1 Introduction

This paper examines the acquisition of word-initial and word-final consonants by one German child, Naomi, between age 1;2.06 and 1;8.21 and compares the findings with data from another German child (Annalena, between age 0;11.29 and 1;5.29) and with data from children learning Dutch, English, and Portuguese. Two standard assumptions in the literature on the early acquisition of phonology (e.g., Fikkert 1994a,b, Jakobson 1941) are: (i) the first words in child speech consist of a consonant followed by a vowel and (ii) the first consonants that appear in child speech are oral plosives. From these two assumptions the following predictions ensue: (i) vowel-initial words are absent in early child speech and (ii) consonants are initially realised as plosives. These predictions are not answered in the study of child speech that we present in this paper. We 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. For instance, word-final fricatives may be realised as such from the onset of speech (e.g., auf ‘on’ /auf/ --> [af], Naomi 1;3), but word-initial fricatives are deleted at the
earliest word stage (e.g., *Fisch* ‘fish’ /fɪʃ/ --> [ɪç], Naomi 1;6). In contrast to the predictions formulated above, word-initial fricatives are not necessarily replaced by any other consonant at the earliest word-stage as long as there is at least one consonant at another position in the word (e.g. in coda position).

The observation that onsetless words are possible in the earliest stages in child speech and that coda consonants are preserved whenever an onset cannot be supplied calls for a different approach than the parameter theory in Fikkert (1994a,b) which fails to predict this set of phenomena. The aim of this paper is to provide an account of the initial stages in the acquisition of German onsets and codas, respectively. We demonstrate how an Optimality-theoretic approach can account for the fact that in early child speech, a word-final consonant is often realised when a word-initial consonant is absent. We also account for the observation that an adult VVC or VCC rhyme is first realised by Naomi with a long vowel without a following consonant, then with a short vowel plus a consonant, and finally as a tripositional rhyme. We argue that these observed stages arise through the gradual increase in complexity of syllable structure and minimal constraint demotion (see Tesar & Smolensky 1993, 1998). We furthermore show that the same set of constraints and the mechanism of constraint demotion can be used to explain different stages in the acquisition of Dutch consonants.

The paper is organised as follows. Section 2 presents the method used to collect the data. Section 3 introduces the German consonant inventory and briefly discusses German syllable structure. Section 4 illustrates Naomi’s and Annalena’s early acquisition of word-initial consonants. Section 5 provides an OT-account for the earliest stages in the acquisition of German and Dutch
word-initial consonants. Section 6 considers the initial stages in the
development of rhyme structure and section 7 concludes.

2 Method

The data used in this paper were compiled in the following way. Sandra
Joppen - Naomi’s mother - took detailed notes about the child’s speech from
age 1;2.06. At this stage, Naomi had an active vocabulary of about 20 words.
From age 1;4.26, audiotape recordings were made on a weekly basis at the
child’s home. Naomi grew up in Krefeld (near Düsseldorf). Both parents
speak modern standard German and, at this time, Naomi did not have any
brothers or sisters. The first recorded session took place on 19 September
1997 and the last one that we will consider in this paper took place on 14
January 1998. The first three taped sessions lasted 15 minutes, later sessions
lasted 30 minutes. All recordings were transcribed by Sandra Joppen the
same day as the recordings took place and the transcriptions were checked by
at least one other person. All possible speech 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 a speech sound. Immediate repetitions of
identical forms are counted as a single speech utterance. The transcriptions
were 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 speech in IPA font.
We also make use of Elsen's (1991) diary study on the speech of Annalena.
Annalena grew up in München and we consider the data collected from 28 January 1988 until 28 June 1988 (i.e. from age 0;11.29 until 1;05.29), because the stages in the acquisition of German consonants we find during this time closely resemble the stages we find in Naomi’s speech from 1;2.06 until 1;8.21.

3 German consonants and syllable structure

The German consonant inventory consists of the segments in Figure 1 (based on Féry 1998, Hall 1992, Ramers & Vater 1995, Wiese 1996):

*Figure 1: The German Consonant Inventory*

<table>
<thead>
<tr>
<th>LABIAL</th>
<th>CORONAL</th>
<th>DORSAL</th>
<th>LAR.</th>
</tr>
</thead>
<tbody>
<tr>
<td>/</td>
<td>/</td>
<td>\</td>
<td></td>
</tr>
<tr>
<td>labial</td>
<td>alveolar postalveolar</td>
<td>palatal</td>
<td>velar uvular glottal</td>
</tr>
<tr>
<td>[-son]</td>
<td>p,b,p',f,v t,d,t',s,z t, s</td>
<td>ç</td>
<td>k,g</td>
</tr>
<tr>
<td>[+son]</td>
<td>m</td>
<td>n,l</td>
<td>j</td>
</tr>
</tbody>
</table>

Word-initially, the affricate /p'/ is realised as [f] in most German dialects and this is also the case in the speech of Naomi’s and Annalena’s parents. We also note that the strident fricative /s/ is rare in word-initial position. It occurs in certain loan words, e.g., *Sphäre* [ˈsfɐːɐ̯] ‘sphere’, and before /k/ in, e.g., *Skandal* [skan'da:l] ‘scandal’. In our corpus, initial /s/ is not attested at all, but initial /ʃ/ is (see below). The glottal stop is not a phoneme in German. In section 4, we argue that the glottal stop is inserted by the grammar
before a vowel in a stressed syllable (i.e. to provide an onset to a foot). German-speaking children never encounter evidence to assume that the glottal stop is a phoneme in German and section 4 shows that German children go through a learning process before they start to use the glottal stop in appropriate contexts.

