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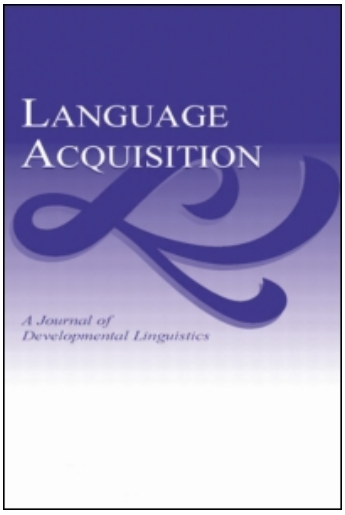

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The Acquisition of Syllable Types

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The Acquisition of Syllable Types

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In this article, we present an account of developmental data regarding the acquisition of syllable types. The data come from a longitudinal corpus of phonetically transcribed speech of 12 children acquiring Dutch as their first language. A developmental order of acquisition of syllable types was deduced by aligning the syllabified data on a Guttman scale. This order could be analyzed as following from an initial ranking and subsequent rerankings in the grammar of the structural constraints ONSET, NO-CODA, *COMPLEX-O, and *COMPLEX-C; some local conjunctions of these constraints; and a faithfulness constraint FAITH. The syllable type frequencies in the speech surrounding the language learner are also considered. An interesting correlation is found between the frequencies and the order of development of the different syllable types.

1. INTRODUCTION

The introduction of Optimality Theory (OT; McCarthy and Prince (1993), Prince and Smolensky (1993)) has given a new impulse to the study of phonological acquisition. By its nature, the work on phonological acquisition has almost always been output based, and the positing of constraints on child outputs formed part of most of the accounts of child language phenomena. Furthermore, child language is in general less marked than the language that has to be acquired (Jakobson (1941/1968), Stampe (1969)). Markedness plays a major role in OT, in which a grammar consists of a hierarchy of interacting constraints on the output, which require either un-

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marked output structures or faithfulness to the underlying representation. It is no surprise, then, that linguists have started to explore phonological acquisition within the framework of OT.

Lately, several interesting findings have been reported. For example, Gnanadesikan (1995) showed that in child language—like in adult language—a constraint that is no longer dominantly present is not shut off, but can still affect the shape of outputs. This effect, referred to as "the emergence of the unmarked," is one of the hallmarks of OT (McCarthy and Prince (1994)). Pater (1997) showed the same thing by comparing child English to adult English: A constraint that is dominant in child English, but outranked in adult English, can still have an effect in the adult language under certain circumstances. Work like this clearly shows the merits of OT as a theory of acquisition, and it justifies further research in this framework. Pater furthermore presented a case in which developmental change is captured by a reranking of constraints. In this article, our main focus is on this latter aspect: development as reranking of constraints.

An OT account is presented of developmental data regarding the acquisition of Dutch syllable structure. Although it is well known that there are initial limitations on syllables, there is hardly any work available on the acquisition of the structure of syllables. An exception is the thorough investigation of the acquisition of syllable structure by Fikkert (1994). She separately studied the development of onsets and the development of rhymes in the data of children acquiring Dutch as their first language. For onsets, she found that, initially, onsets are obligatory; then onsets are optional; and finally, complex onsets appear in the data. For rhymes, she found that initially they only consist of vowels, then coda consonants are allowed, and finally consonant clusters appear. A parametric account of these findings was presented. What we do not get to know, among other things, is how the developments in the onset and the developments in the rhyme line up. For example, are onsets still obligatory when codas appear? In this article, we investigate how the syllable as a whole develops, using the same data that formed the basis of Fikkert's study—namely, the Fikkert–Levelt corpus of child language (Fikkert (1994), Levelt (1994)).

We start out from the idea that the initial state of an OT grammar can be characterized as one in which all structural constraints outrank all faithfulness constraints (Demuth (1995), Gnanadesikan (1995), Levelt (1995), van Oostendorp (1995)). We find that structural constraints that refer to syllable structure, like ONSET, NO-CODA, and *COMPLEX, initially outrank faithfulness constraints, leading to CV syllables as the only possible outputs of the grammar. In the course of acquisition, more marked structures show up in the child's output, and this can be seen as a consequence of subsequent rerankings, in which faithfulness constraints come to outrank the syllable structure constraints one by one. Whether this happens by the promotion of faithfulness constraints or by the demotion of structural constraints (or both; see Boersma (1999)) is left open. At this point, we also do not know how the acquisition of the ranking of the syllable structure constraints

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among themselves proceeds. However, we show that these constraints are not simply shut off, but that they still have some effect in adult Dutch.

The remainder of the article is organized as follows. In section 2, we discuss the materials and methods that formed the basis of this study. In section 3, we turn to the results of our method of studying the data—the Guttman scales. Then, in section 4, we present an OT account of the order of acquisition that we deduced from the Guttman scales. We also discuss the use of conjoined constraints and the effect of the syllable structure constraints in adult Dutch. In section 5, an answer is provided to the question of why the learners of Dutch have the specific order of acquisition that was found, based on a correlation between the order of acquisition of syllable types and the frequency distribution of these syllable types in speech. Finally, the main points of the article are summarized in section 6.

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2. MATERIALS AND METHODS

The developmental data are from 12 children acquiring Dutch as their first language. These data were collected by Fikkert (1994) and Levelt (1994). The children ranged in age from 1;0 to 1;11 years at the outset of the data-collecting period. Spontaneous speech data were collected every other week over a period of 6 to 13 months. The corpus contains approximately 20,000 utterances and can be found in CHILDES as the CLPF corpus.

All the spontaneously produced utterances of this corpus formed the input to a computerized syllabification algorithm developed by Schiller (Schiller, Meyer, Baayen, and Levelt (1996)). The syllabification program applied was based on the Sonority Sequencing Generalization (Selkirk (1984)) and Onset Maximization (Hoard (1971), Kahn (1976), Selkirk (1982)). The token frequencies of the resulting syllable types were calculated, and then the syllable structures—in terms of sequences of C(consonant) and V(vowel)—were determined. For this study, we focused on the development of primary stressed syllables in words, be they monosyllabic, bisyllabic, or multisyllabic. We furthermore concentrated on syllables respecting the Sonority Sequencing Principle. That is, we discarded surface syllables containing extrasyllabic material, such as appendixes of coronal consonants, like /st/ in *herfst* ‘autumn’, or s- clusters, like *stout* ‘naughty’, or *fiets* ‘bicycle’. Finally, we treated structures with long and short vowels as one type; for example, CV and CVV were treated as a single type because of Fikkert’s (1994) finding that vowel length is initially not distinctive. This leaves us with the following syllable types, in terms of Cs and Vs: CV, VC, V, CVC, CCVC, CCV, CVCC, VCC, and CCVCC.

