem. In the literature, e.g., Vennemann (1988) and Wiese (1996), it is assumed that a so-called "coronal-appendix" outside the rhyme accommodates word-final alveolar obstruents in German:[2]

(6) German Syllable Structure:

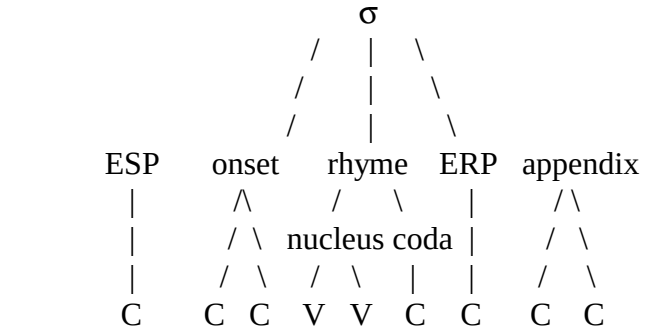


a.		(	ɔ	f)	t	‘often’
b.		(n	ɪ	ç)	t s	‘nothing’
c.	ʃ	(t ʀ	a	n t)	s	‘beach’ (GEN)

German is closely related to Dutch. Since much of the literature on the acquisition of syllable structure concentrates on the latter language, it merits some discussion here. It is usually assumed (e.g., Fikkert 1994a,b and references cited there), that the onset may be occupied by at most two consonants with increasing sonority. Fikkert (1994a:43-51) argues that segments that do not obey the sonority sequencing principle are in an initial extrasyllabic position (ESP), see (7a), or in a final appendix, see (7b). It is furthermore assumed that the two nucleus-positions can only be occupied by vocalic segments (i.e., a short vowel V, a long vowel V_iV_i, or a diphthong V_iV_j) and that the rhyme in Dutch consists of minimally as well as maximally two positions.

Wordfinally, the rhyme may be followed by one consonant which satisfies the sonority sequencing principle and which occupies a so-called "extra-rhymal position" (ERP) within the syllable. This consonant may be followed by at most two coronal obstruents outside the syllable:

(7) Dutch Syllable Structure (Fikkert 1994a):



a.	s	t	r	ɑ		n	t		‘beach’
b.		h		ɛ		r	f	s t	‘autumn’

The different assumptions for German and Dutch, respectively, are (i) that in German the nucleus may be filled by vocalic segments and sonorant consonants, whereas in Dutch the two nucleus positions may only be filled by vocalic segments, and (ii) that the rhyme is

minimally bipositional in German and minimally and maximally bipositional in Dutch. We will now consider how syllable structure is acquired in German and Dutch, respectively.

4 FIRST WORDS

Fikkert (1994a,b) found that at the initial stage of word-production, Dutch children exclusively produce syllables which contain one onset consonant followed by one vowel in the nucleus. In a recent paper, Costa & Freitas (1998) show that at the initial stage, Portuguese children do not insert a consonant before a vowel when there is none in the adult target. They argue that, in contrast to Dutch, the most favoured syllable at the initial stage is not necessarily "CV", but it can also be "V" in Portuguese. To find out whether the acquisition of syllable structure is based on universal principles, it is necessary to test Fikkert's proposal for languages other than Dutch. In this paper, we consider the development of syllables in a closely related language, viz. German.

4.1 Naomi's First Onsets

At the earliest word-stage, Naomi realises word-initial stops and nasals (see 8a-e). Word-final consonants are omitted, unless the target word lacks an initial consonant or has an initial fricative. In the latter two cases, there is no word-initial consonant in Naomi's speech and a consonant is realised somewhere else in the word instead (see 9a-b, 10).

From age 1;2.06 until age 1;4.26, Naomi produces single CV- and CV:-syllables for monosyllabic words which in the adult form have a CV:-structure (8a), a CVC-structure (8b), a CV:C-structure (8c), a CVCC-structure (8d), or a CVCV-structure (8e):

		Adult form:		Child's output:	Gloss
(8)	a.	zu	[tˢu:]	tu (1;2-1;3)	'closed'
	b.	Ball	[bal]	ba (1;2)	'ball'
	c.	Buch	[bu:x]	bu: (1;2-1;4.26)	'book'
	d.	Milch	[mılç]	mi: (1;2)	'milk'
	e.	Buggy	['bagi]	ba: (1;2-1;3)	'stroller'

It is a striking feature in Naomi's early speech that a word-final consonant is always realised when the adult form does not have a word-initial consonant:[3]

(9)	a.	an	[an]	an (1;2-1;4.26)	'at'
	b.	ab	[ap]	apʰ (1;4.26)	'off'

Also at this stage, a consonant in onset position of the first syllable is missing when it is a fricative in the adult form:

(10)		sauber	['zaubɐ]	ˈaubɐ (1;2-1;3)	'clean'

Contrary to Fikkert's (1994a,b) findings for Dutch, but in accordance with the findings of Costa & Freitas (1998) for Portuguese, we find that the German child that we examined realises words without initial consonants at the earliest word-stage. Also contrary to Fikkert,

we found that at the initial stage, the child realises final obstruents (see 9b) as well as final sonorants (see 9a). Observe that final consonants are only realised if there is no initial consonant and that no word consists of a vowel only. Thus, at the initial stage, Naomi's speech is characterised by the presence of one consonant and one vowel per word.

According to Jakobson (1941), the first phonological contrast that a child learns is the contrast between a vowel and a consonant, i.e., the largest contrast in constriction is learnt first. In other words, the first stage in child language is characterised by the following two (presumably universal) principles:[4]

(11) a. Consonantal closure: Every word contains at least one phase which is characterised by complete oral closure (i.e., every word has at least one complete constriction in the oral tract and, hence, one consonantal place of articulation).

b. Vocalic release: Every word contains at least one phase which is characterised by maximal oral release (i.e., every word has at least one vocalic place of articulation).