In word-initial positions, consonant clusters consist of an obstruent followed by a non-homorganic sonorant consonant (Hall 1992, Vater 1992, Wiese 1996). Some examples are:

(1)  a. Knie [kni:] ‘knee’
    b. Prinz [prɪntʰ] ‘prince’
    c. blau [blaʊ] ‘blue’
    d. Flagge [fлагэ] ‘flag’

A strident fricative may precede a single oral plosive or a plosive-sonorant cluster as in, e.g., springen [ˈsprɪŋən] ‘to jump’. Moreover, the strident fricatives /ʃ/ and /s/ are the only fricatives that may precede /m/ word-initially, e.g. Schmied [ʃmiːt] ‘smith’ and Smaragd [smaˈɾakt] ‘emerald’. Word-internally, such clusters are syllabified as a coda-onset sequence. The words Kiste ‘case, box’ and Kosmos, for instance, are syllabified as [kɪstə] and [kʊs.ʊs], respectively, and not as, e.g., *[kɪ.stə] or *[kʊs.ʊs]. The exceptional distribution of word-initial strident fricatives suggests that they are not part of the onset. Following Vennemann (1988), we postulate an extra position at the left edge of words to accommodate /s/ and /ʃ/ before other consonants:
In child speech, we generally find that the first consonant in the onset \(C_1\) is realised (e.g. *Blume* ‘flower’ --> [buːne], Naomi 1;7.16 and *Brille* ‘glasses’ --> [bɛlə], Annalena 1;0.08), whereas the word-initial appendix is ignored (e.g. *stimmt* ‘right’ --> [tint], Naomi 1;7.27, *Schloss* ‘castle’ --> [lɔs], Annalena 1;11.05 and *schmeissen* ‘to throw’ --> [maɪçə], Naomi 1;7.27/ [mɪsən], Annalena 1;6.12). Naomi realises her first /ʃ/-initial consonant cluster at 1;8.10, before she realises complex onsets (i.e., branching \(C_1 C_2\) onsets).²

In adult speech, the rhyme of a syllable may consist of a long vowel, as in the word *See* [zeː] ‘lake’, it may contain a diphthong, as in the word *Frau* [fʁau] ‘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 in adult speech 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* [ˈʃpraːçə] ‘language’) and syllables headed by sonorant consonants (e.g., the final syllables in *sprechen* [ˈʃprɛçən] ‘to speak’ and *Atem* [aːtm] ‘breath’). Such syllables do not require an onset, they are never stressed, and they never form a word on their own. The minimal requirement for a German word is that it contains at least one syllable which has either a
long vowel, a diphthong, or a short vowel plus a consonant, i.e., the minimal German word has two moras. This restriction on the phonology of German has to be learned by the child (see section 6).

In word-final position, a bimoraic rhyme may be followed by another sonorant consonant (see 3), or an obstruent (see 4):

(3) a. Bahn [ba:n] ‘railroad, tram’
    b. sein [zain] ‘to be’, ‘his’
    c. Salm [zalm] ‘salmon’

(4) a. Bad [ba:t] ‘bathroom’
    b. seit [zait] ‘since’
    c. Salz [zalt] ‘salt’

The data presented above are compatible with the so-called “sonority sequencing principle” which requires post-vocalic consonants to fall in sonority (cf., e.g., Jespersen 1904). To ensure that the sonority sequencing principle is not violated, we here propose 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) and that obstruents never occupy a nucleus position. Segments in the nucleus may be followed by a less sonorant consonant in the coda position of a rhyme. Notice, however, that some post-vocalic consonant clusters have an equal level of sonority. In these clusters, the second member is always an alveolar obstruent:
If decreasing sonority in the rhyme is a valid condition for syllable-wellformedness in German, examples with word-final obstruent clusters pose a problem. Vennemann (1988) proposes that a so-called “coronal-appendix” outside the rhyme accommodates word-final alveolar obstruents in German. The appendix is not part of the rhyme. Therefore, the sonority sequencing principle – which holds within the syllable - is not violated by final coronal obstruents:\(^3\)

(6)  \textit{German Syllable Structure:}

\[
\sigma
\]

\[
\text{appendix} \quad \text{onset} \quad \text{rhyme} \quad \text{appendix}
\]

\[
\text{C} \quad \text{C}_1 \quad \text{C}_2 \quad \text{V Son} \quad \text{C} \quad \text{C} \quad \text{C}
\]

a. Saft \[ zaft \] ‘juice’
b. nichts \[ nichts \] ‘nothing’
c. Strands \[ Strands \] ‘beach’ (GEN)
In summary, the syllable structure that we assume for German is characterised as follows. A German onset may be occupied by at most two consonants with increasing sonority and may be preceded by /s/ or /ʃ/. The nucleus may be filled by vocalic segments and sonorant consonants. The rhyme is minimally bipositional and maximally tripositional and may be followed by at most two coronal obstruents.

With respect to syllable structure and language acquisition, the common assumption is that the first onsets that emerge in child speech are single plosives and that coda consonants are often absent. Sections 4 and 5 test this assumption and closely examine the realisation of onset consonants and post-vocalic consonants in early German child speech. In section 6, we proceed to discuss Naomi’s first steps in the acquisition of rhyme structure.

4 First words: one consonant and one vowel

At the initial stage of speech production, three of the twelve Dutch children that Fikkert (1994a) examined exclusively produce syllables which contain one onset consonant followed by one vowel in the nucleus. Basing herself on this observation and on assumptions made in earlier literature (Jakobson 1941), Fikkert claims that children start speech production with consonant-initial syllables, even though there is no support for this assumption in the data of nine of the twelve children that she examined. Costa & Freitas (1998) show that at the initial stage, Portuguese-speaking children do not insert a consonant before a word-initial vowel and, moreover, these children tend to
delete word-initial fricatives. Costa & Freitas conclude from these two observations that a V-initial syllable is common in very early Portuguese child speech. Bernhardt & Stemberger (1998) also point out that there is no reason to believe that children initially require all syllables to have onsets and we will demonstrate below that from the earliest speech-stage, German-speaking children frequently produce onsetless syllables.

Notice first that word-initial oral and nasal plosives are correctly pronounced at the earliest word-stage. From 1;2.06 until 1;5.01, Naomi realises word-initial plosives as such 31 times and as an approximant once. Initial nasals are always realised as nasal plosives by Naomi and Annalena:

\[
\begin{align*}
(7) \quad \text{initial oral plosives are realised as oral plosives} \\
\text{Spelling} & \quad \text{Adult form} & \quad \text{Child’s output} & \quad \text{Gloss} \\
a. \quad \text{Ball} & \quad \text{bal} & \quad \text{ba (Naomi 1;2-1;5.01)} & \quad \text{‘ball’} \\
b. \quad \text{Buggy} & \quad \text{bagi} & \quad \text{ba: (Naomi 1;2-1;3)} & \quad \text{‘stroller’} \\
c. \quad \text{Bauch} & \quad \text{bau} & \quad \text{ba: (Naomi 1;2-1;3)} & \quad \text{‘belly’} \\
d. \quad \text{drauf} & \quad \text{drauf} & \quad \text{dau (Annalena 1;3-1;5)} & \quad \text{‘on it’}
\end{align*}
\]

\[
\begin{align*}
(8) \quad \text{initial nasal plosives are realised as nasal plosives} \\
a. \quad \text{Milch} & \quad \text{mlç} & \quad \text{mi: (Naomi 1;2)} & \quad \text{‘milk’} \\
b. \quad \text{Mülleimer} & \quad \text{mvl}^2\text{aim} & \quad \text{mvmp (Naomi 1;5.01)} & \quad \text{‘wastebasket’} \\
c. \quad \text{nein} & \quad \text{nain} & \quad \text{nai (Naomi 1;5.01)} & \quad \text{‘no’} \\
d. \quad \text{Nase} & \quad \text{na:zæ} & \quad \text{nana (Annalena 1;0.16)} & \quad \text{‘nose’}
\end{align*}
\]
Initial affricates in adult speech are simplified in child speech and they are realised as an oral plosive:

(9) initial affricates are simplified

a. zu t'u: tu (Naomi 1;2-1;3) ‘closed’

b. Ziege t'iːɡə tiː (Naomi 1;5.01) ‘goat’

c. Ziege t'iːɡə kikə (Annalena 1;4.20) ‘goat’

d. Zeh t'eː teː/deː (Annalena 0;11.30) ‘toe’

Naomi’s earliest word-stage (1,2.06 – 1;5.01) is characterised by the fact that word-initial fricatives are mostly not realised at all and sometimes replaced by a plosive (75% of the word-initial fricatives in our corpus are deleted and 25% are realised as a plosive). We also find initial fricative deletion and substitution in Annalena’s earliest speech:

(10) initial fricatives are deleted or realised as a plosive

a. sauber zaʊbə abə (Naomi 1;2-1;5.01) ‘clean’

b. satt zat aʈ (Annalena 1;2.19) ‘satisfied’

c. satt zat daʈ (Annalena 1;2.30) ‘satisfied’

d. Wagen vaːɡə aka (Annalena 1;2.16) ‘car’

e. Waage vaːɡə gaga (Annalena 1;1.09) ‘scale’

Initial fricative deletion in early child speech has also been observed, for instance, by Fikkert (1994a,b) for Dutch (see 11a,b) and by Costa & Freitas (1998) for Portuguese (see 11c,d).
(11) *initial fricative deletion in early Dutch and Portuguese child speech*

a. Du: vis vis is (Jarmo 1;9.09) ‘fish’
b. Du: fiets fi:ts i:s (Jarmo 1;9.09) ‘bicycle’
c. Port: zebra zebrə eբu (Luís 1;9.29) ‘zebra’
d. Port: vēs veʃ eʃ/iʃ (Marta 1;2.0) ‘see’

Example (12a) from Velten (1943) and examples (12b-d) from Menn (1971) provide evidence for initial fricative deletion in early English child speech.

(12) *initial fricative deletion in English child speech*

a. Fuff af (Joan 1;2) dog’s name
b. shoes uz (Daniel 1;10-2;1)
c. fish iʂ (Daniel 1;4-2;1)
d. watch aʂ (Daniel 1;4-2;1)

We furthermore point out that deletion of initial fricatives and the realisation of a consonant somewhere else in the word (e.g., in final position) are related. Whenever a word-initial fricative is deleted, a consonant is realised somewhere else in the word. We find the same phenomenon in monosyllabic words which lack an initial consonant in adult speech. In such cases, a non-initial consonant is also obligatorily realised in early child speech. It is a striking feature in Naomi’s and Annalena’s earliest speech that a word-final consonant is not realised in words with an initial oral or nasal plosive (see
7a,c,d, 8a,c), whereas it is always realised when the adult form does not have a word-initial consonant (13a-e).

(13) **no consonant is inserted when the adult form lacks a word-initial consonantal phoneme and another consonant in the word is realised.**

<table>
<thead>
<tr>
<th>Spelling</th>
<th>Adult form</th>
<th>Child’s output</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>ab</td>
<td>?ap</td>
<td>apʰ</td>
</tr>
<tr>
<td>b.</td>
<td>auf</td>
<td>?auf</td>
<td>af</td>
</tr>
<tr>
<td>c.</td>
<td>auch</td>
<td>?aux</td>
<td>ax</td>
</tr>
<tr>
<td>d.</td>
<td>an</td>
<td>?an</td>
<td>an</td>
</tr>
<tr>
<td>e.</td>
<td>Öl</td>
<td>?ø:l</td>
<td>a:l</td>
</tr>
<tr>
<td>f.</td>
<td>Auto</td>
<td>?auto</td>
<td>atɔ</td>
</tr>
<tr>
<td>g.</td>
<td>Eimer</td>
<td>?aimə</td>
<td>a:mə</td>
</tr>
</tbody>
</table>

In German, vowel-initial words have an initial glottal stop in stressed syllables only (e.g., Wiese 1996). We did not find any word-initial glottal stops in Naomi’s speech. Elsen (1991) reports that Annalena sometimes realises glottal stops at later stages. For *ab* [ʔap] ‘off’, Annalena’s output is [apʰ] from 1;2.15 until approximately 1;5.30 and from then until 1;7.30 her output is [ʔapʰ] (Annalena loses word-final aspiration after 1;7.30, see Goad 1998 for discussion of this phenomenon) and *Auto* is realised without an initial glottal stop from age 1;2 until 1;5. With respect to other words which
lack an initial consonant, a glottal stop is hardly ever realised in Annalena’s early speech. For instance, the adult form satt [zat] ‘satisfied’ is realised by her as [atʰ] at 1;2.19. Hence, this is a real case of fricative deletion and one that we also find in Naomi’s speech (see 10a), the speech of Dutch-speaking children (see 11a,b), Portuguese-speaking children (see 11c,d), and English-speaking children (see 12a-d).

Neither Naomi nor Annalena realise word-final consonants at the earliest acquisition stage, unless the adult word lacks a word-initial consonant or has an initial fricative (e.g., /baʊx/ --> [bɑːt] in 7c versus /ləʊx/ --> [əx] in 13c). We believe this is an important generalisation that a theory of language acquisition has to explain. We address this problem in the following section.