The data come from children of different ages, who are at different stages of development even if they do have the same age. To check whether it was actually possible to compare the data of these 12 children with respect to syllabic development, we attempted to align the data on a Guttman scale for syllable type. The Guttman scaling is a procedure for obtaining an order and for seeing to what ex-

tent an order is followed (Torgerson (1963)). It is a standard procedure in social research, but it can be applied to linguistic data too (see Barton (1976)). It turned out that the data could indeed be aligned quite nicely, and it could thus be concluded that the data fitted a particular order.

3. RESULTS

Figure 1 shows the Guttman scale for all the primary stressed syllables found in utterances from the initial recordings of all the children. Syllable types are arranged from left to right, whereas participants are arranged from top to bottom. A plus indicates that a participant has produced the syllable type at least twice in the period under consideration, whereas an empty box indicates that the syllable type has not been found in the data or at most once. The rows and columns are arranged in such a way that a line can be drawn from top left to bottom right, which captures as many of the pluses as possible. The fewer pluses appear to the right of the line, and the fewer empty boxes to the left of the line, the better the fit is. As can be seen, the fit is close to perfect.

From this scale it can be hypothesized that initially only one syllable type is available to the language learner, namely CV. This is the universally least marked syllable type, the core syllable, and it is therefore not surprising that it is the first syllable type to be acquired. The scale further suggests a general developmental order for the types CV (1), CVC (2), V (3), VC (4), CVCC (5), VCC (6), CCV (7), CCVC (8), and CCVCC (9).

	cv	cvc	v	vc	cvcc	vcc	ccv	ccvc	ccvcc
Noortje	+								
Jarmo	+	+							
Tom	+	+	+						
Robin	+	+	+	+					
Leonie	+	+	+	+					
Elke	+	+	+	+					
Eva	+	+	+	+					
Tirza	+	+	+	+					
David	+	+	+	+	+				
Catootje	+	+	+	+	+	+	+		
Enzo	+	+	+	+	+		+	+	
Leon	+	+	+	+	+	+	+	+	

FIGURE 1 Guttman scale of syllable types from initial recording sessions.

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	cv	cvc	v	vc	cvcc	vcc	ccv	ccvc	ccvcc
Noortje	+	+	+	+					
Jarmo	+	+	+	+					
Tom	+	+	+	+					
Robin	+	+	+	+					
Leonie	+	+	+	+					
Elke	+	+	+	+					
Eva	+	+	+	+	+				
Tirza	+	+	+	+	+	+			
David	+	+	+	+	+	+	+	+	
Catootje	+	+	+	+	+	+	+	+	
Leon	+	+	+	+	+	+	+	+	
Enzo	+	+	+	+	+		+	+	+

FIGURE 2 Guttman scale of syllable types from the first three recording sessions.

Figure 2 shows the Guttman scale for all primary stressed syllables from the first 6 recordings. We see that, compared to the initial point of measurement, more pluses have appeared. The first four syllable types, CV, CVC, V, and VC, have now been acquired by all children, and two more participants have ventured into the acquisition of complex codas.

Figure 3 shows the Guttman scale for syllable types from the first 15 recordings. It now turns out that in order for the data to keep fitting the order, we need to split the participants into two groups. The participants in Group A follow the order of acquisition as established by the previous Guttman scales. The participants in Group B follow the same order for the types CV (1), CVC (2), V (3), and VC (4). Unlike the participants in Group A, however, who then go on to acquire syllables with complex codas, the participants in Group B first acquire syllable types with complex onsets. The type CCVCC remains the last type to be acquired for both groups. Compared to the previous scales, some of the participants have changed position. This just indicates that some participants have been acquiring syllable types at a higher rate as compared to other participants.

Figure 4 shows the Guttman scale for all the recordings of all children.[1] The order of the children has changed again, but like before, this just indicates a difference in the rate of development. There are only few empty boxes left now, neatly

[1]The data were scaled cumulatively to avoid gaps in a scale due to the accidental absence of some acquired syllable type in single recordings. The cutoff points in Figures 2 through 4 were determined by both the distribution through the recordings and the developments that were revealed at these points.

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Group A

	cv	cvc	v	vc	cvcc	vcc	ccv	ccvc	ccvcc
Eva	+	+	+	+	+	+			
Noortje	+	+	+	+	+	+			
Robin	+	+	+	+	+	+			
Leonie	+	+	+	+	+	+	+	+	
Tirza	+	+	+	+	+	+	+	+	
David	+	+	+	+	+	+	+	+	+
Catootje	+	+	+	+	+	+	+	+	+
Leon	+	+	+	+	+	+	+	+	+
Enzo	+	+	+	+	+	+	+	+	+

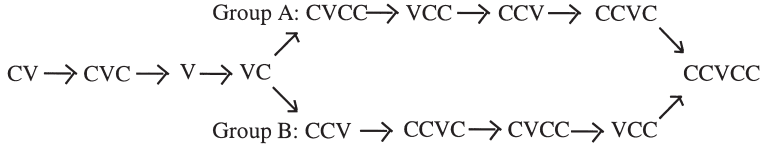
Group B

	cv	cvc	v	vc	ccv	ccvc	cvcc	vcc	ccvcc
Jarmo	+	+	+	+	+				
Elke	+	+	+	+	+	+			
Tom	+	+	+	+	+	+			

FIGURE 3 Guttman scale of syllable types from the first six recording sessions.

to the right of the line. In sum, from the scales the following steps in the order of acquisition of syllable types can be deduced, in which an arrow means "is acquired before."

(1) Steps in the development of syllable types:



We start out by treating the order that came out of the Guttman scaling procedure as a sequence of genuine developmental stages and account for each of them.

4. AN OT ANALYSIS

An OT grammar consists of a set of universal, violable constraints on output representations, ranked in a language-specific way. There are two sets of constraints: faithfulness constraint, which demand that the input and output are identical to

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Group A

	cv	cvc	v	vc	cvcc	vcc	ccv	ccvc	ccvcc
Eva	+	+	+	+	+	+			
Noortje	+	+	+	+	+	+			
Robin	+	+	+	+	+	+	+	+	
Leonie	+	+	+	+	+	+	+	+	
Tirza	+	+	+	+	+	+	+	+	
David	+	+	+	+	+	+	+	+	+
Catootje	+	+	+	+	+	+	+	+	+
Leon	+	+	+	+	+	+	+	+	+
Enzo	+	+	+	+	+	+	+	+	+

Group B

	cv	cvc	v	vc	ccv	ccvc	cvcc	vcc	ccvcc
Jarmo	+	+	+	+	+	+			
Tom	+	+	+	+	+	+			
Elke	+	+	+	+	+	+	+	+	

FIGURE 4 Guttman scale of syllable types from all recording sessions.

each other, and structural constraints, which demand that output representations are unmarked. Constraints are usually in conflict: To be unmarked in one way, a candidate is sometimes marked in another way, just as being faithful to an input representation will often entail that a candidate is structurally marked. The other way around, a candidate can be unfaithful to its input in order to be structurally unmarked in some way. Constraints will thus often be violated. Depending on the language, violations of some constraints are regarded to be worse than violations of some other constraints, and this is expressed by the constraint ranking. The ranking of constraints is thus language specific. An input receives a set of possible linguistic analyses, called *output candidates*. These candidates are evaluated against the constraint hierarchy. The output candidate that is best evaluated is the one which least violates the hierarchy of constraints, and this winning candidate will form the actual output.

