1. Introduction

In this paper, we examine the lack of onsets in German child phonology in the light of recent developments in Optimality Theory (Prince & Smolensky 1993). The paper focuses on the acquisition of word-initial consonants by two German children, Annalena (between age 1;2 and 1;8) and Naomi (between age 1;2.06 and 1;8.21). The data on Annalena’s acquisition of German are taken from Elsen (1991) and the data on Naomi’s acquisition of German are collected by Sandra Joppen-Hellwig. Two standard assumptions in the literature on the acquisition of English (e.g., Ingram 1978, Smith 1973) and Dutch (Fikkert 1994a,b) are: (i) the first words that children produce have a CV-structure and (ii) the first consonants that appear in child speech are oral stops. Based on these assumptions, the expectation is that vowel-initial words are absent in early child speech and that adult words with an initial fricative will be pronounced with an initial stop by the child. These expectations are not answered in the study of German child speech that we present here. We show that Annalena’s and Naomi’s first words consist of at least one consonant and one vowel and the consonant may either precede or follow the vowel. Our findings are confirmed by at least one other study on Portuguese child speech (Costa & Freitas 1998). In early child speech, we find utterances with a CV-structure as well as utterances with a VC-structure, but CVC-utterances are absent at the earliest word-stage. We furthermore find that initial fricatives are omitted by Annalena and Naomi at the earliest word-stage and, contrary to the expectation formulated above, they are not replaced by an oral stop. At a later stage, initial fricatives begin to be replaced by stops and subsequently by stops or continuants.

The present paper attempts to provide an account of these observed stages in the acquisition of onsets.1 We show how an optimality-based approach can account for the fact that at the earliest stage, word-final consonants are realised by Annalena and Naomi only when a word-initial consonant is missing. We also account for the observation that onset fricatives are first omitted by Naomi, then realised as stops, subsequently as stops or continuants, and finally as fricatives. We argue that these observed stages arise through minimal constraint demotion.
The paper is structured as follows. Section 2 describes the method used to elicit the child data. Section 3 introduces the German consonant inventory and briefly discusses the structure of German onsets. Section 4 discusses the acquisition of onsets and the development of manner of articulation of consonants in onset position. Section 5 presents the analysis and section 6 concludes.

2. Method

From age 1;2.06, Naomi’s mother took detailed notes about the child’s speech in everyday situations. At this time, Naomi had 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 near Düsseldorf. The sessions lasted 15 to 30 minutes. Both parents speak modern standard German. All recordings were transcribed by Sandra Joppen-Hellwig - Naomi’s mother - the same day as the recordings took place. All possible speech sounds that Naomi produced during the sessions were transcribed. For the analysis, only utterances that were intended to be real words are counted as an utterance and babbling and uninterpretable utterances are ignored. Immediate repetitions of identical forms are counted as a single utterance. We furthermore use the database from Elsen (1991) who made detailed notes about the acquisition of German phonology by her daughter Annalena.

3. German Word-initial Consonants

The German consonant system includes the segments presented immediately below (based on Féry 1998, Hall 1992, Wiese 1996):

<table>
<thead>
<tr>
<th>labial</th>
<th>alveolar</th>
<th>postalveolar</th>
<th>palatal</th>
<th>velar</th>
<th>uvular</th>
<th>glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>p, b</td>
<td>(p̪)</td>
<td>f, v</td>
<td>t, d, t̪, s, z</td>
<td>t̪, j, ʒ</td>
<td>ç</td>
<td>k, g</td>
</tr>
<tr>
<td>m</td>
<td>n, l</td>
<td>j</td>
<td>ŋ</td>
<td></td>
<td>R²</td>
<td></td>
</tr>
</tbody>
</table>

All consonants except the velar nasal /ŋ/ may occur in word-initial position in adult speech. Syllable-initially, the affricate /p̪/ is realised as [f] in most German dialects and this is also the case in the speech of Annalena's and Naomi's parents. We will therefore ignore this sound in what follows. The strident fricative /s/ is rare in word-initial position. It occurs in certain loan words, e.g., *Sphäre* ['sfɛ:ʁə], *Smog* [smɔk] as well as before /k/, e.g., *Skandal* [skan'da:l] ‘scandal’.
In syllable-initial position, consonant clusters involve an oral stop or fricative which is followed by a non-homorganic sonorant consonant (see Hall 1992, Vater 1992, and Wiese 1996):

(1) a. Knie [kni:] ‘knee’
b. klug [klu:k] ‘smart’
c. Kranz [kranª] ‘wreath’
d. quatschen [kuatªen] ‘to chat’
e. Fleisch [flaª] ‘meat’
f. Frau [fraª] ‘woman’

Single stops and stop-sonorant clusters may be preceded by a strident fricative, e.g., *springen [ˈsprøŋən] ‘to jump’ and Strand [ʃtranª] ‘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 [smarªad] ‘emerald’. Word-internally, such clusters are syllabified as a coda-onset sequence, e.g. Kosmos is syllabified as [kɔº.nɔs] (not as, e.g., *[kɔº.sɔmɔs]).

3 The exceptional distribution of word-initial strident fricatives suggests that they are not part of the onset. Following Vennemann (1988), we assume that there is an extra position at the left edge of words (referred to as the "appendix") to accommodate /s/ and /ʃ/ before other consonants:

(2) Appendix Onset

\[
\begin{array}{c}
\mid \\
(s/ʃ) & C_1 & C_2 \\
\end{array}
\]

The following sections consider the realisation word-initial consonants at the earliest stages of speech production.