We here propose that all children at one stage pay attention to the linear order of the material that they get presented and that they try to reproduce. Naomi's speech is sensitive to this requirement from the earliest stage onwards. For this reason, a word like *ab* [ap] 'off' will be realised by her as a sequence of a vowel plus a consonant, rather than, for instance, as [pa] or [pap] which both have an onset.

The account for consonant and vowel sequences in Naomi's speech that we like to present here is theory independent and can be cast in a parametric model as well as in an optimality-theoretical framework. In this paper, we opt for the latter framework, but nothing crucial hinges on this. From this point onward, we will refer to principle (11a) as a constraint which we will call 'C-Place' and to (11b) as a constraint which we will call 'V-Place'. We will furthermore attribute the fact that segments which are present in adult forms are missing in the child's output to the constraint '*Struc' (no structure). This constraint prohibits segmental structure and is therefore always violated when a segment is realised.[5]

With respect to the lack of an onset in the words in (9) and (10), we point out that there should be at least one consonant in the word. Monosyllabic words which consist of a long vowel only, or a diphthong without a preceding or a following consonant do not occur in Naomi's speech at this stage. Hence, the constraint 'C-Place' is never violated in Naomi's speech. Conversely, there are no words which consist of consonantal segments only and the constraint 'V-Place' is always satisfied. Since every word that the child produces has one consonant and one vowel, the constraints 'C-Place' and 'V-Place' are ranked higher than the constraint '*Struc' and this is illustrated below for the word *ab* [ap] 'off':

(12) Adult Input [ap]; Child's optimal output [ap] at 1;4.26

		C-Place	V-Place	*Struc
a.	a	*!		*
b. ☞	ap			* *
c.	pap			* * *!

The fact that children obey the linear order of segments can be attributed to the constraint 'Linearity' (see McCarthy & Prince 1995) which says that the linear order of segments in the input should be the same as the linear order of segments in the output. Based on the fact that Naomi does not change the order of segments and does not insert a consonant in the case of

vowel-initial words, we conclude that 'Linearity' and *Struc, respectively, are ranked higher than the constraint 'Onset', which requires words to have onsets:

(13) Adult Input [an]; Child's optimal output [an] at 1;2.06

		C-Place	V-Place	Linearity	*Struc	Onset
a.	a	*!			*	*
b. ☞	an				* *	*
c.	na			* !	* *	
d.	nan				* * *!	

At this stage, final consonants are not realised in words like *Bahn* [ba:n] and *Ball* [bal] (see 8b) and this is accounted for by the same constraint ranking:

(14) Adult Input [ba:n] or [bal]; Child's optimal output [ba] at 1;2.06

		C-Place	V-Place	Linearity	*Struc	Onset
a.	a	*!			*	*
b.	al				* *	* !
c. ☞	ba				* *	
d.	bal				* * *!	

In the account presented above, the emergence of $VC_{Obstruent}$ and $VC_{Sonorant}$ sequences is not related directly to syllable structure (i.e., a branching nucleus or rhyme) as in Fikkert (1994a,b). We attribute the fact that both CV- and VC-sequences are present in Naomi's speech at the initial word stage to the interaction between, on the one hand, the need to have one phase of complete oral closure and one phase of maximal release in a word, and, on the other hand, the child's desire to obey the linear order of segments and to have as little structure as possible.

To summarise, our data support Jakobson's thesis that the first contrast in child speech is one between complete closure (for oral and nasal stops) and maximal release (for vowels), but they do not support Fikkert's (1994a) thesis that the first words in child speech have a CV-structure. In the following subsection, we will compare Fikkert's findings with ours and we will propose a unified account of the acquisition of onsets in Dutch and German.

4.1.1 The Acquisition of Onsets in Dutch and German

Fikkert (1994a) found that at the earliest stage of acquisition, Jarmo and Noortje, two of the twelve Dutch children that she examined, avoid the production of words which lack an onset in the adult form. Later, when Jarmo starts to produce these words, there is free variation between forms in which an onset is added (15a) and forms without onsets (15b). Free variation is also found in the production of onsets by Tom and Leonie at a relatively early age:

		Adult form (Dutch):		Jarmo's output:		Gloss
(15)	a.	aap	[a:p]	[ɑp], [a:p]	(1;7.15)	'monkey'
	b.	apie	[a:pi:]	[ta:pi:]	(1;7.15)	'monkey'

		Adult form (Dutch):		Tom's output:		Gloss
(16)	a.	aap	[a:p]	[a:β]	(1;2.27)	'monkey'
	b.	aap	[a:p]	[ba:p]	(1,3.24)	'monkey'

		Adult form (Dutch):		Leonie's output:		Gloss
(17)	a.	aap	[a:p]	[ɑp]	(1;9.15)	'monkey'
	c.	aap	[a:p]	[pa:p]	(1;9.15)	'monkey'

Fikkert (1994a) assumes that for Jarmo and Noortje, the parameter 'Are onsets obligatory?' is first in the default value (i.e., 'yes'). Subsequently, the parameter has to be reset and at this stage we find variation between forms with and without onsets for Jarmo, Tom, and Leonie. Finally, the parameter is set in the marked value (i.e., 'no') and nothing can change once the parameter is set, so that no variation will take place anymore. In our view, this account fails for German, because it misses the generalisation that in Naomi's first words, an onset may be absent if and only if there is another consonant in the word (see 8a-e versus 9a-b and 10). Based on the account we gave in 4.1 for Naomi's acquisition of onsets, we will now present an alternative analysis for the acquisition of onsets in Dutch.

At the earliest stage of the acquisition of Dutch phonology - referred to by Fikkert (1994a) as the stage of "obligatory onsets" - words which lack an onset are not produced by Noortje and Jarmo. In Optimality-theoretical terms, this means that faithfulness constraints are ranked very low and markedness constraints are not ranked with respect to each other, so that the null-parse wins for onsetless words, because it has less violations of constraints than any other form:

(18) Adult Input [a:p]; Nootje's and Jarmo's optimal output is zero at the stage of "obligatory onsets"

		C-Place	V-Place	Onset	*Struc
a.	a:	*		*	*! *
b.	a:p			*	* *! *
c. ☞	ø	*	*		
d.	pa:				* * *!