As mentioned previously, child language is often unmarked compared to the language being learned. In OT, this can be expressed by assuming that constraints come with an initial ranking in which structural constraints are ranked higher than faithfulness constraints (Demuth (1995), Gnanadesikan (1995), Levelt (1995), Tesar and Smolensky (1996)). Outputs of language learners will thus be structurally unmarked, often at the cost of being faithful to the input. The input is assumed

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to be close to the adult output representation. One thing language learners need to acquire, then, is in what respects the language they are acquiring can be structurally marked (i.e., where in the constraint hierarchy faithfulness constraints outrank structural constraints). This can be achieved by comparing the language surrounding them to their own language output. The acquisition process can thus be seen in terms of constraint reranking, in which constraints will be reranked in the hierarchy in such a way that faithfulness constraints will end up outranking structural constraints. Consequently, productions that start out being mostly unmarked and often unfaithful to the input can become more marked and more faithful in the course of acquisition. Reranking will stop when the learners no longer detect differences between their own output and the language surrounding them (Tesar and Smolensky (1996)).

There is a small set of well-known constraints on syllable structure in OT, and these are listed next (Prince and Smolensky (1993)):

ONSET	Syllables should have an onset
NO-CODA	Syllables should not have a coda
*COMPLEX	Syllables should not have complex onsets or codas

These structural constraints interact with faithfulness constraints of the type MAX, militating against deletions, and DEP, militating against insertions. In this article, we are not interested in the exact way learners cope with inputs that cannot satisfy high-ranked structural constraints (e.g., by inserting vowels and thereby violating DEP, or by deleting consonants and thereby violating MAX). Rather, our interest is in the syllable types that appear in the output. Hence, we simply refer to faithfulness as a single constraint, FAITH.

FAITH	Inputs and outputs should correspond to each other

With these constraints, at most four of the deduced nine developmental stages are predicted: (1) CV > (2) CVC > (3) V, VC, > (4) CCV, VCC, CCVC, CVCC, CCVCC, CCCV, CVCCC. We first discuss a four-step developmental grammar. We then refine the grammar by splitting up the *COMPLEX constraint into *COMPLEX-ONSET and *COMPLEX-CODA. Finally, we discuss whether further refinement by means of local conjunction of constraints (Smolensky (1993)) is advantageous.

4.1. Stage I: CV

It was assumed that in the initial state structural constraints would outrank faithfulness constraints. Concentrating on the constraints referring to syllable structure, this means that ONSET, NO-CODA, and *COMPLEX are all ranked above (>>)

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FAITH. At this point we do not know whether the structural constraints are ranked with respect to each other, so we assume no ranking (indicated by commas). The initial (partial) hierarchy is then as in (2):

(2) Initial state of the grammar
ONSET, NO-CODA, *COMPLEX >> FAITH

In the following tableaux, the consequences of this ranking for outputs are shown. Constraints are arranged from left (highest ranked constraint) to right (lowest ranked constraint), and potential linguistic analyses (i.e., output candidates) are arranged on the vertical axis. Asterisks denote violations, and an asterisk with an exclamation mark denotes a fatal violation. Dotted lines indicate no ranking between constraints. Shading is just a typographical aid to reading the tableaux: The shaded areas are not relevant for the comparison between candidates. The pointing finger indicates the winning candidate.

(3) Input: CVC

	*COMPLEX	ONSET	NO-CODA	FAITH
CVC			*!	
V		*!		**
☞CV				*

(4) Input: V

	*COMPLEX	ONSET	NO-CODA	FAITH
V		*!	*	
VC		*!	*	*
☞CV				*

(5) Input: CCVC

	*COMPLEX	ONSET	NO-CODA	FAITH
CCVC	*!		*	
CVC			*!	*
☞CV				**

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As can be seen in (3), (4) and (5), no matter what the input is, the output will always be CV in this initial state of the grammar. Such an initial state could indeed be deduced from the Guttman scale. CV syllables are the first acquired syllables, and only later do other types appear. It has already been mentioned that this is not a surprising finding. The CV syllable is the universal core syllable: All languages have such a syllable, and some languages allow only syllables of this type. Moreover, there are no languages that allow only V, or CVC or CCV, and so forth, or that specifically exclude CV (Blevins (1995)). In OT this is predicted: It is impossible to describe such languages with the current set of constraints (cf. chapter 6 of Prince and Smolensky (1993)). Example (6) has data that illustrate this initial CV stage:

(6) CV outputs

		input	output
a. poes	'cat'	/pus/	[pu]
b. klaar	'finished'	/klar/	[ka]
c. auto	'car'	/oto/	[toto]
d. apie	'monkey'	/api/	[tapi]

(Jarmo, 1;5,2)

In (6a) and (6b) the coda from the input does not appear in the output. In (6b), in addition, the onset cluster is reduced to a single consonant, and in (6c) and (6d) an onset is added. These outputs thus all violate faithfulness to satisfy the structural constraints ONSET, NO-CODA, and *COMPLEX.

4.2. Stage II: CV and CVC

In the second stage, CVC syllables appear in the output next to CV syllables. Input codas are from now on faithfully rendered in the output,[2] and this means that a reranking has taken place in the grammar: FAITH now dominates NO-CODA.

(7) Second state of the grammar
ONSET, *COMPLEX >> FAITH >> NO-CODA

We assume that the domination relations in the ranking change only minimally when a reranking takes place. FAITH is now ranked above NO-CODA, but the domination relation between the other constraints and FAITH does not change, so FAITH will not be equally ranked with ONSET and *COMPLEX after the reranking.

[2]In general, syllable types are produced as correctly as possible. As soon as CVC is acquired, reductions to CV of an input CVC are no longer encountered, unless segmental issues interfere. As long as certain types of segments are problematic to the learner, reduced outputs can occur.

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(8) Input: CVC

	*COMPLEX	ONSET	FAITH	NO-CODA
☞CVC				*
V		*!	**	
CV			*!	

(9) Input: VC

	*COMPLEX	ONSET	FAITH	NO-CODA
VC		*!		*
☞CVC			*	*
CV			**!	

(10) Input: CVCC

	*COMPLEX	ONSET	FAITH	NO-CODA
CVCC	*!			**
☞CVC			*	*
CV			**!	