4. Syllable Onsets in Child Speech

Fikkert (1994a) finds that at the initial stage of speech production, three of twelve Dutch children exclusively produce syllables which contain one consonant in the onset position and one vowel in the nucleus position. She assumes that it is a universal tendency that children start speech production with CV-syllables, even though only 25% of her subjects show this behaviour. Bernhardt & Stemberger (1998) state that there is no reason to believe that all children initially require all syllables to have onsets. Moreover, Costa & Freitas (1998) demonstrate that at the initial stage, Portuguese children produce vowel-initial words. Portuguese children
do not insert a consonant before a vowel when there is no consonant in the adult target and they tend to omit initial fricatives. Costa & Freitas show that the most favoured syllable at the initial stage is not necessarily a CV-syllable and that it can also be V-initial syllable. In what follows, we consider the development of onsets in German. We demonstrate that from the onset of speech, two German children produce vowel-initial words and there is no stage in the acquisition of speech where a CV-structure is preferred.

4.1 Annalena's and Naomi's Stage 1; Omission of Onset Fricatives

At the earliest word-stage (until approx.1;5), Annalena and Naomi correctly pronounce word-initial oral stops (3a,b) and nasal stops (4a-c), but not affricates (5a-c) and fricatives (6a,b; in the examples below, N. = Naomi, A. = Annalena):

(3) *initial oral stops are realised as oral stops (97%)*

<table>
<thead>
<tr>
<th>Spelling</th>
<th>Adult form</th>
<th>Child’s output</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Brot</td>
<td>bʁɔ:t</td>
<td>bo: (N. 1;2-1;4.26)</td>
<td>‘bread’</td>
</tr>
<tr>
<td>b. Buch</td>
<td>bu:x</td>
<td>bu: (N. 1;2-1;4.26)</td>
<td>‘book’</td>
</tr>
</tbody>
</table>

Word-initial nasal stops are always realised as such by Annalena and Naomi:

(4) *initial nasal stops are realised as nasal stops (100%)*

<table>
<thead>
<tr>
<th>Spelling</th>
<th>Adult form</th>
<th>Child’s output</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Mülleimer</td>
<td>'mʏl̩̊ɛmɐ̃</td>
<td>'mʏmɐ (N. 1;5.01)</td>
<td>‘wastebasket’</td>
</tr>
<tr>
<td>b. nein</td>
<td>nam</td>
<td>naɪ (N. 1;5.01)</td>
<td>‘no’</td>
</tr>
<tr>
<td>c. milch</td>
<td>ml̩̊ʃ</td>
<td>mič (A. 1;5.01)</td>
<td>‘milk’</td>
</tr>
</tbody>
</table>

All initial affricates in adult speech are simplified in child speech and they are realised as a stop:

(5) *initial affricates are simplified (100%)*

<table>
<thead>
<tr>
<th>Spelling</th>
<th>Adult form</th>
<th>Child’s output</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. zu</td>
<td>t̩u:</td>
<td>tu (N. 1;2-1;3)</td>
<td>‘closed’</td>
</tr>
<tr>
<td>b. Ziege</td>
<td>t̩iːɡo</td>
<td>tiːɔ (N. 1;5.01)</td>
<td>‘goat’</td>
</tr>
<tr>
<td>c. Zaun</td>
<td>t̩aʊn</td>
<td>dain (A. 1;6.27)</td>
<td>‘gate’</td>
</tr>
</tbody>
</table>

At the earliest acquisition stage, word-initial fricatives are not produced. At this stage in the development of Naomi’s speech, six word-initial fricatives in our corpus are omitted and two word-initial fricatives are realised as an oral stop:
(6) *initial fricatives are omitted (75%) or realised as a stop (25%)*

a. sauber  'zaubər 'abər (N. 1;2-1;5.01) ‘clean’
b. Wasser  'vase  'dəsə (N. 1;04.26) ‘water’

A similar phenomenon can be found in Annalena’s early speech production. She also omits initial fricatives at the earliest stage:

(7) a. satt   zat    atʰ (A. 1;2.19) ‘satisfied’
b. Wagen  'vagən aka (A. 1;2.16) ‘car’

Elsen (1991) reports that Annalena sometimes realises a glottal stop before a stressed vowel from age 1;3.29. It is striking that the adult form *satt* [zat] ‘satisfied’ is realised as [atʰ] at 1;2.19 and not as [ʔatʰ]. Thus, the fricatives in (7a,b) are not replaced by another segment and these examples constitute real cases of fricative omission.

Onset-fricative deletion in early child speech has also been observed, for instance, by Fikkert (1994a,b) for Dutch (8a,b), by Costa & Freitas (1998) for Portuguese (8c,d) and by Velten (1943) and Menn (1971) for English (see 9a-d).

(8) *initial fricative omission in Dutch and Portuguese child speech*

a. fiets   fi:ts   i:s (Jarmo 1;9.09) ‘bicycle’
b. schaap  sχap a:p (Jarmo 1;7.15) ‘sheep’
c. zebra   'zebrə 'ebə (Luís 1;9.29) ‘zebra’
d. vēs    veʃ eʃ/ɪʃ/ɛʃ (Marta 1;2.0) ‘see’

(9) *initial fricative omission in English child speech*

a. Fuff af (Joan 1;2) cat's name
b. woof uf (Joan 1;3)
c. shoes uz (Daniel 1;10-2;1)
d. fish ɪʃ (Daniel 1;4-2;1)

The fact that initial fricatives are omitted rather than replaced by another consonant in German, Dutch, Portuguese, and English child speech is unexpected under Fikkert’s assumption that the first words in child speech have a CV-structure. We furthermore point out that omission of initial fricatives and the realisation of a consonant somewhere else in the word (e.g. in final position) are related. Whenever an onset fricative is not realised, a coda consonant is. We find a similar phenomenon in monosyllabic words which lack an initial consonant in adult...
speech. In the next section, it is demonstrated that in such cases, a coda consonant is also obligatorily realised in early child speech.