For Jarmo, Tom, and Leonie, the constraints begin to be ranked with respect to each other at the stage which Fikkert (1994a) calls the stage of "optional onsets". For these children, the constraints 'C-Place' and 'V-Place' are ranked higher than *Struc and 'Onset'. The constraints *Struc and 'Onset' are not ranked with respect to each other yet and this accounts for the variation that these children show between forms with and without an additional onset. To account for the fact that we do not find metathesis in their speech, we assume that 'Linearity' is ranked higher than 'Onset':

(19) Adult Input [a:p]; Jarmo's, Leonie's, and Tom's optimal outputs vary at the stage of "optional onsets"

		C-Place	V-Place	Linearity	Onset	*Struc
a.	a:	*!			*	* *
b. ☞	a:p				*	* * *
c. ☞	pa:p					* * * *
d.	ø	*!	*			
e.	pa:			*!		* * *

The process of ranking constraints is to a certain extent arbitrary. The prediction, therefore, is that other children may not rank 'Linearity' and 'Onset' with respect to each other, but determine, for instance, that *Struc should be ranked low, so that for them, at a certain stage, the optimal output for [a:p] is [pa:p].

For Jarmo, Tom, and Leonie, it becomes even more important at the next stage to be faithful to the adult target and adding an onset is no longer an option, because they have now ranked all constraints discussed so far above 'Onset':

(20) Adult Input [a:p]; Child's optimal output [a:p]

		C-Place	V-Place	Linearity	*Struc	Onset
a.	a:	*!			* *	*
b. ☞	a:p				* * *	*
c.	pa:p				* * * * !	
d.	pa:			*!	* * *	

The first three stages in Jarmo's, Tom's and Leonie's acquisition of Dutch syllables can be characterised as follows:

(21) <u>Development of Onsets for some Dutch children:</u>

Stage i "Obligatory Onsets"
no ranking: C-Place, V-Place, *Struc, Onset, Linearity

Stage ii "Optional Onsets"
rankings: C-Place, V-Place >> *Struc
Linearity >> Onset

Stage iii "Faithful Onsets"
rankings: C-Place, V-Place >> *Struc
Linearity >> Onset
*Struc >> Onset

In Fikkert's analysis of the acquisition of Dutch, the basic assumption is that a child which acquires a language tries to produce a syllable and, hence, the concept of "onset" is highly relevant to her analysis. We do not want to take issue with the claim that because every language admits consonant-initial syllables and some languages allow no others, this must reflect some universal principle or constraint. The question is, whether this principle or constraint always plays the most important role in the initial stage of acquisition of every language. We propose that, at least in Dutch and German, the effect of a principle, a parameter, or a constraint referring to the onset diminishes at a relatively early stage in the

acquisition of phonology. In OT-terms, this means that children determine relatively early that other constraints are ranked above 'Onset'.

In 4.1 and 4.1.1, we have suggested a more prominent role in the acquisition of phonology for the contrast between consonantal closure and vocalic release. Each word in German and Dutch child language is characterised by a phase of complete closure in the oral tract and a phase of maximal release and children set the corresponding parameters first (or, in OT-terms, they rank the corresponding constraints 'C-Place' and 'V-Place' high).

We have furthermore argued that the variation observed for some Dutch children between onsetless words and adding an onset (see 15-17) can be attributed to the indecisive ranking of the constraints *Struc and 'Onset' at their stage ii in the acquisition of onsets. These constraints are ranked with respect to each other next. The ranking of constraints that the Dutch children Jarmo, Tom, and Leonie arrived at at stage iii, is the same as the ranking of constraints that other Dutch children have from the onset of speech and it also conforms to the ranking Naomi has between age 1;2.06 and 1,4.26. We conclude from this, that the process of ranking constraints does not always proceed in exactly the same way for every child. In general, children start with a stage in which markedness constraints are top-ranked and they must learn which faithfulness constraints are ranked higher than markedness constraints. The way they get to the ultimate constraint-ranking for their particular language may vary from child to child.

As we showed in tableaux (12) and (13) above, the ranking of C-Place, V-Place >> *Struc, of Linearity >> Onset, and of *Struc >> Onset accounts for the fact that Naomi realises the final consonant in words like *ab* [ap] and *an* [an]. At this stage, final consonants are not realised in words like *Ball* [bal] and *Bahn* [ba:n] and this is accounted for by the same constraint ranking (see 14).

Our suggestion that one consonantal place of articulation per word suffices at the initial stage in Naomi's speech, is supported by utterances that involve more than one syllable. This issue will be considered next.

4.1.2 One consonantal place of articulation per word

Until 1;4.26 Noami mainly uses a single CV:-syllable for disyllabic words which have open syllables (see 8e). Occasionally, she produces words with a (C)VCV-structure for disyllabic or trisyllabic words. In the latter case, she always stresses the first syllable and the final vowel is [ə], [ɐ], or a copy of the initial vowel.[6] The segments [ə] and [ɐ] are not characterised by a V-Place feature, and in the case of identical vowels, the second vowel does not have a different V-Place feature than the one in the first syllable. Thus, there is only one V-Place feature in the words in (22) and (23).