In (8), (9), and (10), it is shown that in this stage input codas also appear in the output, unless they are complex. Complex codas no longer totally disappear from the output, however, but are reduced to a single consonant. Due to the fact that FAITH is now more important in the grammar than NO-CODA, violations against FAITH are counted heavier against a candidate than violations against NO-CODA. With respect to onsets, nothing has changed; they are still obligatorily present in the output. In (11), this stage is illustrated:

(11) CVC outputs

		input	output	
a. poes	'cat'	/pus/	[pus]	(Jarmo, 1;7,29)
b. schaap	'sheep'	/sxap/	[hap]	(Jarmo, 1;7,15)
c. dicht	'closed'	/dɪxt/	[dɪs]	(Elke, 1;10,21)
d. aap	'monkey'	/ap/	[pap]	(Leonie, 1;9,15)

In (11a) the word *poes* 'cat', which was formerly rendered [pu], is now a faithful [pus] in the output. In (11b), too, the coda appears in the output. The complex

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onset is reduced because *COMPLEX is still ranked above FAITH. The complex coda in (11c) is also reduced, but a single coda consonant does appear in the output. This form illustrates the fact that optimal outputs can only minimally violate the constraint ranking: an output [dɪ] for input /dɪxt/, with no coda consonants at all, would also satisfy *COMPLEX. However, this constraint is already satisfied with one violation of FAITH. Due to the fact that NO-CODA is now ranked below FAITH, extra violations of FAITH to serve satisfaction of NO-CODA are no longer necessary and now work against such output candidates. In (11d), finally, it is shown that onsets are still obligatorily present in the output: An onset consonant is added in the output.

An important prediction of OT is that dominated constraints do not disappear from the grammar. The presence of a dominated constraint, under certain circumstances, can still be felt. However, the effect of NO-CODA in adult Dutch is only minimal. A trace of a NO-CODA effect could be the general nonproduction of coda /n/ in case it follows a schwa in the plural, perfective and infinitive forms of the verb, and in the plural of nouns:

(12) NO-CODA in Dutch

a. lopen	'to walk'	/lopən/	[lopə]
b. honden	'dogs'	/hɔndən/	[hɔndə]

This /n/ does show up in cases in which an enclitic like *het* /ət/ 'it', or *hem* /əm/ 'him', is attached to the plural verb, as in the examples in (13). In the input, then, /n/ is present and ONSET forces /n/ to show up in the output:

(13) Coda in input

a. we weten het	'we know'	/və vetənət/	[və vetənət]
b. we zagen hem	'we saw him'	/və zaxən əm/	[və zaxənəm]

4.3. Stage III: V and VC

In the next stage, onsetless syllables appear in the data. The grammar has evolved again: FAITH now dominates ONSET. Only *COMPLEX still dominates FAITH at this point:

(14) Third stage of the grammar

*COMPLEX >> FAITH >> ONSET >> NO-CODA

Again, the domination relations are changed minimally: The relation between FAITH and ONSET has changed, but not the relation between ONSET and NO-CODA, which remains ONSET >> NO-CODA.

Apart from syllables containing consonant clusters, all onsetless syllables and syllables with codas are predicted to be faithfully rendered in the output now.

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(15) Input: VC

	*COMPLEX	FAITH	ONSET	NO-CODA
☞VC			*	*
CVC		*!		*
CV		*!*		

The input syllable VC, which would become CV in Stage I, and CVC in Stage II can now finally appear as VC in the output. This is illustrated in (16):

(16) V and VC outputs

		input	output	
a. auto	'car'	/oto/	[oto]	(Jarmo, 1;6,13)
b. aap	'monkey'	/ap/	[ap]	(Jarmo, 1;7,15)

In adult Dutch, the constraint ONSET does still have a clear effect on outputs—namely, in the syllabification of words, both derived and underived. Within the domain of syllabification, which for Dutch is the Prosodic Word, we find the following syllabifications (syllable boundaries are indicated by dots):

(17) ONSET in Dutch

Underived words

a. erker	/ɛrkər/	'bay window'	.ɛr.kər *.ɛrk.ər.
b. balkon	/bɑlkɔn/	'balcony'	.bɑl.kɔn. *.bɑlk.ɔn.

Derived words: one prosodic word.

c. werker	/wɛrk-ər/	'worker'	.wɛr.kər. *wɛrk.ər
d. handig	/hɑnd-əx/	'handy'	.hɑn.dəx *.hɑnt.əx.

Although the sequences /rk/, /lk/, and /nt/ in (17) are well-formed coda clusters in Dutch, a syllabification is preferred whereby the second syllable starts with an onset. In (17c,d) it is shown that such a syllabification is even preferred when the stems in the derived words end in such clusters. The edges of the morphemes /wɛrk/, /hɑnd/, /ər/, and /əx/ do not coincide with the edges of the syllables /wɛr/ and /kər/ of *werker* 'worker' or /hɑn/ and /dəx/ of *handig* 'handy'. In the grammar of Dutch, ONSET thus outranks an alignment constraint, ALIGN-MORPH-L, which requires the alignment of the left edge of a morpheme and the left edge of a syllable. At Prosodic Word boundaries, however, ONSET is violated, meaning that ALIGN-PRWD-L, which requires alignment of the left edge of a Prosodic Word and the left edge of a syllable, must outrank ONSET. This is shown in (18):

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(18) No onset at Prosodic Word boundaries: ALIGN-PRWD-L >> ONSET

a. aarde	/ardə/	'earth'	.ar.də.	
b. oor	/or/	'ear'	.or.	
c. roodachtig	/rod-ɑxtəx/	'reddish'	.rot.ɑx.təx.	*.ro.dɑx.təx.
d. bankoverval	/bɑŋk-ovərvɑl/	'bank-robbery'	.bɑŋk.ovər.vɑl	*.bɑŋ.ko.vər.vɑl.

4.4. Stage IV: All Syllable Types

As a final step, FAITH dominates *COMPLEX too, which entails that inputs with complex onsets, codas, or both are rendered as such in the output.

(19) Input: CCVC

	FAITH	*COMPLEX	ONSET	NO-CODA
☞CCVC		*		*
CVC	*!			*
CV	*!*			

(20) Input: CVCC

	FAITH	*COMPLEX	ONSET	NO-CODA
☞CVCC		*		*
CVC	*!			*
CV	*!*			

From now on it will always be the most faithful output candidate, in terms of syllabic structure, that will be the winning candidate.[3]

The data in (21) illustrate the possibility to have complex onsets or codas in the output:

(21) CCVC or CVCC outputs

		input	output	
a. klaar	'ready'	/klar/	[kʀa]	(Jarmo, 1;8,12)
b. drinken	'drink'	/drɪŋke/	[tlɪŋke]	(Jarmo, 2;4,1)
c. bank	'couch'	/bɑŋk/	[pɑŋk]	(Noortje, 2;6,5)
d. mond	'mouth'	/mɔnt/	[mɔnt]	(Noortje, 2;6,5)

[3]We should add, again, that other constraints can interfere with these syllabic constraints so that, for instance, some but not all types of clusters are allowed.

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Some remaining effects of *COMPLEX in the grammar of Dutch are shown in section 4.5, after a modification of this constraint.

The evolving grammar we have presented so far captures in broad outlines the developmental picture that was deduced from the Guttman scales. However, some aspects of the syllabic development need a more detailed analysis, most obviously the development of syllables with consonant clusters. If we interpret the Guttman scale in a deterministic way, then every step on the scale represents a developmental stage. So far we paired the nine deduced developmental stages with four grammatical stages. To pair every developmental stage with a grammatical stage, we can extend the grammar in two ways: splitting up the constraint *COMPLEX and invoking local conjunctions of constraints.