4.1.1 Stage 1: No Insertion of Initial Consonants

It is a striking feature in Annalena's and Naomi's early speech that a word-final consonant is not realised in words with an initial stop or nasal, whereas it is always realised when the adult form does not have a word-initial consonant:

(10) **final consonant is omitted when the adult form has an initial stop or nasal consonant**

<table>
<thead>
<tr>
<th>Spelling</th>
<th>Adult form</th>
<th>Child’s output</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Ball</td>
<td>bal</td>
<td>ba (N. 1;2-1;5.01)</td>
<td>‘ball’</td>
</tr>
<tr>
<td>b. Bein</td>
<td>bam</td>
<td>ba₁ (A. 1;4.22)</td>
<td>‘leg’</td>
</tr>
<tr>
<td>c. Milch</td>
<td>milç</td>
<td>mi: (N. 1;2)</td>
<td>‘milk’</td>
</tr>
</tbody>
</table>

(11) **no consonant is inserted when the adult form does not have a word-initial consonant (100%) and another consonant in the word is realised instead**

| a. ab    | ap         | apʰ (N. 1;4.26)   | ‘off’ |
| b. ab    | ap         | apʰ (A. 1;2.15-1;5.30) | ‘off’ |
| c. auf   | af         | (N. 1;3)          | ‘on’  |
| d. Eimer | ‘aːmə’     | ‘aːmə’ (N. 1;5.01) | ‘bucket’ |

Both Naomi and Annalena omit word-final consonants, unless the target word lacks an initial consonant or has an initial fricative. We think this is an important generalisation that a theory of language acquisition has to account for.

Our findings so far indicate that (i) onsets are not obligatory in early child speech, (ii) a coda consonant is realised in child speech iff a word lacks an onset due to initial-fricative deletion (see 6a, 7a,b, 8a-d, 9a-d), or to the absence of an initial consonant in adult speech (see 11a-d), and (iii) each word has at least one vowel and one consonant at the earliest stage of acquisition.

The next stage in the development of onsets is characterised by the fact that Annalena and Naomi begin to substitute initial fricatives by stops.
4.2 Stage 2: Substitution of Onset Fricatives by Stops

From approximately 1;5.02 to 1;7.01, Naomi replaces initial fricatives mostly by oral stops (see 12a-c). The option to omit initial fricatives is still there (see 12d), but this reflects the earlier stage discussed in 4.1. Furthermore, we occasionally find that fricatives are replaced by approximants at this stage (see 12e).

(12) Stage 2: initial fricatives are omitted (11%), realised as plosives (78%), or realised as continuants (11%)
   a. Sonne 'zɔnə 'duːjeː (N. 1;5.21) ‘sun’
   b. fertig 'fɛɾtʃ 'daːtʃ (N. 1;5.15 - 1;7.02) ‘ready’
   c. Frau 'frau 'bau (N. 1;6.05 -1;6.12) ‘woman’
   d. Fisch fis tɕ (N. 1;6.19) ‘fish’
   e. Frau 'frau 'wau⁶ (N. 1;6.05 -1;6.12) ‘woman’

Fricative substitution in child speech is a well-observed phenomenon in other languages too. The following examples from Fikkert (1994a) and Velten (1943) illustrate this phenomenon for Dutch and English, respectively.

(13) a. fiets fiːʦ tiːʦ (Jarmo 2;0.4) ‘bicycle’
    b. vogel 'voːxɛl 'toːχɔ (Jarmo 2;0.4) ‘bird’
    c. vinegar bidu (Joan 1;3)

In a strident fricative plus stop cluster as in Stuhl [ʃtuːl] ‘chair’, or a strident fricative plus nasal cluster as in schmeißen [ʃmaɪsən] ‘throw’, Annalena and Naomi select the non-strident consonant, i.e., these words are pronounced as [ˈtuːə] (N. 1;5.08) and [ˈmaɪçި] (N. 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 (C₁) of a branching onset. We believe that the child ignores the strident fricative in the appendix in (2), because she wants to start a word with a non-continuant segment (see section 5.3). For this reason, strident fricatives which precede oral and nasal stops are always omitted at this stage and the child only realises the first non-continuant consonant. These extra-syllabic strident fricatives are not included in the examples in this paper and they are not included in the percentages that we present for onset fricatives.
4.3 Stage 3: Substitution of Onset Fricatives by Stops and Continuants

In Naomi's development of onsets, there is a clear turning point with respect to the realisation of fricatives from 1;7.02. From that age onwards, Naomi substitutes initial fricatives as often by oral stops as by continuants (approximants or fricatives):

(14) Stage 3: initial fricatives are realised as stops (48%), approximants (47%), or fricatives (5%)

a. sauber 'zaubə 'daubə (N. 1;8.21) 'clean'
b. sauber 'zaubə 'jaubə (N. 1;8.21) 'clean'
c. fertig 'fɛ̃t̪ɪç 'datɪç (N. 1;7.27) 'ready'
d. fertig 'fɛ̃t̪ɪç 'jatɪç (N. 1;7.16) 'ready'
e. Seite 'zaɪtə 'daitə (N. 1;7.16-1;8.04) 'page'
f. sehen ze:n de:n (N. 1;7.09-1;7.27) 'see'
g. sehen ze:n şe:n (N. 1;7.09) 'see'

In word-initial strident + stop and strident + nasal clusters, Naomi realises the non-strident consonant only, e.g., stimmt is realised as [tint] (1;7.27), and schmutzig is realised as [mUtśiC] (1;8.21). As pointed out in section 4.2, we believe that in these cases, the child uses the option to realise the word in question with the non-continuant consonant, rather than with the absolute initial consonant. We do not consider these cases as instances of fricative substitution and we ignore them here.