5 The acquisition of consonants in German child speech: an OT-account

In section 4, we showed that onsetless words are present from the beginning of language acquisition and that each word is characterised by at least one vowel and one consonant in early child speech. With respect to the acquisition of onsets and coda consonants, two interesting problems arise for an OT-analysis. Optimality Theory (Prince & Smolensky 1993, McCarthy & Prince 1995) assumes that unmarked syllable structures emerge through the interactions of the constraints ONS - which requires that syllables have onsets - and NOCODA – which says that syllables should not have codas. These two constraints account for the fact that languages favour a CV-structure and the
prevailing view is that these constraints are highly ranked in child speech. Under this assumption, it is surprising that we find V-initial syllables at the earliest acquisition stage in Naomi’s speech, in Annalena’s speech, and at the earliest stage in the speech of English-speaking and Portuguese-speaking children. We will argue below that in early child speech, ONS never outranks a constraint against inserting segments (DEP-IO).

Final consonants are only realised by Naomi and Annalena in an early stage if there is no initial consonant and no word consists of a vowel only. Hence, at the initial stage, the speech of these two German children is characterised by the presence of one consonant and one vowel per word. In other words, the first stage in child language is characterised by the following two (presumably universal) principles:

\[(14) \quad \begin{align*}
\text{a. CONSONANT: Every word contains at least one phase which is} \\
\text{characterised by oral closure (i.e., every word has at least one} \\
\text{consonantal place of articulation).}
\end{align*}\]

\[\begin{align*}
\text{b. VOWEL: Every word contains at least one phase which is} \\
\text{characterised by maximal oral release for vowels (i.e., every word} \\
\text{has at least one vocalic place of articulation).}
\end{align*}\]

The account for consonant-vowel sequences in Naomi’s and Annalena’s speech that we present here is cast in an Optimality-theoretic framework. Henceforth, we refer to (14a) as a constraint which we call CONS and we refer to (14b) as a constraint which we call VOWEL. These constraints
interact with other constraints. The familiar faithfulness constraints in (15a,b) below demand that any output form has as many segments as the input form.

(15) a. MAX-IO  A segment in the input must have a correspondent
                in the output (no deletion)

        b. DEP-IO  A segment in the output must have a correspondent
                in the input (no epenthesis)

The fact that segments which are present in adult forms are missing in the child's output forms can be attributed to constraints which prohibit structure. In particular, we suggest that the constraints below (based on Prince & Smolensky 1993 and McCarthy & Prince 1995) play a significant role. These constraints prohibit consonantal places of articulation:6

(16) a. *LAB  Have no Labial C-Place feature

        b. *COR  Have no Coronal C-Place feature

        c. *DORS  Have no Dorsal C-Place feature

Onsetless words pronounced by Naomi from 1;2.06 until 1;5.01 and by Annalena from 0;11.29 until approximately 1;3 have at least one consonant (see 10a, b, d, 13a-g). 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 and Annalena’s speech at this stage. Hence, the constraint CONS is never violated in their speech. Conversely, there are no words
which consist of consonantal segments only and the constraint VOWEL is always satisfied. Since every word in German child speech has one consonant and one vowel (which may be in a vowel-consonant order), the constraints CONS and VOWEL must be ranked higher than ONS and, possibly, NoCODA. In anticipation of the discussion in 5.1, this is illustrated in the tableau below for the word ab [?ap] ‘off’. We assume that the child can distinguish the phonemes of her language. Since the glottal stop is not used as a distinctive phoneme in German, the most likely assumption is that the child does not postulate a glottal stop in underlying - or input - representations (why postulate more structure than is absolutely necessary to distinguish one word from another?). This assumption is supported by the fact that we do not find initial glottal stops in early German child speech. In the following tableau, candidates (17a,c,d,e) each have more violations of highly ranked constraints than candidate (17b) which is selected as the optimal one even though it has a violation of ONS as well as NoCODA. The pointing finger $F$ marks the optimal candidate and *! marks the fatal constraint violation.

(17) Input form /ap/; Naomi’s output is [ap] at 1:4.26

<table>
<thead>
<tr>
<th></th>
<th>CON S</th>
<th>VOWEL</th>
<th>DEP-IO</th>
<th>MAX-IO</th>
<th>*COR</th>
<th>*LAB</th>
<th>ONS</th>
<th>NoCODA</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>a</td>
<td>*</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>$F$ ap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>p</td>
<td></td>
<td>*</td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>ta</td>
<td></td>
<td>*</td>
<td>*!</td>
<td></td>
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<td>*</td>
<td></td>
</tr>
<tr>
<td>e</td>
<td>?ap</td>
<td></td>
<td>*</td>
<td></td>
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<td></td>
<td>*!</td>
<td>*</td>
</tr>
</tbody>
</table>
Naomi’s and Annalena’s early word production supports Jakobson’s (1941) proposal that the first contrast in child speech is one between consonantal closure and vocalic release. In OT-terms, we need constraints which say that one consonantal place of articulation and one vocalic place of articulation are minimal requirements for words. When these constraints are ranked higher than the constraint which says that every word should have an onset (ONS), vowel-initial words with a consonant in another position may emerge. The question is how the child arrives at such a ranking. This question is the topic of the next subsections.

5.1 Constraint demotion in German child speech

Tesar & Smolensky (1993, 1998) advocate the view that the acquisition of the adult phonology involves the step-by-step demotion of one constraint below another constraint. We now have to ask the question whether such an account may offer an explanation for (i) the lack of codas in early child speech when an onset is present (e.g., /bal/ --> [ba], see 7a) and (ii) the presence of codas when there is no onset (e.g., /ka:l/ --> [a:l], see 13a). We assume the faithfulness constraints MAX-IO and DEP-IO and the markedness constraints CONS, ONS, NOCODA, *LAB, and *COR. There are, of course, more constraints than those assumed here (e.g. NOCOMPLEXONSET, IDENTLABIAL and IDENTCORONAL) but these constraints would not change the outcome of the selection of the word-initial or word-final consonants that
we discuss in this paper (cf. footnote 6) and we ignore these constraints here for the sake of clarity.

Tesar & Smolensky (1993) observe that for their algorithm to learn to rank constraints, it is irrelevant how constraints are ranked at the earliest stage. Naomi and Annalena do not insert a segment to provide an onset, but realise an available consonant somewhere else in the word instead. We conclude from this that ONS must be ranked lower than constraints which are violated by losing candidates with an epenthetic onset, i.e. below the constraints CONS and DEP-IO (see tableau 18).