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4.5. *COMPLEX

The first refinement in the grammar is to split up *COMPLEX into *COMPLEX-O(NSET) and *COMPLEX-C(ODA). This appears to be necessary not only to describe the developmental data, but also to characterize languages in general. Some languages allow complex onsets but not complex codas (Spanish, Sedang), whereas other languages allow complex codas but not complex onsets (Finnish, Klamath; Blevins (1995)). There does not appear to be an implicational or markedness relation between having complex onsets and having complex codas. Independently, this same move of splitting up *COMPLEX has been made by Kager (1999).

For the children of Group A, who appeared to acquire syllables with complex codas before syllables with complex onsets, the grammar then changes from the third stage, in (14), to the final stage in the following way:

(22) Acquisition of complex codas first (Group A)
Third stage: *COMPLEX-C, *COMPLEX-O >> FAITH >> ONSET >> NO-CODA
Fourth stage: *COMPLEX-O >> FAITH >> *COMPLEX-C >> ONSET >> NO-CODA
Final stage: FAITH >> *COMPLEX-O >> *COMPLEX-C >> ONSET >> NO-CODA

For Group B, we deduced that a complex onset was acquired first, so for this group *COMPLEX-O is outranked by FAITH first, followed by *COMPLEX-C:

(23) Acquisition of complex onsets first (Group B)
Third stage: *COMPLEX-C, *COMPLEX-O >> FAITH >> ONSET >> NO-CODA
Fourth stage: *COMPLEX-C >> FAITH >> *COMPLEX-O >> ONSET >> NO-CODA
Final stage: FAITH >> *COMPLEX-C >> *COMPLEX-O >> ONSET >> NO-CODA

In adult Dutch there is a whole array of coda clusters that are usually broken up by insertion of a schwa in the output. These clusters consist of a liquid followed by a nonhomorganic nasal or nonhomorganic obstruent. Due to the fact that clusters of a nasal followed by an obstruent are always homorganic, and clusters of a fricative plus a stop are extremely rare, we can generalize and say that nonhomorganic clusters are broken up by a schwa in Dutch:[4]

(24) *COMPLEX-C in Dutch

a.	warm	'warm'	/ʋɑrm/	[ʋɑrəm]
b.	harp	'harp'	/hɑrp/	[hɑrəp]
c.	elf	'eleven'	/ɛlf/	[ɛləf]
d.	melk	'milk'	/mɛlk/	[mɛlək]
e.	wilg	'willow'	/ʋɪlx/	[ʋɪləx]

*COMPLEX-C thus outranks a constraint against the insertion of schwa, DEP-V, in the grammar of Dutch, while being outranked by a constraint against the breaking up of linked structures such as homorganic clusters

For *COMPLEX-O the evidence is scarce in adult Dutch. It is only in emphatic speech that speakers of Standard Dutch will break up an initial cluster, like in (25):

(25) *COMPLEX-O in Dutch

a.	wat een trutten!	/ʋɑt ən trʉtən/	'what a bunch of cows!'	[ˈʋɑtən təˈrʉtə]
b.	klaar!	/klar/	'ready!'	[kəˈlahar]

Also, a presenter of a radio or television program can be caught to say:

(26) prima! /prima/ 'great!' [pəˈrima]

In some variants of Dutch, however, initial obstruent plus liquid clusters are regularly broken up by a schwa. *COMPLEX-O can thus be promoted to an active position in the hierarchy under circumstances such as emphatic speech, and therefore it can be concluded that it has not totally disappeared from the grammar.

4.6. Local Conjunction of Constraints

For a further refinement of the account we turn to the notion of *local conjunction* (Alderete (1997), Ito and Mester (1998), Kirchner (1996), Smolensky (1993)). There are cases in which multiple constraint violations in a local context are

[4]The few words that contain a fricative plus stop cluster, words like *wesp* /wɛsp/ 'wasp' and *rasp* /rɑsp/ 'grater', in production often lead to a transposition of the consonants in the final cluster: [wɛps] and [rɑps]. By this transposition, /s/ is now in an extrasyllabic position, and this way the complex coda has disappeared.

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avoided while the same violations in a nonlocal context are allowed (Booij (1995), Cairns (1988)). Local conjunction is an operation on the constraint set whereby two or more constraints are conjoined to form a derived constraint. This constraint is violated just in case all the conjoined constraints are violated by an output candidate, and it is ranked above the individual constraints it consists of.

It appears that in the developmental data we find exactly such situations. At some point, both complex onsets and complex codas are allowed, but within the local context of a single syllable these marked options cannot be combined. In the constraint ranking, then, there is a constraint that conjoins *COMPLEX-C with *COMPLEX-O, *COMPLEX-O & C, which is ranked above the separate constraints *COMPLEX-O and *COMPLEX-C. At some point in development, FAITH outranks both *COMPLEX-O and *COMPLEX-C but is still dominated by *COMPLEX-O & C. At this point, both CCVC and CVCC syllable outputs are allowed, but not CCVCC:

(27) Local conjunction and the development of complex margins (I)
Prefinal stage (Group A):
*COMPLEX-O & C >> FAITH >> *COMPLEX-O >> *COMPLEX-C >> ONSET >> NO-CODA

Local conjunction of constraints can help us to account for another developmental order as well—namely, that the syllable type VC appears to be acquired later than both V and CVC. Again, two structural constraints are violated within the local context of a single syllable: ONSET and NO-CODA. Conjoining these two constraints and ranking the resulting constraint above ONSET and NO-CODA makes it possible to account for this deduced developmental stage. In this case, FAITH outranks both ONSET and NO-CODA but is still dominated by the conjoined constraint ONSET & NO-CODA (O&NC). In (28), we show how the derived constraint O&NC in the ranking O&NC >> FAITH >> ONSET >> NO-CODA results in a fatal violation for the faithful output candidate VC. The winning candidate for this ranking, CVC, violates NO-CODA but not ONSET.