(22)	a.	Banane	[ba'na:nə]	ˈna:nə	(1;2-1;3)	'banana'
	b.	Naomi	[na'o:mɪ]	ˈnana	(1;2-1;3)	'Naomi'
	c.	bitte	['bɪtə]	ˈdɪtə	(1;2-1;3)	'please'
	d.	danke	['daŋkə]	ˈdatə	(1;2-1;3)	'thank you'

(23)	a.	Tasche	['taʃə]	ˈtætə	(1;4.26)	'(hand)bag'
	b.	trinken	['tʀɪŋkən]	ˈtitə	(1;4.26)	'to drink'
	c.	Decke	['dɛkə]	ˈditə	(1;4.26)	'blanket'
	d.	Mülleimer	['mʏlaimɐ]	ˈmʏmɐ	(1;5.01)	'wastebasket'

Our suggestion in sections 4.1 and 4.1.1 that each word is characterised by one consonantal place of articulation is supported by the fact that in the speech of the German girl that we investigate here, all consonants within a word share one place of articulation and there seems to be a bias for alveolars. In (22a-c)[7], for instance, the adult word contains alveolar and labial consonants. The child realises alveolar obstruents only, even though she produces labials in words that do not contain alveolar obstruents (see 8b-e and 23d).[8] The fact that each word has *at least* one consonantal place of articulation is attributed to the high-ranked constraint 'C-Place' which requires a place of articulation. Conversely, the fact that each word has *at most* one consonantal place of articulation can be attributed to markedness constraints which prohibit consonantal places of articulation, for instance *Coronal and *Labial which prohibit a coronal and a labial place of articulation, respectively. The bias for alveolars is attributed to the fact that *Labial is ranked higher than *Coronal (e.g., Prince & Smolensky 1993):

(24) Adult Input [bɪtə]; Child's optimal output [dɪtə] at 1,2.06

		C-Place	V-Place	*Labial	*Coronal
a.	ɪ	*!			
b.	dətə		*!		* *
c. ☞	dɪtə				* *
d.	bɪtə			*!	*
e.	bɪpə			*! *	

To summarise our findings concerning Naomi's first words, we have observed the following:

(25) Naomi's First Words

I Each word contains minimally and maximally one consonantal place of articulation

II Each word contains minimally and maximally one vocalic place of articulation

III Onsets are optional iff there is a consonant somewhere else in the word

IV Alveolar consonants are preferred to labial ones

We accounted for these generalisations by the following constraints and their respective rankings:

(26) I C-Place >> *Struc
II V-Place >> *Struc
III a. *Struc >> Onset
b. Linearity >> Onset
IV *Labial >> *Coronal

From 1;5.01 vowel length gradually becomes distinctive in Naomi's speech. We will consider the development of this aspect next.

4.2 The Acquisition of Rhymes

Fikkert (1994a,b) found that the development of rhymes in the acquisition of Dutch proceeds as follows. At the initial stage, Dutch children exclusively produce syllables which contain one onset consonant followed by one vowel in the nucleus. At the second stage, stops and fricatives begin to emerge after a vowel. With respect to syllable structure, Fikkert concludes that this is the stage in which Dutch children learn that the rhyme may branch. Subsequently, Dutch children become sensitive to vowel-length distinctions and they begin to produce nasals, liquids, and glides at the right word-edge. According to Fikkert, this implies that at this stage, children have acquired the knowledge that the nucleus may branch in Dutch. She speculates that, for some children at least, sonorants may be represented in the nucleus.[9] At a later stage in the acquisition of syllable structure, Dutch children produce final consonant clusters and are aware that the rhyme may be followed by another segment, the so-called "extrarhymal" consonant (see 7a-b).

(27) Development of Rhymes in Dutch (according to Fikkert 1994b):

Stage 1: Core (CV) Syllables

Stage 2: Final Obstruents
-Branching rhymes ($CVC_{Obstruent}$)

Stage 3: Final Sonorants and Vowel Length
-Branching nuclei (CVV, $CVC_{Sonorant}$)

Stage 4: Extrarhymal Consonant

Some Dutch children skip stages, but the order of acquisition is consistent.

At 1;2 and 1;3, Naomi produces some words with an initial consonant followed by a short or a long vowel, and some words without an initial consonant. From 1;4.26 words with an initial consonant and a single short vowel have become very rare and most monosyllabic words have either a long vowel (see 28a-b), or a short vowel plus a sonorant (9a, 29a,b), or an obstruent (9b, 29c).

(28)	a.	Bahn	[ba:n]	ba:	(1;4.26-1;6.05)	'tram'
	b.	Buch	[bu:x]	bu:	(1;4.26-1;5.08)	'book'
(29)	a.	warm	[wa:m]	bam	(1;6.05)	'warm'
	b.	Bahn	[ba:n]	ban	(1;6.12)	'tram'
	c.	Buch	[bu:x]	buχ	(1;6.19-1;7.09)	'book'

As pointed out above, for Fikkert, the order of acquisition of final consonants is related to the acquisition of the syllable structure presented in (7). If one were to assume the same syllable structure for German, it might be argued that Naomi has "skipped" stages one and two in (27) and that we started to examine Naomi's progress when she had already arrived at stage three. However, due to the fact Naomi realises her first $VC_{Sonorant}$ word at the onset of speech (when

she is one year and two months old), this does not seem plausible to us. Rather, we believe that the correct generalisation is that each word should have at least one consonantal place of articulation at the earliest stage. From 1;5.01, Naomi no longer produces syllables with a single short vowel, i.e., from that age onwards, each rhyme is filled by minimally two positions.[10] The following constraints which are based on Fikkert (1994a:44-45) say that a rhyme must have at least and at most two positions (30a and 30b, respectively):

(30) a. Minimal Rhyme Constraint: Rhymes are minimally bipositional.

b. Maximal Rhyme Constraint: Rhymes are maximally bipositional.

We will now consider which aspects determine whether the two positions in a rhyme are filled by a long vowel or by a sequence of a short vowel and a consonant.