Naomi and Annalena do not delete the final consonant in monosyllabic vowel-initial words, so that at least one consonant is present in their output forms. From this, we conclude that NOCODA is ranked lower than CONS. In conclusion, we propose that ONS and NOCODA are ranked relatively low in the initial constraint hierarchy. We cannot determine how the other constraints are ranked with respect to each other, and it is neither possible to determine how ONS and NOCODA are ranked with respect to each other. The following two tableaux illustrate that the proposed ranking renders the correct output candidates for Naomi’s and Annalena’s speech at the earliest stage (stage 1):
Children favour an oral or nasal plosive in onset position, i.e. the best onset is a consonant which is [-continuant]. Initial fricatives are avoided in early German, Dutch, English, and Portuguese child speech. To capture this generalisation, we draw on Zonneveld (1998) who proposes the following constraint which prohibits a fricative in onset position:

(20) **INITIAL MANNER: \[^n\text{+continuant}\]_{\text{ONSET}}**

This constraint is crucial in the selection of the winning candidate in child speech for words with an initial fricative in adult speech:  

<table>
<thead>
<tr>
<th>CONS</th>
<th>*COR</th>
<th>*LAB</th>
<th>MAX-IO</th>
<th>DEP-IO</th>
<th>ONS</th>
<th>NOCODA</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. a</td>
<td>*</td>
<td></td>
<td><em>!</em></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. &amp; an</td>
<td>*</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c. ?a</td>
<td></td>
<td>*</td>
<td>*</td>
<td>!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. ?an</td>
<td>*</td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONS</th>
<th>*COR</th>
<th>*LAB</th>
<th>MAX-IO</th>
<th>DEP-IO</th>
<th>ONS</th>
<th>NOCODA</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. a</td>
<td>*</td>
<td></td>
<td><em>!</em></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. al</td>
<td>*</td>
<td></td>
<td>*</td>
<td>!</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c. &amp; ba</td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. bal</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
</tr>
</tbody>
</table>
We pointed out in section 4 that for vowel-initial words like *ab* ‘off’, Annalena’s output is one without a glottal stop ([apʰ]) from 1;2.15 until approximately 1;5.30 and from that age onwards Annalena regularly realises glottal stops. We here propose that the constraint ranking in (17), (18), (19), and (21) correctly predicts vowel-initial words at the earliest word-stage for Annalena and Naomi. Based on positive evidence (i.e., adult words with an epenthetic glottal stop in stressed syllables), the constraint DEP-IO is demoted below ONSET-FOOT in Annalena’s grammar at the next stage. Also, positive evidence urges the child to demote *COR and *LAB below MAX-IO (i.e., under that ranking [ʔan] and [ʔap] are optimal outputs for /an/ and /ab/, respectively):
Input form /an/; Annalena’s output is [?an] at stage 2

<table>
<thead>
<tr>
<th></th>
<th>CONS</th>
<th>MAX-IO</th>
<th>*COR</th>
<th>*LAB</th>
<th>ONSET-FOOT</th>
<th>NOCODA</th>
<th>DEP-IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. a</td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. an</td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
</tr>
<tr>
<td>c. ?a</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>d. ?an</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For Naomi, demotion of DEP-IO to a stratum below ONSET-FOOT has not taken place before 1;8.21.

Under the assumption that constraints are universal and available to the child (irrespective of the language he/she is learning), we expect effects of the same constraints in the acquisition of other languages. In the next section, we propose an account of the acquisition of Dutch onsets which resembles the OT-account that we gave for the German data in this section.

5.2 Constraint demotion in Dutch child speech

At the earliest acquisition stage, two of the twelve Dutch children that Fikkert (1994a) examined (Jarmo and Noortje), avoid the production of words which lack an onset in the adult form. At a later stage, when Jarmo starts to produce such words, there is free variation between forms with an epenthetic onset and forms without onsets (23b and 23a, resp.). This variation is also found in
the production of onsets by two other Dutch children (Tom and Leonie) at an early age:

<table>
<thead>
<tr>
<th>Adult form (Dutch)</th>
<th>Jarmo’s output</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>(23) a. aap a:p</td>
<td>ap, a:p</td>
<td>(1;7.15) ‘monkey’</td>
</tr>
<tr>
<td>b. apie a:pi:</td>
<td>ta:pi:</td>
<td>(1;7.15) ‘monkey’</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Adult form (Dutch)</th>
<th>Tom’s output</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>(24) a. aap a:p</td>
<td>a:β</td>
<td>(1;2.27) ‘monkey’</td>
</tr>
<tr>
<td>b. aap a:p</td>
<td>ba:p</td>
<td>(1;3.24) ‘monkey’</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Adult form (Dutch)</th>
<th>Leonie’s output</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>(25) a. aap a:p</td>
<td>qap</td>
<td>(1;9.15) ‘monkey’</td>
</tr>
<tr>
<td>b. aap a:p</td>
<td>pa:p</td>
<td>(1;9.15) ‘monkey’</td>
</tr>
</tbody>
</table>

The transition from one stage to the next is explained by Fikkert (1994a) as the setting of one or more parameters. She proposes 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 to the marked value (i.e., ‘no’) and nothing can change once the parameter is set, so that no variation will take place anymore. This account fails for German, because it misses an important generalisation: in Annalena’s and Naomi’s first words, an onset may be
absent if and only if there is another consonant somewhere else in the word (see 10a,b,d, and 13a-f). Based on the account we gave in 5.1 for the acquisition of onsets in German, an alternative analysis will be presented now for the acquisition of onsets in Dutch.