(28) Input VC

	O&NC	FAITH	ONSET	NO-CODA
VC	*!		*	*
V		*	*!	
☞ CVC		*		*

From the Guttman scales the following derivational steps, repeated from (1), were deduced:

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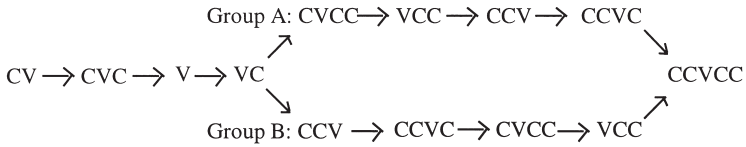
(29) Steps in the development of syllable types



All but two of the developmental steps can now be described. What remains to be explained is why both in Groups A and B the structure CVCC appears to be acquired before VCC and the structure CCV appears to be acquired before CCVC. For this two-step acquisition of structures with either complex onsets or complex codas, we may again consider local conjunction. This time the two doubly marked structures that are initially banned are the types VCC, combining a complex coda with no onset, and CCVC, combining a complex onset with a coda. Conjunctions of the constraints *Complex-O and No-Coda, *Complex-O&NC, and of *Complex-C and Onset, *Complex-C&O capture this. Both groups employ these derived constraints, but they vary in the timing of the reranking of these constraints with respect to Faith. The participants in Group A appear to first allow a syllable with a complex coda but no other marked structure (CVCC) and subsequently the more marked version of a syllable with a complex coda: a complex coda and no onset (VCC). They then turn to the most unmarked version of a syllable type with a complex onset—a complex onset and no coda (CCV)—and finally to another syllable with two marked options, a complex onset and a coda (CCVC). Group B first works out the syllables with complex onsets—initially without other marked characteristics (CCV) and then with (CCVC)—and then turns to syllables with complex codas, again initially without other marked characteristics (CVCC) and then with (VCC):

(30) Local conjunction and the development of complex margins (II)
Stage (5), Group A:
*Complex-O&C, *Complex-C&O, *Complex-C, *Complex-O&NC >> Faith >> *Complex-O >> . . .
Stage (5), Group B:
*Complex-O&C, *Complex-C&O, *Complex-O, *Complex-O&NC >> Faith >> *Complex-C >> . . .
Stage (6), Group A:
*Complex-O&C, *Complex-C&O, *Complex-C >> Faith >> *Complex-O&NC >> *Complex-O >> . . .
Stage (6), Group B:
*Complex-O&C, *Complex-O&NC, *Complex-O >> Faith >> *Complex-C&O >> *Complex-C >> . . .

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Although the conjoined constraints enable us to give a grammatical description of every developmental step deduced from the Guttman scaling procedure, we need to ask ourselves at this point if this result is satisfactory.

Concerning the exact status of local conjunction in the grammar, several questions remain to be answered. Which constraints can be conjoined? The possibilities to conjoin constraints need themselves to be constrained because unrestricted local conjunction is likely to result in excessive descriptive power. Kirchner (1996) tentatively observed that local conjunction could be limited to conjunction of a constraint with itself or with closely related constraints. The constraints conjoined in our analysis are certainly closely related: They all refer to syllable structure. Conjoined constraints are probably already more common than expected. Several well-known contextual structural constraints can be directly translated into conjoined constraints, like *VoicedCoda as *Voice & No-Coda, and *Place]σ as *Place & No-Coda. Also, although local conjunction seems to be powerful machinery, we are able to make testable predictions concerning developmental stages. We do not expect children to acquire syllable structures that are banned by a conjoined constrained before syllable structures that are banned by any of the separate constraints forming the conjoined constraint. So we do not expect, for example, VCC syllables to be acquired before CVCC syllables or CCVC before CCV, although they could be acquired simultaneously. It turns out that this is indeed the case in our data.

However, the conjoined constraints would gain more support if we could come up with more acquisitional or cross-linguistic evidence for their presence in the grammar. Up until now, our evidence for the conjoined constraints consists solely of the fact that certain syllable types are not present in the data at some point. Of course, this could be an artifact of the data. For every conjoined constraint we check whether there is evidence that inputs of the type banned by the conjoined constraint are adapted in the output, while inputs of the types that are banned by the separate constraints appear in the output unchanged.

4.6.1. Onset&No-Coda. In our child language data we do not find any input VC forms that are modified in the child's output, while input V forms are rendered unchanged in the child's output. Our information thus consists solely of the fact that the Guttman scale presents us with a declining line, indicating an order. However, it appears that in the language Central Sentani (Hartzler (1976)) it is precisely the syllable type VC that is absent from the syllable inventory, whereas both CVC and V are present. This language, then, appears to have an active local conjunction of Onset and No-Coda.

*4.6.2. *Complex-O & No-Coda.* We expect to find modified CCVC inputs in the child's output, whereas CCV inputs are produced as such. Some striking

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cases are indeed present in the data, of which a nonexhaustive list is presented in (31):

(31) CCVC versus CCV

			input	output	
a.	groen	'green'	/xrun/	[χun]	(Enzo, 1;11,8)
b.	allemaal groen	'all green'	/ɑləmal xrun/	[ɑˈχrunə]	(Enzo, 1;11,15)
c.	groen	'green'	/xrun/	[xun]	(Enzo, 1;11,15)
d.	dit is groen	'this is green'	/dɪtɪs xrun/	[tɪtɪ χʁu:]	(Enzo, 2;3,14)
e.	groen	'green'	/xrun/	[χun]	(Enzo, 2;3,14)
f.	groen	'green'	/xrun/	[χʁun]	(Enzo, 2;4,11)
g.	bloem	'flower'	/blum/	[χuŋ]	(Tom, 1;5,0)
h.	bloemen	'flowers'	/blumə/	[pjɔmə]	(Tom, 1;5,0)
i.	bloem	'flower'	/blum/	[pum]	(Tom, 1;6,11)
j.	bloem	'flower'	/blum/	[blɔm]	(Tom, 1;7,9)
k.	vlieger	'kite'	/vlixər/	[fliχə]	(Tom, 1;11,27)
l.	vlieg	'fly'	/vlix/	[vˈliχ]	(Tom, 1;11,27)

As can be seen, the same target cluster, often in the same or a similar (32h,i) target word and in the same recording session, is pronounced as a cluster in an open syllable but reduced to a single consonant in a closed syllable. This indicates an active role for the conjoined constraint *COMPLEX-O & NO-CODA.

*4.6.3. *COMPLEX-C & ONSET.* Although there is hardly any material to test whether CVCC is possible, but not VCC (VCC words are rare, and most of them are not likely to be used by 2-year-olds), we do find some promising cases in our data:

(32) CVCC versus VCC

			input	output	
a.	eend	'duck'	/ent/	[In]	(Robin, 1;9,1)
b.	brandweerauto	'fire engine'	/brɑntʋeroto/	[bɑnt]	(Robin, 1;9,1)
c.	eend	'duck'	/ent/	[ent]	(Robin, 1;9,21)
d.	mond	'mouth'	/mɔnt/	[mɔnt]	(Cato, 1;10,11)
e.	hond	'dog'	/hɔnt/	[hɔnt]	(Cato, 1;10,11)
f.	eend	'duck'	/ent/	[en]	(Cato, 1;10,11)
g.	eend	'duck'	/ent/	[int]	(Cato, 1;11,9)

It can be seen in (32) that in the same recording sessions, the target coda-cluster /nt/ is realized by the child in case the syllable starts with an onset, but not when the syllable starts with a vowel. A little later a VCC production becomes possible. This suggests that a conjoined constraint *COMPLEX-C & ONSET is lingering above

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FAITH for some time, whereas both *COMPLEX-C and ONSET are already dominated by FAITH.