With respect to the acquisition of onsets, two interesting problems arise for an OT-analysis. Optimality Theory (Prince & Smolensky 1993, McCarthy & Prince 1995) assumes that the unmarked syllable structure emerges through the interactions of two constraints, viz. ONSET -which requires that syllables have onsets- and NoCoda -which says that syllables should not have codas. These constraints account for the fact that languages favour a CV-structure and the prevailing view is that these constraints are high-ranked in child speech. Under this assumption, it is surprising that we find vowel-initial syllables at the earliest acquisition stage in Naomi's speech (see 6a, 11a,c,d), in Annalena's speech (7a,b, 11b), and at the earliest stage in the speech of Portuguese children (8c,d). We will address this problem in the following sections.
5. The Presence of Consonants and Vowels in German Child Speech

Contrary to Fikkert's (1994a,b) findings for Dutch, but in accordance with the findings of Costa & Freitas (1998) for Portuguese, we find that German children realise words without initial consonants at the earliest word-stage. Final consonants are only realised by Annalena and Naomi if there is no initial consonant and no word consists of a vowel only. Thus, at the initial stage, their speech 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 principles:

(15) a. **CONSONANT:** Every word contains at least one phase which is characterised by oral closure (i.e., every word has at least one consonantal constriction in the oral tract).

b. **VOWEL:** Every word contains at least one phase which is characterised by maximal oral release for vowels.

The account for consonant and vowel sequences in Annalena's and Naomi's speech that we would like to present here is cast in an optimality-theoretic framework. From this point onward, we will refer to (15a) as a markedness constraint which we will call **CONS** and we refer to (15b) as a markedness constraint which we will call **VOWEL**. The faithfulness constraints in (16a,b) below demand that any output form has as many segments as the input form.

(16) 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 epentheses)

We will attribute the fact that segments which are present in adult forms and are missing in the child's output to constraints which prohibit structure. In particular, we suggest that the markedness constraints below (based on Prince & Smolensky 1993 and McCarthy & Prince 1995) which prohibit consonantal and vocalic places of articulation play a significant role:
Tesar & Smolensky (1993, 1998), Hayes (to appear), and others show that the acquisition of the adult phonology involves the step-by-step demotion of one constraint below another constraint. With this assumption in mind, we now have to offer an explanation for (i) the lack of codas in early child speech when an onset is present and (ii) the presence of codas when there is no onset.

Tesar & Smolensky’s proposal concerning the acquisition of a grammar involves that a constraint which is violated by the optimal candidate is demoted to the next highest possible stratum in the hierarchy, i.e., immediately below the constraint which is responsible for the fact that a non-optimal output candidate loses. Since Annalena and Naomi do not violate the constraint CONS in vowel-initial words, we conclude that all constraints which militate against the realisation of a consonant (e.g., *COR, *LAB) have been demoted to stratum immediately below the constraint which is violated by losing candidates without a consonant or with an epenthetic consonant in the onset, i.e. immediately below the constraints CONS and DEP-IO. Moreover, these children always realise at least one vowel in a word and, hence, they do not violate VOWEL. We conclude from this that a constraint militating against the realisation of a vowel (here *V-PLACE) is demoted to a stratum immediately below VOWEL (see the constraint-rankings in 18, 19, 20).

With respect to the lack of an onset in the German words in (6a), (7a,b), and (11a-d), and in the English words in (9a-d), we point out that a word should contain at least one consonant. Note that the glottal stop [?] is not a German phoneme (see figure 1) and neither is it a phoneme in English. There are no minimal pairs involving a glottal stop in these languages. When a stressed syllable does not have an underlying onset, a glottal stop is inserted in German adult speech (see e.g. Wiese 1996). The data collected by us as well as data from the Elsen (1991) corpus indicate that German learning children do not use a glottal stop at the earliest acquisition stage. The same observation is made by Bernhardt & Stemberger (1998: 370-375) for English learning children, i.e., English children do not insert a glottal stop with vowel-initial words, and neither do they insert one when an onset consonant is deleted. Based on the observation that in earliest child speech we do not find epenthesis of a glottal stop, we assume that in child grammar DEP-IO is ranked higher than ONSET. Finally, basing ourselves on the observation that most codas are

(17) a. *LAB Have no Labial C-Place feature
b. *COR Have no Coronal C-Place feature
c. *DORS Have no Dorsal C-Place feature
d. *V-PLACE Have no V-Place feature
not realised in child speech, we assume that the markedness constraint NoCODA is ranked higher than the faithfulness constraint MAX-IO.