For Jarmo, Tom, and Leonie, one stage is characterised by an optional onset for words which lack an onset but have a coda in the adult grammar. At this stage, the constraint NOCODA is subordinate to MAX-IO, so that final consonants may be realised. The following tableau illustrates that the assumed ranking correctly predicts variation between forms with and without an additional onset:

(26) Input form /a:p/: Jarmo’s, Leonie’s, and Tom’s outputs vary at an early stage after minimal demotion of NOCODA

<table>
<thead>
<tr>
<th></th>
<th>CONS</th>
<th>*COR</th>
<th>*LAB</th>
<th>MAX-IO</th>
<th>DEP-IO</th>
<th>ONS</th>
<th>NOCODA</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>a:</td>
<td>*</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>a:p</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>ba:p</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>ba:</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

At a later stage, a consonant is no longer inserted to provide onsets in the speech of these children and we conclude from this that ONS is minimally demoted to a position in the hierarchy where it is dominated by the constraint CONS, i.e., at the same stratum as NOCODA:
(27) Input form /a:p/; Jarmo's Leonie's and Tom's output [a:p] at the next stage, due to minimal demotion of ONS

<table>
<thead>
<tr>
<th></th>
<th>CONS</th>
<th>#COR</th>
<th>#LAB</th>
<th>MAX-IO</th>
<th>DEP-IO</th>
<th>ONS</th>
<th>NoCODA</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>a:</td>
<td>*</td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>a:p</td>
<td>*</td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>ba:p</td>
<td>*</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>d.</td>
<td>ba:</td>
<td>*</td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The process of demoting constraints is to a certain extent subject to variation. Therefore, we predict that other children may demote another constraint, for instance DEP-IO instead of ONS, so that for them, the optimal output for [a:p] is [ba:] or [ta:] at a certain stage. We point out, however, that constraint demotion takes place on the basis of positive evidence only and Dutch children are never exposed to words with an epenthetic initial consonant. It is therefore unlikely that they will ever demote DEP-IO in their native language.\(^{10}\)

We do not take issue with the claim that because every language allows consonant-initial syllables and some languages permit no others, this must reflect some universal principle or constraint. We suggest, though, that this principle or constraint does not always play the most important role at the initial stage of acquisition of every language. In Dutch, German, and Portuguese,\(^{11}\) the effect of a principle or constraint referring to the onset diminishes at an early stage in the acquisition of phonology. In OT-terms, this implies that children determine relatively early that other constraints are ranked higher than ONS.
The ranking of constraints that three of twelve Dutch children (i.e., Jarmo, Tom, and Leonie) arrive at at a relatively late stage, is the same as the ranking of constraints that other Dutch children have from the onset of speech. We conclude from this, that the process of ranking constraints does not always proceed in exactly the same way for every child. The way they get to the ultimate constraint-ranking for a particular language may vary to some extent from child to child, but it is always triggered by positive evidence.

With respect to German child speech, we argued in section 5.1 that the ranking of ONS and NoCODA below CONS and MAX-IO accounts for the fact that Naomi and Annalena realise the final consonant in monosyllabic words like *ab* and *an* (see 17 and 18). At this stage, final consonants are not realised in words like *Ball* and *Bahn* and this is accounted for by highly ranked constraints against consonantal places of articulation (see 19). The next development in Naomi’s speech is that final consonants begin to emerge in consonant-initial words. We will illustrate and account for this development now.

6 The acquisition of German rhyme structure

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

(28) a. Bahn [baːn] baː (1;4.26-1;5.01) ‘tram’
    b. Buch [buːx] buː (1;4.26-1;5.08) ‘book’

(29) a. an [ʔan] an (1;2-1;4.26) ‘at’
    b. auf [ʔauf] af (1;3-1;5.01) ‘on’

From 1;6.12, Naomi no longer produces syllables with a single short vowel, i.e., from that age onwards, each rhyme is filled by minimally two positions.12

We attribute this to a so-called “minimality requirement” which says that a rhyme must branch (i.e. a rhyme has at least and at most two moras).

(30) **RHYME BINARITY**: a rhyme is minimally and maximally bimoraic.

The question is whether this constraint has been present from the beginning of speech production. Rice & Avery (1995) propose that initial phonological representations are relatively impoverished, with little or no structure. Segmental structure is elaborated under pressure from the phonology, i.e. positive evidence forces the addition of structure to representations. If we were to adapt this proposal to explain the growing complexity in word-structure, we might argue that the underlying representation of words is initially very simple, viz. each word has a vowel and a consonant. Word-structure is elaborated minimally in the sense that the child discovers that
segments combine into syllables and that a syllable has a branching rhyme,
i.e. the next step (stage II) is one in which each rhyme is bimoraic (cf. 30).
Under this assumption, RHYMEBINARITY (RBIN) is a constraint which is
vacuous at the earliest stage of speech production.

The markedness constraint RBIN interacts with the faithfulness constraint
which says that each mora in the input should have a correspondent in the
output (MAX-µ). At stage II in Naomi’s acquisition of rhyme structure, it is
more important to have a bimoraic rhyme than to be faithful to the adult
trimoraic rhyme, i.e. RBIN is ranked higher than MAX-µ (see 31).

We consider next which aspects determine whether the two positions
available for a mora in a rhyme are filled by a long vowel, or by a sequence
of a short vowel and a consonant. A sequence of a short vowel plus a
consonant constitutes one violation of *LAB, *COR, or *DORS. To account for
the fact that CV:C words are realised mostly as CV: words and not as CVC
words until approximately 1;5.08, we propose that constraints which prohibit
consonantal places of articulation are not yet demoted to a position lower
than RBIN.13 This ranking will give [ba:] as the child's optimal output for the
adult target [ba:n].14
(31) Input form /baːn/; Naomi’s output is [baː] at stage II

<table>
<thead>
<tr>
<th></th>
<th>MAX-IO</th>
<th>*LAB</th>
<th>*Cor</th>
<th>RBIN</th>
<th>MAX-µ</th>
<th>ONS</th>
<th>NoCODA</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>an</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*!</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b.</td>
<td>ba:</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*!</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>ban</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*!</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>ba</td>
<td>*</td>
<td>*</td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>baːn</td>
<td>*</td>
<td>*</td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

Until 1;4.26, there is a strong tendency for one consonantal place of articulation per word, but from 1;5.01 more and more exceptions to this generalisation begin to emerge. The examples below each have a labial as well as a coronal consonant:

(32) a. Butter ‘butə’15 ‘buːtə (1;5.29) ‘butter’
    b. kaputt kaˈput butɛ (1;6.05)16 ‘broken’
    c. Tomate toˈmaːtə ‘maːtə: (1;6.27) ‘tomato’

It is interesting to note that at the same time, monosyllabic words with a long vowel plus a consonant are no longer realised with a long vowel (as in 28a,b), but with a short vowel plus a consonant:

(33) a. Bahn [baːn] ban (1;6.12) ‘tram’
    c. warm [vaːm] bam (1;6.05) ‘warm’
The examples above show that it becomes more important at this stage to be faithful to the target places of articulation, and we account for this by means of gradual constraint demotion. That is to say, we propose that $\textit{LAB}$, $\textit{COR}$ (and $\textit{DORS}$) are demoted in the constraint hierarchy to a position lower than Max-IO. We illustrate this for consonantal places of articulation in the tableau below for the word $\textit{Bahn}$ [ba:n] ‘railroad, tram’:

(34) Input form /ba:n/; Naomi’s output is [ban] at stage III

<table>
<thead>
<tr>
<th></th>
<th>MAX-IO</th>
<th>RBIN</th>
<th>MAX-$\mu$</th>
<th>ONS</th>
<th>NoCODA</th>
<th>*LAB</th>
<th>*COR</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>an</td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b.</td>
<td>ba:</td>
<td>*!</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>ban</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>ba</td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>ba:n</td>
<td>*!</td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We attribute the fact that adult words which have three positions in the rhyme are realised by Naomi with a short vowel and one consonant to the highly ranked constraint RBIN. This constraint requires exactly two positions in the rhyme and forbids words with more than two moras and for this reason, adult words with a final consonant cluster are realised with at most one consonant at this stage:

(35) a. Hund [hunt] hut$\text{'}$(1;5.01-1;5.21) ‘dog’
    b. Milch [miłç] miç (1;5.29) ‘milk’
From 1;6.12, we find that most adult words which have three positions in the rhyme are realised by Naomi with three positions in the rhyme:

(36) a. stimmt [ʃumt] tnt (1;7.27) ‘that's right’
   b. Buch [bu:x] buːχ (1;7.16-1;7.27) ‘book’
   c. Hund [hunt] huːtʰ (1;6.12) ‘dog’
   d. Geld [gɛlt] deːlt (1;6.19) ‘money’
   e. Milch [mi:ç] miːç (1;7.02) ‘milk’

The following figure shows that until 1;6.05, a bipositional rhyme is preferred in child speech for an adult tripositional rhyme, 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**

<table>
<thead>
<tr>
<th>input rhyme</th>
<th>CVXC</th>
<th>rhyme one position (-V)</th>
<th>rhyme two positions (-VV, -VC)</th>
<th>rhyme three positions (-VVC, -VCC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1;2.06-1;4.26</td>
<td>0</td>
<td>7 (100%)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1;5.01-1;6.05</td>
<td>3 (6%)</td>
<td>35 (71%)</td>
<td>11 (23%)</td>
<td></td>
</tr>
<tr>
<td>1;6.12-1;7.27</td>
<td>0</td>
<td>19 (24%)</td>
<td>60 (76%)</td>
<td></td>
</tr>
<tr>
<td>1;8.04-1;8.21</td>
<td>0</td>
<td>0</td>
<td>63 (100%)</td>
<td></td>
</tr>
</tbody>
</table>

Before 1;8.04, words with a so-called “coronal appendix” (see 6) are not attested. From 1;8.04 until 1;8.21, such words are realised without an appendix in 50% of the cases (e.g. Mond /moːnt/ ‘moon’ → [moːt] 1;8.10
and Keks /keːks/ --> [teːʃ]17) and with an appendix also in 50% of the cases (e.g. Mond --> [moːnt] 1;8.10 and eins ‘one’ /ains/ --> [aintʃ] 1;8.14).

In summary, we find that from 1;2 to 1;4.26 each word has a vowel, but it does not matter whether the rhyme branches or not. From 1;5.01, Naomi produces words with two positions in the rhyme. From 1;6.12, the rhyme structure is more complex (i.e. a rhyme may have three positions). In the framework that we assume here, this may be attributed to minimal demotion of RBIN to a stratum below the constraint which says that the output should be faithful to the number of moras in the input, i.e. MAX-μ:

(37) Input form /baːn/: Naomi’s output is [baːn] at stage IV

<table>
<thead>
<tr>
<th></th>
<th>MAX-IO</th>
<th>ONS</th>
<th>NoCoda</th>
<th>*Lab</th>
<th>*Cor</th>
<th>MAX-μ</th>
<th>RBIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>an</td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>ba.</td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>ban</td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td>*!</td>
</tr>
<tr>
<td>d.</td>
<td>ba.</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td>**</td>
<td>*</td>
</tr>
<tr>
<td>e.</td>
<td>ba:n</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Naomi’s steps in the development of rhymes can be characterised as follows:

(38) Naomi’s first steps in the acquisition of rhyme structure:

Stage I (1;2.06 – 1;4.26): Vowel length is not distinctive

One consonant per word
Stage II (1;4.26 – 1;5.08): Rhyme exactly two positions
One consonant per word

Stage III (1;5.08 – 1;6.05) Rhyme exactly two positions
More than one consonant per word

Stage IV (1;6.12 – 1;8.21) Rhyme may have three positions

Adult CV(C)C- and CV:C-words which had a CV:-structure in stage II are more often realised with a CVC-structure in stage III. This effect can be attributed to the fact that Naomi realises more consonantal places of articulation per word in stage III. In OT-terms, this means that the child reranks markedness constraints and faithfulness constraints. In particular, we see that the constraints penalising consonantal places of articulation are demoted to a position lower than MAX-IO. We have argued that the step from stage III to stage IV involves the demotion of the markedness constraint $\text{RHYMEBIN}$ to a position lower than $\text{MAX-}^\mu$.

(39) The acquisition of Rhyme structure and gradual constraint demotion

Stage I: $\text{MAX IO, } *\text{LAB, } *\text{COR, RBIN, MAX-}^\mu >> \text{ONS, NOCODA}$

Stage II: $\text{MAX IO, } *\text{LAB, } *\text{COR, RBIN } >> \text{MAX-}^\mu, \text{ONS, NOCODA}$

Stage III: $\text{MAX IO, RBIN } >> \text{MAX-}^\mu, \text{ONS, NOCODA, } *\text{LAB, } *\text{COR}$

Stage IV: $\text{MAX IO } >> \text{MAX-}^\mu, \text{ONS, NOCODA, } *\text{LAB, } *\text{COR } >> \text{RBIN}$
7 Conclusion

Naomi’s and Annalena’s early speech are characterised by exactly one consonant and exactly one vowel. They may occur in a consonant-vowel sequence, but also in a vowel-consonant sequence. In accordance with the findings of Bernhardt & Stemberger (1998) and Menn (1971) for English-speaking children and Costa & Freitas (1998) for Portuguese-speaking children, we found that words without initial consonants are pronounced at the earliest word-stage in German. We pointed out that word-final consonants are realised in early German child speech if there is no word-initial consonant. Two types of cases occur in which vowel-initial words emerge in early child speech: (i) in a sequence of fricative + vowel + consonant, the initial fricative may not be realised (e.g., /zat/ → [at]; /zaʊbet/ → [aʊbet]) and (ii) in a sequence of a vowel + consonant, no onset is realised (e.g. /ab/ → [ap]; /aimœ/ → [aimœ]). There is no stage which might be characterised as “avoid onsetless words” in the development of German onsets. 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. In the framework of OT, this implies that the constraints ONS and NOCODA are ranked below the constraints CONS, MAX-IO, and DEP-IO in the grammar of these children.