*4.6.4. *COMPLEX-O & *COMPLEX-C.* Evidence for this local conjunction is scarce in the data, mainly because of a paucity of targets of the type CCVCC. Only one clear example is available that could illustrate an active role for such a constraint in the construction of outputs:

(34) CCVCC versus CCV(C) and (C)VCC

			input	output	
a.	grond	'floor'	/xrɔnt/	[χɔnt]	(Leon, 1;11,12)
b.	grond vallen	'drop (on) floor'	/xrɔnt vɑlə/	[χlɔn fɑlə]	(Leon, 2;4,3)
c.	daar op grond	'there on floor'	/darɔp xrɔnt/	[darɔp χʁɔnt]	(Leon, 2;4,17)

In sum, for the conjoined constraint ONSET&NO-CODA, cross-linguistic evidence is available in the form of the language Central Sentani, in which the syllable inventory consists of CV, CVC, and V. Furthermore, for both *COMPLEX-O&NO-CODA and *COMPLEX-C&ONSET, promising data is available, pointing to an active role for these conjoined constraints in the grammars of at least some learners in determining the output of either VCC or CCVC inputs. Paucity of CCVCC targets in our data prevented us from finding strong evidence for *COMPLEX-O&*COMPLEX-C as a determining factor in the rendition of CCVCC inputs. Finally, in our data there are no cases in which complex margins are rendered faithfully in VCC, CCVC, or CCVCC productions before they are rendered faithfully in CVCC, CCV, or either CCV(C) or (C)VCC productions. We therefore conclude that the proposed local conjunctions are not simply ad hoc tools to describe a developmental pattern. A general developmental pattern can be accounted for without them, but to describe both individual developmental patterns and specific output patterns of learners in greater detail, they appear to be a sensible addition to the set of syllable structure constraints.

To summarize the OT account, then, the following constraints were employed:

(34) Employed constraints

FAITH	NO-CODA	ONSET & NO-CODA (O&NC)
	ONSET	*COMPLEX-O & NO-CODA (*COMPLEX-O&NC)
	*COMPLEX-O	*COMPLEX-C & ONSET (*COMPLEX-C&O)
	*COMPLEX-C	*COMPLEX O & C

Initially, all structural constraints outranked FAITH, leading to CV outputs only. By subsequent promotions of FAITH, outranking the structural constraints one by one, the different steps in the development of output syllable types could be described. Two different routes were found in the data:

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(35) Developmental steps: FAITH gradually rises in the hierarchy

Group A		Group B	
*COMPLEX O&C	<┐	*COMPLEX O&C	<┐
*COMPLEX O&NC	<┐	*COMPLEX C&O	<┐
*COMPLEX C&O	<┐	*COMPLEX C	<┐
*COMPLEX O	<┐	*COMPLEX O&NC	<┐
*COMPLEX C	<┐	*COMPLEX O	<┐
O & NC	<┐	O & NC	<┐
ONSET	<┐	ONSET	<┐
NO-CODA	<┐	NO-CODA	<┐
	FAITH		FAITH

Furthermore, we showed that the syllable structure constraints that are being dominated in the course of development can still have an effect on the form of the output. In adult Dutch, ONSET is active under domination of, among other constraints, ALIGN-PRWD-L, because it still dominates ALIGN-MORPH-L. The activity of *COMPLEX-C results from it dominating DEP-V. The evidence for NO-CODA in the grammar of Dutch is weaker, but the general nonpronunciation of coda /n/ following a schwa could be analyzed in these terms. Finally, in general *COMPLEX-O is not active in the grammar of Dutch, but because it can be promoted to an active position in the hierarchy under circumstances such as emphatic speech, the conclusion is that it has not totally disappeared. This, then, gives the ultimate support to the idea that acquisition consists of constraint reranking. All or none approaches to acquisition (in which use is made of either disappearing constraints or parameter settings) would have difficulty with the fact that previously present constraints or previous settings of parameters could reemerge under certain circumstances.

One important question still remains. In the data we have found a specific order of development for the syllable types, with a variation at one point: Some learners acquired complex onsets before complex codas, whereas other learners acquired complex codas before complex onsets. The question is whether these are universally the patterns of development, or whether other learning paths are possible too. Given that we assumed that initially the syllable structure constraints are

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TABLE 1
Syllable Structures and Corresponding Proportion of All Syllable Tokens (CELEX Data)

Syllable Type	*Frequency*	*Developmental Order*
CV	36.28	1
CVC	32.44	2
VC	15.06	4
CVCC	5.51	5 (A)/7 (B)
CCVC	3.57	8 (A)/6 (B)
CCV	2.58	6 (A)/5 (B)
V	**1.52**	**3**
VCC	1.03	7 (A)/8 (B)
CCVCC	.97	9

Note. C = consonant; V = vowel.

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unranked with respect to each other,[5] other rerankings with respect to FAITH could have been possible in the course of development. For instance, as a first developmental step in the grammar, FAITH could have been reranked with respect to either ONSET or *COMPLEX-O instead of NO-CODA.[6] These alternative rerankings would lead to either CV and V or CV and CCV outputs, instead of CV and CVC outputs. In the next section, we turn to syllable frequencies for Dutch, because it turns out that there is a close correlation between these frequencies and the specific developmental order of syllable types that was found in our data.

5. SYLLABLE TYPE FREQUENCIES AND DEVELOPMENTAL ORDER

In Schiller et al. (1996), syllable frequencies were computed for Dutch. To compare the syllable types from Schiller et al. with those used in this study, the frequencies found for syllables with long vowels and those with short vowels are added together. The resulting syllable frequencies are given in Table 1.

The order of acquisition corresponds quite closely to the frequency order of the different syllables in Dutch. Variation is found predominantly in the syllable types in which clusters are involved. The real odd man out in the comparison between the lexical frequency data and the order of development is the syllable V,

[5]We concentrate on the simple (i.e., nonconjoined) constraints.

[6]Due to the fact that *COMPLEX-C is in a way dependent on NO-CODA, an initial reranking in which FAITH comes to dominate *COMPLEX-C would not have an effect on outputs.

on the bold-faced line in Table 1. The syllable V has a very low frequency in Dutch, yet it is acquired very early. However, the database used to compute syllable frequencies, CELEX, and hence the frequency data in Table 1, is based on printed texts. Many of the V syllables that regularly appear in spoken language, such as *uh* 'er', are hardly ever printed. More specifically, it could be that in the language surrounding the child, the V syllable type occurs with a much higher frequency than it does in CELEX. A preliminary analysis of child directed speech—data from one caretaker—indeed shows a much higher occurrence of this syllable (J. C. Van de Weijer, personal communication (1997)). In adult-directed speech too—data from the same caretaker—the syllable V occurs with a relatively high frequency. The relative frequencies of the other syllable types do not deviate much from the frequencies found in CELEX. The V syllable is thus very much a speech syllable, occurring in utterances like *O ja?* 'Oh, really?', *O, o* 'Uh, o', *okee* 'Okay', and *au* 'ouch'. The speech syllable frequencies are shown in Table 2; for details of the caretaker speech analysis, see Van de Weijer (1999).