Grijzenhout (2000) observes that if a high-ranked markedness constraint forces the child to violate a faithfulness constraint, it is more common that we find deletion of a segment in child speech (which incurs MAX-IO-violations) than insertion of a segment (which would incur Dep-IO violations). For instance, in the case of complex onsets, children prefer to realise only one of the consonants to inserting a vowel between the two consonants (see, e.g., 3a). This observation supports our conclusion that Dep-IO must be high-ranked and MAX-IO must be low-ranked in early child speech (cf. the ranking in tableaux 18, 19, 20).

In the tableau below for the word ab ‘off’, candidates (18a,c,d) each have more violations of highly ranked constraints than candidate (18b) which is selected as the optimal one, even though it violates Onset as well as NoCODA. A dotted vertical line between two constraints indicates that the constraints are not ranked with respect to each other and a straight line means that the constraints to the left of that line are higher ranked than the constraints to the right of that line. The pointing finger marks the optimal candidate and *! marks the fatal constraint violation.8

<table>
<thead>
<tr>
<th></th>
<th>CONS</th>
<th>VOWEL</th>
<th>Dep-IO</th>
<th>*Lab</th>
<th>*V-Place</th>
<th>Onset</th>
<th>No CODA</th>
<th>MAX-IO</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>*!</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>?a</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

Monosyllabic words which consist of a vowel without a preceding or a following consonant do not occur in Annalena’s and Naomi’s speech at the earliest 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 that the child produces has one consonant and one vowel which may be in a VC-sequence, the constraints that we called CONS and Vowel are ranked higher than Onset. At the right edge of monosyllabic vowel-initial words, Annalena and Naomi do not delete the final consonant, so that at least one consonant is present in all their output forms. From this, we conclude that NoCODA is ranked below CONS. Thus, assuming Tesar & Smolensky’s theory of minimal constraint demotion, we propose that the constraints against consonantal place features, the constraint against vowel place features, as well as Onset and NoCODA are minimally demoted in the constraint hierarchy. This set-up will give us
the correct output candidates for Annalena's and Naomi's speech at stage 1, which is also illustrated by the two tableaux below:

(19) Input /an/; Child’s optimal output [an] at stage 1

<table>
<thead>
<tr>
<th></th>
<th>CONS</th>
<th>VOWEL</th>
<th>DEP-IO</th>
<th>*COR</th>
<th>*LAB</th>
<th>*V-PLACE</th>
<th>ONSET</th>
<th>No Coda</th>
<th>MAX-IO</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>
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</tr>
<tr>
<td>b.</td>
<td>n</td>
<td>*!</td>
<td>*</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>c.</td>
<td>an</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>?an</td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(20) Input /bal/ (or /ba:n/); Child’s optimal output [ba] at stage 1

<table>
<thead>
<tr>
<th></th>
<th>CONS</th>
<th>VOWEL</th>
<th>DEP-IO</th>
<th>*COR</th>
<th>*LAB</th>
<th>*V-PLACE</th>
<th>ONSET</th>
<th>No Coda</th>
<th>MAX-IO</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>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>b</td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>c.</td>
<td>al</td>
<td></td>
<td>*</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>
<td>*</td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>bal</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Elsen (1991) reports 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. Her pronunciation for ab is [ʔapʰ] from 1;5.30 (she loses word-final aspiration after 1;7.30, see Goad 1998 for discussion of this phenomenon). Based on positive evidence (i.e. adult words with an epenthetic glottal stop), the constraint DEP-IO is demoted below ONSET in Annalena’s grammar at stage 2 (i.e., under that ranking [ʔan] and [ʔap] are optimal outputs for /an/ and /ab/, respectively). For Naomi, demotion of DEP-IO has not taken place before 1;8.21.

To summarise, our data do not support Fikkert’s (1994a) thesis that the first words in child speech have a CV-structure. In OT-terms, we need constraints which say that a consonant and a vowel are minimal requirements for words. When these constraints are ranked higher than ONSET, vowel-initial words with a consonant in another position within the word may emerge.
5.2 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 and forms without onsets. For instance, Jarmo realises /a:p/ ‘monkey’ as [a:p] and [ta:pi] at 1;7.15. Free variation is also found in the production of onsets by two other children at a relatively early age.

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 and two other children. 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. In our view, this account fails for German, because it misses the generalisation that 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 9a-c versus 10a-d).

In Grijzenhout & Joppen (to appear) it is argued that the variation observed for some Dutch children between onsetless words and words with an epenthetic consonant in onset position can be attributed to the indecisive ranking of the constraints DEP-IO and ONSET at what Fikkert refers to as their "stage ii" in the acquisition of onsets. These constraints are ranked with respect to each other next, i.e. at the stage where a consonant is no longer inserted to provide onsets in the speech of Jarmo and two other children, ONSET is minimally demoted to a position in the hierarchy where it is dominated by the constraint DEP-IO.

The process of reranking constraints is to a certain extent subject to variation. The prediction, therefore, is that other children may demote another constraint, for instance DEP-IO instead of ONSET, so that for them, at a certain stage, the optimal output for /a:p/ is [ta:]. We note 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.

In Fikkert's analysis of the acquisition of Dutch, the basic assumption is that a child who acquires a language tries to produce the "unmarked" CV-syllable. With Bernhardt & Stemberger (1998) and Costa & Freitas (1998), we believe that V-initial syllables are as unmarked as CV-syllables in child grammar. 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 constraint.
The question is whether this markedness constraint always plays the most important role at the initial stage of acquisition of every language. We propose that, at least in Dutch, German, English, and Portuguese, the effect of a parameter or a constraint referring to the onset diminishes at an early stage in the acquisition of phonology. In OT-terms, this means that children determine relatively early that other constraints are ranked higher than ONSET. 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 from child to child, but it is always triggered by positive evidence only.