The no-structure constraint which prohibits the occurrence of V-Place (i.e., *V-Place) is only violated once for long vowels because one vocalic segment is involved. A sequence of a short vowel and a consonant constitutes one violation of *V-Place and one violation of *C-Place (i.e., *Labial or *Coronal). To account for the fact that CV:C words are realised mostly as CV: words from 1;4.26 until approximately 1;5.08, we propose that the 'Minimal Rhyme Constraint' and the 'Maximal Rhyme Constraint' are ranked higher than *Labial and *Coronal. This ranking will give [ba:] as the child's optimal output for the adult target [ba:n]:[11]

(31) Adult Input [ba:n]; Child's optimal output [ba:] at 1;5.01

		C-Place	Minimal Rhyme	Maximal Rhyme	Onset	*Labial	*Coronal
a.	a:	*!			*		
b.	an				*!		*
c. ☞	ba:					*	
d.	ban					*	*!
e.	ba		*!			*	
f.	ba:n			*!		*	*

Until 1;4.26, there is a strong tendency for one consonantal place of articulation per word, but gradually more exceptions to this generalisation begin to emerge:

(32)	a.	Mann	[man]	man	(1;5.01)	'man'
	b.	Buggy	['bagi]	ˈbaˌti	(1;5.01)	'stroller'
	c.	Butter	['bʊtɐ]	'bu:tɐ	(1;5.29)	'butter'
	d.	kaputt	[kaˈpʊt]	butˀ	(1;6.05)[12]	'broken'
	e.	Tomate	[to'ma:tə]	'matə:	(1;6.27)	'tomato'

It thus becomes more important to be faithful to the target, and *V-Place and *Coronal are demoted in the constraint hierarchy to a position lower than constraints which require faithfulness to V-Place features and C-Place features, respectively.[13] We will illustrate this for consonantal places of articulation in the tableau below for the word *Bahn* [ba:n] 'railroad, tram':

(33) Adult Input [ba:n]; Child's optimal output [ban] at 1;6.12

		C-Place	Minimal Rhyme	Maximal Rhyme	*Labial	MAX C-Place	*Coronal
a.	ba:				*	*!	
b. ☞	ban				*		*
c.	ba		* !		*	*	
d.	ba:n			* !	*		*

Adult words which end in a long vowel plus a consonant and adult words which end in a short vowel plus two consonants are realised by Naomi with a short vowel and one consonant at this stage. When the adult word has a final consonant cluster, at most one consonant is realised until 1;6.05:

(34)	a.	klappt	[klapt]	dat	(1;5.15)	'(it) works'
	b.	Hund	[hʊnt]	hut^{j}	(1;5.01-21)	'dog'
	c.	Milch	[mɪlç]	miç	(1;5.29)	'milk'

From 1;6.12, we find that most adult words which have three positions in the rhyme are realised with three positions in the child's rhyme:

(35)	a.	stimmt	[ʃtɪmt]	tɪnt	(1;7.27)	'that's right'
	b.	Hund	[hʊnt]	hu:t^{ç}	(1;6.12)	'dog'
	c.	Geld	[gɛlt]	dɛlt	(1;6.19)	'money'
	d.	Milch	[mɪlç]	mi:ç	(1;7.02)	'milk'

The following Figure shows that until 1;6.05, a bipositional rhyme is preferred, whereas from 1;6.12, -VVC and -VCC rhymes are mostly realised with three positions:

Figure 2: Structure of Naomi's Rhymes for Adult -VVC and -VCC Rhymes

Input Rhyme CVXC	Rhyme one position (-V)	Rhyme two positions (-VV, -VC)	Rhyme three positions (-VVC, -VCC)
1;2.06-1;4.26	0	7 (100%)	0
1;5.01-1;6.05	3 (6%)	35 (71%)	11 (23%)
1;6.12-1;7.27	0	19 (24%)	60 (76%)

Naomi thus begins to realise rhyme structure more faithfully. We tentatively assume the following constraint to express faithfulness to positions in the rhyme:

(36) MAX Rhyme-Position: Every position in the rhyme of an input corresponds to a position in the rhyme of the output.

This faithfulness constraint is promoted to a position higher than the 'Maximal Rhyme Constraint' which says that a rhyme may have at most two positions:

(37) Adult Input [bo:t]; Child's optimal output [bo:t^{j}] at 1;6.12

		C-Place	Minimal Rhyme	MAX Rhyme Position	Maximal Rhyme
a.	bo:			*!	
b.	bot^{j}			*!	
c.	bo		*!	* *	
d. ☞	bo:t^{j}				*

Naomi's steps in the development of Rhymes can be characterised as follows:

(38) Development of Rhymes in German

Stage 1: Vowel length is not distinctive
One consonantal place of articulation per word

Stage 2: Minimally and maximally bipositional rhymes
i. One consonantal place of articulation per word
ii. More consonantal places of articulation per word

Stage 3: Minimally two positions in the rhyme,
maximally three positions in the rhyme

We have argued that Naomi has learnt in stage 2 that rhymes must branch in German:

(39) Stage 1: Rhymes are not acquired yet (and, for this reason,
constraints referring to the Rhyme have no effect)

Stage 2: Minimal Rhyme Constraint, Maximal Rhyme Constraint

Adult CV(C)C- and CV:C-words which had a CV:-structure in stage 2i are more often realised with a CVC-structure in stage 2ii. Formulated in this way, it may seem that the transition is one from a branching nucleus to a branching rhyme. In actuality, however, this development has nothing to do with a change in the structure of rhymes. Rather, this effect can be attributed to the fact that Naomi realises more consonantal places of articulation per word in stage 2ii. In OT-terms, this means that the child reranks markedness constraints and faithfulness constraints. In particular, we see that the faithfulness constraints which say that a place feature in the input should have a correspondent in the output are promoted:

(40) Stage 2i: *Labial >> *Coronal >> Max C-Place
Stage 2ii: *Labial, Max C-Place >> *Coronal

We have argued that the step from stage 2 to stage 3 involves a reranking of the 'Maximal Rhyme Constraint' (which is a markedness constraint) and the faithfulness constraint which says that every rhyme position in the input should be filled in the output:

(41) Stage 2: Maximal Rhyme Constraint >> Max Rhyme-Position
Stage 3: Max Rhyme-Position >> Maximal Rhyme Constraint

In summary, we have seen that with respect to syllable structure, three developmental stages can be distinguished within period that we investigated. At the first stage - 1;2.06 to 1;4.26 - there is only one consonantal place of articulation per word and vowel-length is not distinctive (see 4.1). At the second stage - 1;5.01 to 1;6.05 - most rhymes have exactly two positions and from 1;6.12 we find that the rhyme may be more complex (see 4.2). We have accounted for these stages by assuming that syllable structure has to be learnt (i.e., rhyme structure has to be acquired) and that constraint ranking must be learnt (in our case, Naomi must learn which faithfulness constraints are ranked higher than markedness constraints in German).