The frequency orderings of child-directed and adult-directed speech in the child's environment are essentially the same in Van de Weijer's (1999) data. They also correspond closely to the developmental ordering in our data. In particular, there is no exceptional position for V syllables. This raises the question as to what causes this close correspondence.

One possibility is that the order of acquisition causes the frequency distribution of the different syllable types in the language. The syllable types acquired early are in one way or another preferred in the language and therefore are more frequent, whereas the syllable types acquired later are less preferred and are therefore less frequent in the language.

Another possibility is that the frequency distribution in the language causes the order of development, but how would this proceed? In a sequel to this study, by

TABLE 2
Speech Syllable Structures and Corresponding Proportions of All Syllable Tokens (Child- and Adult-Directed Speech Data, Corpus Van de Weijer)

Syllable Type	*Child Directed*	*Adult Directed*	*Developmental Order*
CV	42.1	36.2	1
CVC	30.1	31.9	2
VC	11.3	14.3	4
V	3.6	4.3	3
CVCC	3.6	5.0	5 (A)/7 (B)
CCVC	2.9	2.1	8 (A)/6 (B)
CCV	2.0	2.1	6 (A)/5 (B)
VCC	0.4	1.1	7 (A)/8 (B)
CCVCC	0.4	0.6	9

Note. C = consonant; V = vowel.

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Levelt and Van de Vijver (1998), the frequencies are thought to guide the language learner through a series of possible learning paths that link the initial state of the grammar to the final state of the grammar. The learner does not simply copy the frequencies, which would be hard to imagine anyway, but makes use of them in the following way. Every time different rerankings of the grammar are theoretically possible, the learner opts for the reranking that leads to the possibility of producing the most frequent syllable type of the surrounding language, which the previous grammar did not allow for.

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5.1. First Reranking

The first reranking leads to *COMPLEX-C, *COMPLEX-O, ONSET >> FAITH >> NO-CODA. As a first developmental step in the grammar, FAITH outranks NO-CODA. However, FAITH could just as readily have been reranked with respect to either *COMPLEX-O or ONSET. In fact, there are languages that would exactly need either of these rerankings to reach their final state grammar: languages like Cayuvava, which have a syllable inventory consisting of CV and V, and languages like Arabela, with a syllable inventory consisting of CV and CCV (Blevins (1995)). However, Dutch contains all of these types, so why do our Dutch learners rerank FAITH with respect to NO-CODA first? The syllable type CVC has a frequency of 31.1 in the speech corpus and is the most frequent syllable by far after CV (43.4). Moreover, it is far more frequent than both V (3.7) and CCV (1.3). The choice for a grammar allowing for the CVC syllables, instead of choosing a grammar allowing for V or CCV syllables, could thus very well be based on frequency information.

5.2. Second Reranking

The second reranking leads to *COMPLEX-C, *COMPLEX-O >> FAITH >> ONSET >> NO-CODA. FAITH can now be promoted over ONSET, *COMPLEX-C, or *COMPLEX-O. The Dutch learners opt for ONSET, but again, there are languages that would require FAITH to rerank with respect to *COMPLEX-C in order to reach their final state grammar (languages like Klamath with an inventory CV, CVC, and CVCC) or alternatively to rerank with respect to *COMPLEX-O (languages like Sedang with an inventory CV, CVC, and CCV; see Blevins (1995)). The choice of the Dutch learners for onsetless syllables instead of a syllable with a complex margin could again be based on frequency information. Counting up the frequencies of the syllable types that would be possible outputs in the resulting reranked grammars we have V + VC = 15.3, CVCC = 3.2, CCV + CCVC = 3.2. The onsetless syllables V and VC, with a frequency of 15.3, are more frequent than either the type CVCC (3.2) or the types with complex onsets CCV and CCVC (3.2). To allow for these most frequent onsetless syllables in the output, FAITH is promoted over ONSET.

5.3. Third Reranking

The third reranking leads to *COMPLEX-O >> FAITH >> *COMPLEX-C >> ONSET >> NO-CODA (Group A) or *COMPLEX-C >> FAITH >> *COMPLEX-O >> ONSET >> NO-CODA (Group B). FAITH can now be reranked with respect to either *COMPLEX-O or *COMPLEX-C. Languages like Spanish require a ranking in which FAITH outranks *COMPLEX-O but not *COMPLEX-C, whereas languages like Finnish require FAITH to outrank *COMPLEX-C but not *COMPLEX-O. This time we indeed find both options with the Dutch learners. The frequency of the syllable types that would be added to the inventory by reranking FAITH with respect to *COMPLEX-O, CCV, and CCVC is 3.2, whereas the frequency of the types CVCC and VCC, which would be allowed by reranking FAITH with respect to *COMPLEX-C, is 3.6. As can be seen, this difference is small. It thus appears that learners need a certain threshold to notice a frequency difference. Due to the fact that the child-directed speech data available to us come from only one caretaker, and because the frequencies of these syllable types lie so close together, it could also be that the frequencies of these syllable types are balanced differently in different speech environments. Some learners may hear more complex onsets than complex codas and will opt for reranking FAITH with respect to *COMPLEX-O first, whereas for other learners the balance is in favor of complex codas, which will result in reranking FAITH with respect to *COMPLEX-C first. This remains to be studied.

The findings of Levelt and Van de Vijver (1998) thus provide a possible answer to the question posed at the end of section 4. The developmental order which was found in this article is not universal, but language specific. The (OT) grammar provides learners with possible learning paths, linking the initial grammar to the final state grammar, through intermediate grammars. Frequency information can determine the specific route that will be taken by the learner. Different languages require different learning paths. Moreover, it is predicted that learners of languages with similar syllable inventories, but with different frequency distributions of the syllable types, will follow different learning paths.

6. CONCLUSIONS

A developing OT grammar underlies the order of acquisition of syllable structure by children acquiring their first language. In this grammar, structural constraints concerning the structure of syllables initially outrank faithfulness constraints. This leads to rigorously unmarked structure—namely, the syllable CV—as the only possible output of the grammar. By subsequent rerankings of faithfulness with respect to the syllable structure constraints in the grammar, more and more marked structures can appear in the output. The syllable structure constraints do not disappear from the grammar but could be shown to remain active, to a greater or lesser extent, in the adult grammar.

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Although the general course of development can be captured by referring to the syllable structure constraints ONSET, NO-CODA, *COMPLEX-O, and *COMPLEX-C, a more detailed picture can be obtained by making reference to derived constraints, consisting of local conjunctions of two of the syllable structure constraints. Both cross-linguistic and developmental data were provided that suggest a justification of these constraints.

Finally, the question was addressed whether the developmental order found for the Dutch learners represented a universal order of acquisition or whether more developmental routes would be possible. An answer is found in a study by Levelt and Van de Vijver (1998), based on syllable type frequencies in speech, which correlated surprisingly well with the order of development of syllable types. It turns out that this frequency information could very well act as a guide through the possible learning paths provided by the OT grammar.

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