At the initial stage in the acquisition of German words, vowel length is not distinctive. From 1;5.01, Naomi realises each monosyllabic word with either a long vowel, or a short vowel followed by one consonant. We concluded from this that at age 1;5.01, Naomi has learned that the rhyme matters and from that age onwards until approximately 1;6.12, she presupposes that rhymes have minimally and maximally two positions. Under the theory assumed in this paper, this means that the constraint RHYMEBINARITY outranks MAX-µ at this stage.
Gradually, Naomi begins to realise more than one consonant per word. We attributed this development to a change 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 [baː]), but distinctively (i.e., as [ban] and [bam], respectively). We attributed this development to the minimal demotion of constraints against places of consonantal articulation (*LAB* and *COR*).

The next step in the acquisition of German phonology is a distinction between rhymes with two positions and rhymes with three positions. We accounted for this development by assuming that at this stage, the child demotes the constraint *RHymeBinarity* below *Max-µ*.

**References**


Goad, Heather & Yvan Rose (this volume), “Input Elaboration, Head Faithfulness and Evidence for Representation in the Acquisition of Left-edge Clusters in West Germanic”.


Hall, T. (1992), Syllable Structure and Syllable-Related Processes in German, Max Niemeyer: Tübingen.


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1 Syllable boundaries are indicated by a dot.

2 In this paper, we focus on the absence versus presence of onset consonants and we do not discuss the development of consonantal clusters in any detail. However, for completeness’ sake, we here note that this particular development may be attributed to the gradual demotion of a constraint like NOINITIALAPPENDIX below MAX-IO. In Naomi’s grammar, the former constraint is presumably demoted earlier than the constraint NOCOMPLEXONSET. For a detailed discussion of the acquisition of word-initial clusters involving an appendix, we refer to Goad & Rose (this volume).

3 In (6) and below, ‘V’ = vowel, ‘Son’ = sonorant (vowel, glide, liquid, or nasal), and ‘C’ = consonant. The symbol ‘σ’ denotes a syllable.

4 The glottal stop [?] is not a phoneme in German. It is not present in underlying representations, but added by the grammar (in OT-terms: the constraint ranking) to provide an onset to stressed syllables. We argue below that in adult German grammar, the constraint which says that a foot should have a consonantal onset (ONSET-FOOT) outranks a
constraint against epenthesis (Dep-IO) and this particular ranking is acquired relatively late by German children.

5 For Naomi this stage ranges between age 1;2.06 and 1;5.01 and for Annalena this stage lasts from 0;11.29 until approximately 1;3.

6 These markedness constraints crucially outrank the corresponding faithfulness constraints IdentLabial, IdentCoronal and IdentDorsal in early child speech.

7 At a later stage, the child assumes a ‘minimally and maximally binary rhyme’, i.e. /baːn/ \(\rightarrow\) [baː] (1;5.01), then *Cor is demoted, so that /baːn/ \(\rightarrow\) [ban] (1.6.12), and finally the markedness constraint on rhymes is demoted and the most faithful parse [baːn] wins (see section 6).

8 In Grijzenhout & Joppen-Hellwig (in press) we account for fricative substitution. The constraint which is relevant there (Ident[CONTINUANT]) is left out of consideration here. For a detailed account of the developmental stages with respect to the acquisition of initial fricatives, we refer to Grijzenhout & Joppen-Hellwig (in press).

9 We tentatively assume that the feature Labial is shared between the final consonant and the epenthetic initial consonant in Tom’s and Leonie’s outputs to avoid a Dep-C-Place violation. Jarmo makes use of another option, viz. to insert /t/. We assume that in his grammar, *Cor is demoted and ranked lower than a constraint which prohibits shared association lines.

10 If second language acquisition is based on first language grammar, we expect to find effects of this constraint in a second language, because it is never demoted in the first language (see Grijzenhout 2000). This prediction seems to be borne out, because learners of German whose first language is Dutch are notorious for not producing glottal stops when they first learn German. In their first language grammar, Dep-IO is ranked higher than Ons and they have to demote this constraint when they acquire the grammar for German.

11 Costa & Freitas (1998) found that Portuguese-learning children may pronounce words with one vowel only (e.g. the adult form é /e/ ‘is’ is realised as [e] by João 1;0.12 and Inês
1:0.25). To us this suggests that the constraints ONS and NoCODA are ranked lower than Dep-IO in the grammar of these children. Moreover, fricative-initial words may be realised without a consonant (e.g. the adult form vou /val/ ‘go’ is realised as /o/ by Luís 1:9.29) and this may be due to the fact that CONS is ranked relatively low in Portuguese child speech.

12 From 1:4.26 until 1:6.05 there is still variation and some words are realised with short vowels. For instance, at 1:5.01 Hund [hunt] ‘dog’ is realised once as [hu], once as [hu:] and once as [hut] and zu [tsu:] is realised twice with a short vowel and once with a long one. Fikkert (1994a) found that most Dutch children first acquire a rhyme that branches into a nucleus and a coda (i.e. the first rhymes have a VC-structure) and later a nucleus may branch as well (i.e. the next rhymes have a Vson- or VsonC- structure). In the German data available to us, vowel-obstruent rhymes are not acquired before vowel-sonorant ones.

13 We did not find evidence for this stage in Annalena’s speech. We assume that Annalena “skipped” this stage and demoted *LAB, *COR, and *DORS at an earlier age.

14 Previous sections showed that ONS and NoCODA are lowly ranked at this stage.

15 Primary stress is indicated by ’ before the stressed syllable.

16 Naomi regularly produces a fricated release after word-final /t/.

17 Naomi always replaces velar plosives by coronal ones.

18 The emergence of consonants in the coronal appendix may be attributed to the demotion of a constraint "NoAPPENDIX" to a position below MAX-IO.