In sections 5.1 and 5.2, we suggested a more prominent role in the acquisition of phonology for the contrast between consonants and vowels. Each word in German and Dutch child language is characterised by a phase of consonantal closure in the oral tract and a phase of vocalic release and children set the corresponding parameters first (or, in OT-terms, they do not demote the corresponding constraints CONS and VOWEL at this stage).

As we showed in tableaux (18) and (19) above, the demotion of ONSET and NOCODA below other constraints accounts for the fact that Annalena and Naomi realise the final consonant in monosyllabic words like ab and an. At this stage, final consonants are not realised in words like Ball and Bahn and this is accounted for by the same constraint ranking (see 20).

So far, we have not answered the question why onset fricatives are not realised as such in early child speech. This is the topic of the next section.

5.3 The Acquisition of Onset Fricatives; Recursive Demotion

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

Naomi does not realise word-initial fricatives as such. Sometimes, single initial fricatives are not realised at all (21a,b). Most often, they are replaced by an oral stop11 (22a-e), and they are occasionally replaced by another continuant at a relatively late stage (23a-c).

(21) a. sauber  'zaubɐ  'aubɐ  (1;4.26 - 1;6.12)  ‘clean’
    b. Fisch  fiʃ  iç  (1;6.19)  ‘fish’
(22) a. Sonne  'zɔnə  'du:je: (1;5.21)  ‘sun’
b. Schuhe  'ʃuə  'tu:a (1;6.12-1;7.09)  ‘shoe’
c. Saft  zaft  dat (1;7.27)  ‘juice’
d. fertig  'fɛʁtʃɛ̃  'datʃɛ̃ (1;5.15 - 1;7.02)  ‘ready’
e. Fisch  fiʃ  biʃ (1;7.02)  ‘fish’

(23) a. Salz  zalt  ja:ltɛ (1;7.16)  ‘salt’
b. sehen  ze:n  je:n (1;7.27)  ‘see’
c. fertig  'fɛʁtʃɛ̃  'jatʃɛ (1;7.16)  ‘ready’

The different realisations of initial fricatives at different stages are summarised below. We can detect a clear development, i.e., first, initial fricatives are omitted, then they are mostly replaced by a stop and, subsequently, initial fricatives are as often replaced by a stop as by a continuant consonant:

(24) *Naomi’s realisations of initial fricatives:*

<table>
<thead>
<tr>
<th></th>
<th>stop</th>
<th>continuant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>6 (75%)</td>
<td>2 (25%)</td>
</tr>
<tr>
<td>Stage 2</td>
<td>7 (11%)</td>
<td>47 (78%)</td>
</tr>
<tr>
<td>Stage 3</td>
<td></td>
<td>58 (48%)</td>
</tr>
</tbody>
</table>

Children favour an oral stop in onset position, i.e. the best onset is a consonant which is [-continuant]. Syllable-initial fricatives are avoided in early German, Dutch, English and Portuguese child speech. To capture this generalisation, we propose the following constraint which says that every word should start with a non-continuant consonant:

(25) *INITIAL MANNER: Word([-cont])*

The feature [-continuant] is a consonantal feature and the constraint above says that if a word begins with a consonant, it is a [-continuant] consonant: The constraint is satisfied in words which begin with oral and nasal stops and it is vacuous in words which do not begin with a consonant (see 26). It is violated in adult words that begin with an approximant, a fricative, or a glottal stop. To explain the fact the children produce forms which are less marked than adult forms, it is often assumed that in the initial stage of language acquisition, constraints against markedness outrank faithfulness constraints (e.g. Gnanadesikan 1996). With respect to constraints involving manner of articulation, this assumption implies that the markedness constraint `Word([-cont])` should outrank the faithfulness constraint IDENT.
at the earliest acquisition stage. Candidates in (26) which violate the constraint \( \text{word([-cont])} \) always lose (26b,c). The constraint \( \text{word([-cont])} \) is vacuous in the winning candidate (26a). Furthermore, a candidate that satisfies this constraint but violates the constraint which says that a segment in the input should have identical specifications for features as a corresponding segment in the output (\( \text{IDENT [cont]} \)) also loses at this stage (26d), which suggests that this identity constraint outranks \( \text{MAX-IO} \):\(^{13}\)

(26) Input /zaub\H{a}/; Child’s optimal output [aba] at stage 1\(^{14}\)

<table>
<thead>
<tr>
<th></th>
<th>( *\text{COR} )</th>
<th>( *\text{LAB} )</th>
<th>( \text{WORD([-cont])} )</th>
<th>( \text{ONSET} )</th>
<th>( \text{IDENT [cont]} )</th>
<th>( \text{MAX-IO} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. aba</td>
<td>( \ast )</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b. jaba</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c. zaba</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>d. daba</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td>*</td>
<td>!</td>
</tr>
</tbody>
</table>

The next stage is characterised by the fact that Naomi replaces an initial fricative by a voiced coronal stop. We suggest that the change from Naomi’s stage 1 to stage 2 may be attributed to the minimal demotion of the constraint \( *\text{COR} \), i.e., this constraint is minimally demoted to a stratum below the constraints \( \text{ONSET} \) and \( \text{WORD([-cont])} \), as illustrated in the next tableau:

(27) Input /zaub\H{a}/; Child’s optimal output [daba] at stage 2

<table>
<thead>
<tr>
<th></th>
<th>( *\text{LAB} )</th>
<th>( \text{WORD([-cont])} )</th>
<th>( \text{ONSET} )</th>
<th>( *\text{COR} )</th>
<th>( \text{IDENT [cont]} )</th>
<th>( \text{MAX-IO} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. aba</td>
<td>*</td>
<td>!</td>
<td>*</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. jaba</td>
<td>*</td>
<td>!</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c. zaba</td>
<td>*</td>
<td>!</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>d. daba</td>
<td>*</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

It is striking that voiceless initial fricatives are mostly replaced by a voiced stop. We believe that this is not an accident. At this stage in the acquisition of German, Annalena and Naomi hardly ever use a voiceless stop in word-initial position, but voiced stops are abundant:

(28) a. Papa \('[\text{papa}]'\) \('\text{bapa}'\ (N. 1;5:01) \( \text{‘daddy’} \)
b. Puppe \('[\text{pup\H{e}}]'\) \('\text{but\H{r}}'\ (N. 1;5:21) \( \text{‘doll’} \)
c. kaputt \('[\text{ka\'put}]'\) \('\text{but\H{r}}'\ (N. 1;6:05) \( \text{‘broken} \)
Voicing in word-initial position is a common phenomenon in child language. It is, for instance, also attested in Dutch child language and in English (see Smith 1973, Velten 1943, and example 29 from Menn 1971):

(29)  tea  \(\text{di}\)  \(\text{(Daniel -2;0)}\)

Annalena and Naomi have developed a strong tendency to conform to the following system with respect to obstruents. They favour voiced plosives in word-initial position and voiceless plosives or fricatives in coda position. To capture the fact that Annalena and Naomi - as well as Dutch and English children - prefer to have voicing at the left word edge, we propose a constraint which says that every word should start with a voiced consonant:

(30)  **INITIAL VOICING**:  \(\text{Word}([+\text{voice}])\).

This constraint helps to explain that in child language, the best output for a word which has an initial obstruent in the adult form is a word which has an initial voiced obstruent. At the right word edge, Annalena and Naomi realise fricatives from an early age. The constraints formulated in (25) and (30) crucially refer to the left word edge and, hence, there is no constraint that would exclude word-final voiceless stops and fricatives.

(31)  **Input**  \(\text{fertig} \, ['f\text{\'e\text{\'e\text{\'i\text{\'c}}}]\)  \(\text{'ready'}\); **Child's optimal output**  \(\text{[\text{\'d\text{\'a\text{\'t\text{\'i\text{\'c}}}]}]}\)  \(\text{(stage 2)}\)

<table>
<thead>
<tr>
<th></th>
<th>(\text{Word}([-\text{cont}]))</th>
<th>(\text{ONSET})</th>
<th>(\text{Word}([+\text{voice}]))</th>
<th>(\text{IDENT CONT})</th>
<th>(\text{IDENT VOICE})</th>
<th>(\text{MAX-IO})</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.  atič</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.  jatič</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c.  fatič</td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>d.  (\varphi)  datič</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>e.  tåtč</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

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

(32)  a.  sehen  \(\text{['ze:n]}\)  \(\text{de:n, he:n, je:n (1;7.27)}\)  \(\text{‘to see’}\)

     b.  fertig  \(\text{['f\text{\'e\text{\'e\text{\'i\text{\'c}}}]}}\)  \(\text{‘jatč, ‘datč (1;7.16-27)}\)  \(\text{‘ready’}\)

Basing herself on the evidence that German allows word-initial continuants, the child is "forced" to demote constraint (25). Since constraint demotion is minimal,
her first attempt to demote this constraint is such that it arrives at the stratum where
it is equally ranked with IDENT([cont]) (stage 3). Under this ranking, candidates with
a voiced continuant are as optimal as candidates with a voiced stop (see 33). Next,
the constraint in question is demoted further, i.e. to a position where it is dominated
by IDENT([cont]) and this stage characterises the stage in which initial fricatives are
no longer replaced by a stop (stage 4).

(33) Input *fertig* /'fɛ̂t̪i̯t̪/: Child's optimal outputs ['datiç] and ['jatiç]](stage 3)

<table>
<thead>
<tr>
<th></th>
<th>ONSET</th>
<th>w_\text{word}([+\text{voice}])</th>
<th>w_\text{word}([-\text{cont}])</th>
<th>IDENT CONT</th>
<th>IDENT VOICE</th>
<th>MAX-IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>atiç</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>jatiç</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c.</td>
<td>fatiç</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>datiç</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

To explain the fact that initial obstruents are eventually faithful to their input
specification for voicing, we assume that not only the INITIAL MANNER constraint in
(25) is demoted below IDENT[cont], but the INITIAL VOICING constraint in (30) is
demoted below IDENT[voice] as well at stage 4:

(34) Input *fertig* /'fɛ̂t̪i̯t̪/: Child's optimal outputs ['fatiç] (stage 4)

<table>
<thead>
<tr>
<th></th>
<th>ONSET</th>
<th>IDENT CONT</th>
<th>IDENT VOICE</th>
<th>w_\text{word}([-\text{cont}])</th>
<th>w_\text{word}([+\text{voice}])</th>
<th>MAX-IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>atiç</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>jatiç</td>
<td></td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>fatiç</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>datiç</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
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</tbody>
</table>

In this section, we hope to have shown that the developmental stages in the
acquisition of initial fricatives can be accounted for by means of constraint
demotion. Three stages in the development of onset fricatives can be distinguished
in Naomi’s speech. Fricatives are:
1) omitted (accounted for here by high-ranked markedness constraints at stage 1)
2) replaced by a voiced coronal stop (accounted for here by minimal demotion of
*COR below ONSET at stage 2).
3) replaced by a voiced stop or a voiced continuant (accounted for here by
minimal demotion of INITIAL MANNER at stage 3).
4) faithfully realised as a fricative (accounted for here by further minimal demotion of Initial Manner and Initial Voicing to a stratum lower than the respective Identity Constraints at stage 4).