With respect to places of articulation, we have seen that Naomi produces labial and alveolar consonants from an early age and she clearly favours alveolars. In the next section, we will account for the development in the places of articulation that she produces.

5 CONSONANTAL PLACES OF ARTICULATION

From 1;4.26, Naomi usually realises word-final fricatives (see 42a), except velar /x/. A word-final velar fricative is sometimes replaced by a phoneme with a different place of articulation (42b,d). For Naomi, a velar fricative may be hard to articulate and she uses the nearest available continuant - i.e., /h/ - instead:

(42)	a.	auf	[auf]	af	(1;5.01)	‘on’
	b.	auch	[aux]	ah	(1;4.26)	‘also’
	c.	Buch	[bu:x]	bu:	(1;5.01)	‘book’
	d.	Buch	[bu:x]	buh	(1;5.15)	‘book’

Word-initial velar stops are replaced by /d/ (see 43a-c), as is uvular /ʀ/:

(43)	a.	Kissen	['kɪsən]	'ditje:	(1;4.26)	‘pillow’
	b.	Katze	['kat^{s}ə]	'date:	(1;5.08)	‘cat’
	c.	geht nicht	[ge:t] [niçt]	'detiç	(1;5.08)	‘doesn’t work’
(44)		Rutsche	['ʀʊtʃə]	'dute:	(1;5.15)	‘slide’

Two opposing conclusions present themselves. On the one hand, a performance-based account along the lines of Reiss & Hale (1996) may run as follows: it may be that the child physically is not able to reach the velar and uvular region with the tongue dorsum at the age of one year and five months. This is a plausible explanation for the facts presented in (42b-c), when we assume that the child aims for a dorsal articulation, but fails and, hence, produces another continuant.

In our view, this position is not easy to defend in the case of stops and uvular /ʀ/. First, according to the mother, Naomi realised uvular /ʀ/ at an earlier stage in babbling. Thus, the child is capable of making this sound. Furthermore, if it is the case that /k/, /g/, and /ʀ/ are not pronounced as such due to a production failure, why then are they not realised in word-initial position as a consonant which is closer to the target (e.g., a postalveolar stop, see 32b), but always as /d/? It seems to us that there is more to this than just a performance problem.

An alternative explanation for similar facts in English child phonology is suggested in Rice & Avery (1995). With respect to the acquisition of segmental structure, they assume the following principles:

(45) a. Minimality: Initial phonological representations are relatively impoverished, with little or no structure.

b. Monotonicity: Structure is elaborated under pressure from the phonology: positive evidence in the form of acquiring a contrast between two sounds forces the addition of structure to representations.

With respect to segmental structure, we assume that consonantal places of articulation are characterised as below (see Clements & Hume 1995):

(46) a. LABIALS
C-Place
|
Labial

b. CORONALS
C-Place
|
Lingual
|
Coronal

c. DORSALS
C-Place
|
Lingual
|
Dorsal

Rice & Avery (1995) propose that at the first stage in the development of consonantal places of articulation, the child assumes little or no structure at all in the representation. This implies that the realisation of the structure in (47) may be any place of articulation:

(47) Development of Place of Articulation
Stage i: structure: C-Place
realisation: *any place*

Next, the structure is made more complex - i.e., under our assumption of consonantal place in (46a-c), the Labial feature and the Lingual node are added to the less complex structure in (47) - and the child has now developed a contrast between Labials and Non-Labials:[14]

(48) Development of Place of Articulation
Stage ii: structures: a. C-Place
|
Labial

b. C-Place
|
Lingual

realisations: *labial* versus *dorsal or coronal*

Subsequently, the structure is made even more complex - i.e. Coronal and Dorsal are added - and a three-way contrast emerges:

(49) Development of Place of Articulation

Stage iii:	structures:	a.	b.	c.
		C-Place	C-Place	C-Place
		|	|	|
		Labial	Lingual	Lingual
			|	|
			Coronal	Dorsal
	realisations:	*labial*	*coronal*	*dorsal*

Next, finer distinctions can be acquired, for instance, between alveolar and postalveolar places of articulation.

This is the only possible learning path given monotonicity and the feature hierarchies in (46). The acquisition of the structures in (49) does not happen overnight and from 1;6.19 until 1;7.27, word-initial /k/ and /g/ are still realised as alveolar stops forty-two times and they are realised as /h/ five times. In our corpus, Naomi realises an initial velar stop only three times.

In Naomi's speech, initial consonants are mostly stops. The realisation of initial fricatives is the topic of the next section.

6. AVOID ONSET FRICATIVE; VOICE ONSET STOP

Fikkert (1994) shows that Dutch children develop different strategies to avoid initial fricatives; children either omit them (e.g., [ɪs] for *vis* 'fish'), they replace them with /h/ (e.g. ['hisə] for *fietsen* 'to ride a bicycle'), or they replace them with a stop (e.g. [to] for *vogel* 'bird'). A similar phenomenon can be observed in Naomi's speech.

Naomi does not realise word-initial /ʃ/ or /z/. Of the 58 instances in our corpus of recorded speech, ten times single initial strident fricatives are not realised at all (=17%), see (50). In forty-one cases, initial strident fricatives are replaced by a stop (=71%)[15], see (51a-d), and they are replaced by another continuant seven times (=12%) at a relatively late stage, see (52a-c).

