On the Acquisition of Place

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Because I know that time is always time
And place is always and only place
And what is actual is actual only for one time
And only for one place
I rejoice that things are as they are and
I renounce the blessèd face
And renounce the voice
Because I cannot hope to turn again
Consequently I rejoice, having to construct something
Upon which to rejoice

from: T.S. Eliot, 1930, *Ash-Wednesday*

Contents

1 Introduction

> *We're all going on an Expedition," said Christopher Robin as he got up and brushed himself. "Thank you, Pooh." "Going on an Expotition?" said Pooh eagerly. "I don't think I've ever been on one of those. Where are we going to on this Expotition?" "Expedition, silly old Bear. It's got an 'x' in it." "Oh!" said Pooh. "I know." But he didn't really.*
>
> ——— A. A. Milne, *Winnie-the-Pooh*

1.1 Aims of this study

In two reports that appeared independently of each other at the end of the eighties (Koster, van Geert & Bowerman 1988, Spencer 1989) it was pointed out that up to that moment, hardly any attempt had been made to incorporate non-linear phonology in studies of phonological development. Spencer states: "This neglect was all the more bewildering given the way that phonological theory has changed over the past 15 years or so. Analytical techniques have been developed for handling all those phenomena which abound in child language and to which the SPE model was least suited." (p. 14). And the reports are right: in the published literature the choice is limited and, surprisingly, most of the relevant works address phonological disorders. About ten papers make use of 'normal' language acquisition data, among others Menn (1978), one of the earliest autosegmental analyses of child language data; Spencer (1986), a non-linear re-analysis of some of Smith's (1973) data; Iverson & Wheeler (1987) and Stemberger & Stoel-Gammon (1991), non-linear analyses of Consonant Harmony. Outside of mainstream non-linear phonology, Waterson (1987) provides a non-linear analysis, based on Firth's Prosodic Phonology. Except for these works, there are unpublished manuscripts that contain non-linear analyses of child language, e.g. Stemberger & Stoel-Gammon (1989), Ingram (1988), McDonough & Myers (1991). However, thorough investigations are lacking and none of the above mentioned works provides a systematic account of child phonology in current phonological terms, the main interest lying in providing non-linear analyses of singular phenomena like Consonant Harmony. The consequences of such an analysis for the child's phonological system as a whole and the predictions the account makes with regard to the remaining host of child productions that are not instances of some specific phenomenon are in general not considered. The present study, in response to the appeal in Koster, van Geert & Bowerman's report that "[...] the time is ripe for a renewed attack on phonological development" (p. 9), attempts to provide a broader perspective on the issue.

In order to be able to come up with systematic analyses that are both detailed and generally valid, a suitable data corpus is needed. Solid child language data that are specifically apt for use in phonological studies are not easily attainable, however. The CHILDES database (MacWhinney & Snow 1985) contains longitudinal data from a large number of children from different nationalities. However, the transcriptions of these data are not detailed enough for phonological analysis. The majority of the proposals in the above mentioned literature is either based on, often unpublished, diary studies from a single child, or on a small amount of facts from a lot of children. Although detailed studies of one child are indispensable, it is not possible to distinguish individual strategies from general developmental patterns this way. In contrast, in studies by Stemberger & Stoel-Gammon (1989, 1991) data from 51 subjects are included. In this case, however, 33 of them were recorded only once every three months, over a period of nine months (Stoel-Gammon 1985).[1] Given that at the early stages of phonological acquisition events occur in quick succession, the picture of development we get from these data is fairly incomplete. Furthermore, the data that are actually presented in these publications and manuscripts are too limited to work with — sometimes consisting of percentages only (Stemberger & Stoel-Gammon 1989); the data illustrate the various processes, but neither permit alternative analyses nor allow for any insight in the complete phonological system. In short, except for Smith (1973), who faithfully presents all of his data in an appendix to his book, sources are difficult, if not impossible, to consult.

A large corpus of longitudinal child language data has been gathered, which forms the basis of this study. This database also makes a contribution to the availability of cross-linguistic data. Up until now, non-linear analyses have been based on productions from children acquiring English; the corpus investigated in the present study contains longitudinal data of 12 children acquiring Dutch as their first language. The findings presented in this thesis are richly illustrated with this material.