It is noteworthy that in our corpus there is not a single instance of a complex onset. Naomi does not realise more than one consonant in onset position before 1,8.21. The question is why it takes relatively long for complex onsets to emerge. We here suggest that the answer may be that, under the assumption that initially, markedness constraints are high-ranked, the markedness constraint in question (NoComplexOnset) has to be demoted to a very low stratum. If our assumption that the faithfulness constraint Max-IO is ranked lower than other faithfulness constraints is correct, the prediction that follows from this assumption is that demotion of markedness constraints to a position below those faithfulness constraints precedes demotion of markedness constraints below Max-IO.

The effect of markedness constraints can be suppressed once they are ranked below the respective faithfulness constraints. For instance, a word-initial fricative is faithfully realised as a continuant once the markedness constraint Word([-cont] is demoted to a position where it is ranked equally high or lower than Ident(CONT). For complex onsets to emerge, the markedness constraint NoComplexOnset has to be demoted to a position lower than Max-IO. Since the faithfulness constraint Max-IO is ranked very low at the initial stage, the correct prediction is that demotion of NoComplexOnset takes longer that the demotion of markedness constraints which have to be demoted below a position of relatively high-ranked faithfulness constraints.

Children show variation in the stages of acquisition, but not all variation is possible. For instance, no German child acquires voiced codas and no child acquires CCV syllables before CV syllables. We account for this observation as follows: (i) constraint demotion takes place on the basis of positive evidence only, hence, a constraint which says that word-final obstruents are voiceless will never be demoted to a position below Ident(voice) in the constraint ranking for German and (ii) constraint demotion is minimal and for this reason, it may take longer to acquire the correct ranking for markedness constraints which in the adult language are ranked below a relatively low-ranked faithfulness constraint.

6. Conclusion

The first step in the acquisition of German phonology is the acquisition of the contrast between oral closure and vocalic release. In Annalena's and Naomi's
speech, early words 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. There is no stage which might be characterised as "avoid onsetless words" in Annalena's and Naomi's development of onsets and in this paper we question the standard assumption that a CV-sequence is the unmarked syllable in child speech. 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 a contrast between a consonant and a vowel.

In the earliest stage of production, initial fricatives are omitted in the majority of cases. At a later stage, Annalena and Naomi no longer omit initial fricatives, but realise them as a voiced oral stop. We concluded that this development may be attributed to the fact that realising an onset consonant when there is one in the adult form has become more important than being faithful to the underlying specification for place of articulation, continuancy, and voicing, i.e. at this stage, *COR, IDENT[cont] and IDENT[voice] are dominated by ONSET.

At the third stage of the acquisition of onsets that we considered in this study, Naomi realises initial fricatives as a voiced stop or an approximant. We concluded that at this stage, a constraint which says that a word should start with a non-continuant is ranked as high 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.

References


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1 In Grijzenhout & Joppen (1999), we discuss the early acquisition of rhyme structure.
2 In most German dialects, /R/ is a uvular vibrant prevocally and it is vocalised postvocally, e.g., Rutsche ‘slide’ is pronounced ['Rʊtə] and Uhr ‘clock, watch’ is pronounced [uːɐ] (Trubetzkoy 1939/1969).
3 Syllable boundaries are indicated by a dot.
4 Primary stress is indicated by ‘ before the stressed syllable.
5 These words have an initial glottal stop in the adult pronunciation when stressed (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, e.g., she pronounces an ‘at’ with a glottal stop from 1:3.29. 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].
6 We assume that the approximant reflects the initial fricative in this case. In a plosive–sonorant cluster, Naomi also selects the first consonant for production, e.g., Brot [bʁoːt] ‘bread’ is realised by her as [boː] (1:2.06-1:4.26) and later as [boːtʰ] (1:7.27).
7 These principles can also be called parameters (default value: ‘yes’) or constraints.
8 Studies on infant perception have shown that children know the phoneme inventory of their native language and that they are sensitive to word boundaries before they begin to produce words. We tentatively assume that the child’s input representations match the adult input representations.
9 At a later stage, the child assumes a 'minimally and maximally binary rhyme', (see Fikkert 1994a,b), i.e. /baːn/ → [baː] (1:5.01), then *COR is demoted, so that /baːn/ → [ban] (1:6.12), and
finally the markedness constraint on rhymes is demoted and the most faithful parse [ba:n] wins (see Grijzenhout & Joppen to appear).

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. 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. This may be attributed to the fact that for them, the constraint DEP-IO is ranked higher than ONSET and they must learn to rerank them when they acquire the grammar for German.

11 In the majority of cases, the stop in question is voiced (33 instances), less frequently, it is voiceless (7 instances), and once initial /z/ is realised as /n/ by Naomi.

12 A glottal stop is not characterised by closure in the oral tract and is therefore specified as [+cont].

13 In 5.1 we argued that MAX-IO is a low-ranked constraint in child grammar and the data presented in this section support this assumption.

14 In the tableaux in this section, we do not consider candidates such as [vaba] for (26) which would lose, because they violate IDENT([C-PLACE]).