(50)		sauber	['zaubɐ]	'auba (1;4.26 - 1;6.12)	'clean'
(51)	a.	Sonne	['zɔnə]	'du:je: (1;5.21)	'sun'
	b.	Sonne	['zɔnə]	'done: (1;6.12-1;7.16)	'sun'
	c.	Schuhe	['ʃuə]	'tu:a (1;6.12-1;7.09)	'shoe'
	d.	Saft	[zaft]	dat (1;7.27)	'juice'
(52)	a.	Salz	[zalt^{s}]	ja:lt^{ɕ} (1;7.16)	'salt'
	b.	sehen	[ze:n]	ʂe:n (1;7.09)	'see'
	c.	sehen	[ze:n]	je:n (1;7.27)	'see'

Word-initial labial fricatives are omitted once (=3%), see (53), they are nineteen times replaced by a stop (=59%), see (54), and twelve times by an approximant (=38%), see (55). The stop in question is either alveolar (9 times), see (54a), or labial (10 times), see (54b):

(53)	Fisch	[fɪʃ]	ɪç	(1;6.19) 'fish'

(54) a. fertig ['fɛʁtɪç] 'datıç (1;5.15 - 1;6.12) ‘ready’
b. Fisch [fıʃ] bış (1;7.02) ‘fish’

(55) fertig ['fɛʁtıç] 'jatıç (1;7.16) ‘ready’

As is the case in Dutch (see Fikkert 1994a,b and Lohuis-Weber & Zonneveld 1996), German children favour a stop in onset position, i.e. the best onset is a consonant which is [-continuant]. Syllable-initial fricatives are avoided in Dutch and German child speech. To capture this generalisation, we propose the following condition which says that every word should start with a non-continuant:

(56) Initial manner: $_{\text{Word}}$([-cont]

This condition is complied with in words which begin in oral and nasal stops. It is violated in adult words that begin in a vowel or that begin in a fricative. In the former case, Naomi does not insert a stop. This implies that the condition in (56) is not as strong as a condition against inserting material. Such a condition is formulated as a constraint by McCarthy & Prince (1995):

(57) DEP-IO: Every segment of the output has a correspondent in the input.

We account for the observation that a stop is not inserted by assuming that DEP-IO is a highly-ranked constraint:

(58) Adult input [an]; Child's optimal output [an]

		DEP-IO	$_{\text{Word}}$ ([-cont]
a. ☞	an		*
b.	**f**an	*!	*
c.	**d**an	*!	

It is striking that initial /z/, /ʃ/, and /f/ are mostly replaced by a *voiced* stop, or - occasionally - an approximant. We believe that this is not an accident. At this stage in the acquisition of German, Naomi hardly ever uses a voiceless labial stop in word-initial position, but voiced labial stops are abundant:

(59) a. Papa ['papa] 'bapa (1;5:01) ‘daddy’
b. Puppe ['pʊpə] 'but^{j}i (1;5:21) ‘doll’
c. Piep [pi:p] be:, pi: (1;5:08) ‘pip’
d. kaputt [ka'pʊt] 'but^{ç} (1;6;05) ‘broken’

Presumably, it is easier to start an utterance with a voiced consonant and for this reason we find many initial voiced obstruents in Naomi’s speech. Naomi has developed a strong tendency to conform to the following system with respect to voicing of obstruents. She favours voiced stops in word-initial position and voiceless stops or fricatives in coda position. To capture the fact that Naomi prefers to have voicing at the left word edge, we propose the following constraint which says that every word should start with a voiced sound:

(60) Initial voicing: $_{Word}$([+voice]

The markedness constraints in (56) and (60) ensure that the best output for a word which has an initial fricative in the adult form, is a word which has an initial voiced stop.

(61) Adult form *fertig* ['fɛʁtɪç]; Child's optimal output [datɪç] from 1;5.15 until 1;6.05

		DEP-IO	$_{Word}$([-cont]	$_{Word}$([+voice]
a.	atɪç		* !	
b.	**j**atɪç		* !	
c.	**f**atɪç		* !	*
d. ☞	**d**atɪç			

Furthermore, there is a bias for alveolars. Naomi needs a voiced stop instead of a voiceless fricative to fill the onset position and alveolar /d/ seems to be the default consonant for this position.

At the right word edge, Naomi realises fricatives from an early age. The conditions formulated in (56) and (60) crucially refer to the left word edge and, hence, there is no condition that would exclude word-final voiceless fricatives.

From 1;6.05, Naomi not only substitutes initial fricatives by stops, but also by approximants:

(62) a. sauber ['zaubɐ] 'hauba (1;7.27) ‘clean’
b. sehen ['ze:n] de:n, he:n, je:n (1;7.27) ‘to see’
c. fertig ['fɛʁtɪç] 'jatɪç, 'datiç (1;7.16-27) ‘ready’

This suggests to us that faithfulness conditions such as "every input feature [+continuant] must have a correspondent in the output" (i.e., Max [+cont]) begin to play a more prominent role and this is illustrated in the following tableau:

(63) Adult form *fertig* ['fɛʁtɪç]; Child's optimal outputs ['datɪç] and ['jatɪç] from 1;6.05 until 1;7.27

		$_{Word}$([-cont]	$_{Word}$([+voice]	Max [+cont]
a.	atɪç	*		*!
b. ☞	**j**atɪç	*		
c.	**f**atɪç	*	*!	
d. ☞	**d**atɪç			*

At the onset of speech, markedness constraints such as Maximal Rhyme, *Labial, *Coronal, and $_{Word}$([-cont] are ranked higher than the corresponding faithfulness constraints MAX Rhyme Position, Max C-Place and Max [+cont]. Gradually, however, the child begins to experiment and we find variation in ranking. Faithfulness conditions on separate features first begin to be ranked equally high as markedness constraints (see, e.g. 33 and 63) and, finally, higher.

7. CONCLUSION

The first step in the acquisition of German phonology is the acquisition of the contrast between complete oral closure and vocalic release. In Naomi's speech, early words are characterised by exactly one consonant (an oral or nasal stop) and exactly one vowel. They may occur as a consonant-vowel sequence, but also as a vowel-consonant sequence, depending on the linear order of the adult form. We have not found evidence for an initial CV-structure in her speech and in this paper we question the assumption that children have the knowledge that CV is the unmarked syllable. Contrary to Fikkert (1994a,b), we propose that CV-structures do not emerge because an onset is favoured in early child language, but rather because ideally each word shows the maximal contrast between a consonant and a vowel.

At the earliest stage in the acquisition of German words, vowellength is not distinctive. From 1;5.01, each monosyllabic word has a long vowel or a short vowel followed by one consonant. We concluded from this, that Naomi initially assumes as little structure as possible, but at age 1;5.01 she has learnt that the rhyme matters and from that age onwards until approximately 1;6.12, she presupposes that rhymes have minimally two positions.

Gradually, Naomi begins to realise more than one consonant per word. We attributed this development to the fact that the initial stage in which the child produces as little structure as possible changes to a stage in which she is forced to realise consonantal places of articulation more faithfully, so that, for instance, *Bahn* 'railroad, tram' and *warm* 'warm' are no longer realised by the same form (viz. as [ba:]), but distinctively (i.e., as [ban] and [bam], respectively). The next step in the acquisition of German phonology is a distinction between rhymes with two positions and rhymes with three positions.

With respect to places of articulation, we have seen that Naomi distinguishes between labial and alveolar stops from the onset of speech, but the feature Dorsal is not distinctive yet and she does not contrast alveolar and velar stops.

In the earliest stage of production, initial fricatives are omitted in the minority of cases and they are mostly realised as voiced stops. Voiced stops seem to be favoured generally in word-initial position and we have tentatively proposed two positive markedness constraints (57 and 61, respectively) to capture this generalisation. Further evidence from data from other German and non-German children (e.g. from children in whose native language voicing is not distinctive) is needed to confirm the validity of these constraints. At a later stage, initial fricatives are no longer omitted, but realised either as stops or as approximants. We concluded that at this stage, a constraint which says that a word should start with a non-continuant is as prominent as a constraint which says that a feature [+continuant] in the input should be realised in the output. This may account for the variation between forms with voiced stops and forms with (inherently voiced) approximants for initial voiceless fricatives.

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[1] There is a considerable variation in the pronunciation of /ʀ/ in German (see Trubetzkoy 1939/1969). In most dialects - and in the speech of Naomi's parents - it is a uvular vibrant prevocalically, and it is vocalised postvocalically, e.g., *Rutsche* 'slide' is pronounced ['ʀʊtʃə] and *Uhr* 'clock, watch' is pronounced [u:ɐ].

[2] In (6) and below, 'V'= vowel, 'X' = vowel, glide, liquid, or nasal, and 'C' = consonant. The symbol 'σ' denotes a syllable and what Vennemann (1988) refers to as "the core syllable" is put between round brackets.

[3] In the adult pronunciation, these words have an initial glottal stop when stressed (e.g., Wiese 1996). We have not found any word-initial glottal stop in Naomi's pronunciation, but Elsen (1991) reports that for the child that she investigated, these words mostly have glottal stops, e.g., in her word for *an* 'at', Annalena realises a glottal stop from 1;3.29: [ʔan]. For *ab* [ʔap] 'off', Annalena's output is [ap^{h}] from 1;2.15 until approximately 1;5.30, and from then until 1;7.30 her output is [ʔap^{h}]. With respect to other words which lack an initial consonant in Annalena's speech, we note that a glottal stop is not always realised. For instance, the adult form *satt* [zat] 'satisfied' is realised as [at^{h}] by Annalena at 1;2.19.

[4] These principles can also be called parameters (default value: 'yes').

[5] *Struc covers any constraint that prohibits structure. We will use this constraint as a 'No-Segment' constraint, and in later sections also as a shorthand notation for more particular constraints like 'DEP-IO', '*V-Place', '*C-Place Labial', '*C-Place Coronal', '*C-Place Dorsal', etc.

[6] We assume that syllables with [ə] or [ɐ] are "degenerate" in the sense that they are the only permissible syllables in German which do not have two positions in the rhyme and which may lack an onset.

[7] The adult word in (22d) contains an alveolar stop and a velar nasal and the words in (23b,c) have alveolar stops and velar stops. The child produces alveolar stops only, because at this stage, the child has not yet acquired velars (see 5 below).

[8] Elsen (1991:152) reports that there are forms indicating a bias for alveolars in a single word in the speech of another German girl, e.g., the adult form *Banane* [ba'na:nə] 'banana' is realised by Annalena as [ˈnanə] at age 0;11.16.

[9] This is in accordance with the nucleus structure which we assume for German (see 6), but contrary to the nucleus structure which Fikkert (1994a) assumes for Dutch (see 7).

[10] At 1;4.26 and 1;5.01 there is still some variation and some words are realised with short vowels. For instance, at 1;5.01 *Hund* [hʊnt] 'dog' is realised once as [hu], once as [hu:] and once as [hutʲ] and *zu* [tsu:] is realised twice with a short vowel and once with a long one.

[11] Another possible output which has no violations of *Labial is [da:]. This form would fare better under the constraint ranking proposed in (31), but worse if we adopt from McCarthy & Prince (1995) the notion that correspondent segments are identical in features. In particular, the constraint 'IDENT C-Place' is needed here to rule-out candidate [da:]. This constraint should be ranked higher than *Labial.

[12] Naomi regularly produces a fricated release after word-final /t/.

[13] Max C-Place is not ranked with respect to *Labial, because we find alternations between forms which satisfy Max C-Place and violate *Labial and forms which violate Max C-Place and satisfy *Labial (e.g. timt → tint in 35a).

[14] For Naomi, the Lingual node is interpreted as 'Coronal', but other German and Dutch children produce velars instead of alveolars. For instance, Naomi's friend Jan Pierre says [kain] for *Schwein* [ʃʊaɪn] 'pig' and Haike Jacobs (p.c.) reports that his son Maurits did not produce alveolars until 1;6. For instance, Maurits says [bɑk] for *bad* [bɑt] 'bath' at the early word stage.

[15] In the majority of cases, we are dealing with an oral voiced stop (33 instances), less frequently, the oral stop is voiceless (7 instances), and only once /z/ is realised as /n/ by Naomi.