[1] The other data are drawn from the literature and unpublished diaries (Stemberger & Stoel-Gammon 1989, 1991).

1.2 Nature of the study

Traditionally, a distinction has been made between the logical and the developmental problem of language acquisition (Ingram 1989). The logical problem of language acquisition concerns the question how children get from an initial zero state of a grammar of language S_0 to the mature adult grammar of state S_f on the basis of the surrounding language, given that it is endowed with innate principles of Universal Grammar. The assumption is that the mature grammar can be characterized in terms of a series of grammatical parameters that have been set. These parameters are innate, but the child needs to set them on the basis of certain triggers that are supplied by the language it hears (or sees, for that matter). The research topics in this field include questions such as the default setting of the parameters, the order in which the parameters are set, and the kind of data the child needs to consider in order to fix a parameter. In the field of phonological acquisition a study in this framework is Dresher & Kaye (1990).

While the logical problem of language acquisition is theory-based and in principle needs no actual child language material to be solved, the developmental problem of language acquisition emerges from considering actual child language data. Studies of language development, then, focus on the nature of the actual course of language acquisition. Topics in this area are: the children's production strategies, the units in the child's emerging linguistic system, the nature of the child's grammar at a certain stage. In this field a theory is built on the observed characteristics of child language. Most of the studies on phonological acquisition are of this type; usually these are not so much involved with linguistic theory (cf. the majority of articles on phonological development in the *Journal of Child Language*).

There is, of course, a third type of research that lies in between the two extremes. The analyses of child language within the framework of non-linear phonology mentioned above are examples of this approach. Here, linguistic theory forms the basis for accounts of the developments in the actual acquisition process. The present study is of this nature. The analyses of child language presented here are guided by and measured against current phonological theories. Principled accounts are sought that follow from claims made by phonological theory. Finally, the nature of this study is also explorative, the original question being: what will result from the combination of non-linear phonology and child language data. A wealth of research topics manifested itself, not all of which could be addressed in a single thesis (or even two: cf. Fikkert 1994). The investigations reported here are only the beginning.

1.3 Topics in this study

Firstly, in chapter 2, information on the data collection and the organization of the database is presented. The remainder of the present study deals exclusively with aspects of the acquisition of place feature representations in speech production. However, unlike most of the segmentally oriented studies on the acquisition of phonology, we will not be concerned here with the acquisition of the segment inventory of the language. A major topic is the interaction of Place of Articulation features of consonants and vowels during phonological development. It turns out that the data, and with the data the picture of the acquisition of Place, becomes much more insightful when use is made of an organization of place features that allows for direct interaction of vowels and consonants. Both the search for a 'unified set of place features', which recognizes, for instance, the relation between coronal consonants and front vowels, and the question of how dependent or independent vowels and consonants should be in terms of place features, are major topics in segmental phonology. Several 'new' types of place feature organization have been proposed, among others by Clements (1989b, 1991), van der Hulst (1993), Lahiri & Evers (1991) and Hume (1992). In chapter 3, a survey is presented of the history of place features, starting with Jakobson (1938) and ending with Clements & Hume (1993). Specific attention is paid to the reasons for either unifying or segregating the place features of vowels and consonants.

In chapter 4 the actual study of child language starts with a reanalysis of a phenomenon that is considered a pre-eminent child language phenomenon, Consonant Harmony. This process has gained quite some attention in the child language literature, and it has, as one of the very few phenomena in child phonology, been provided with accounts in the framework of non-linear phonology. It will be shown that these accounts are not satisfactory, and that the process should be considered from a different point of view, namely from the perspective of the vowel intervening between the two consonants that were thought to be involved in the process. In this chapter it will become clear that in child language there is overwhelming evidence that vowels and consonants share the same set of place features, and that, in fact, consonant-to-consonant harmony (which ignores the intervening vowel) does not exist.

With this knowledge of the groupings of consonants and vowels in terms of their place of articulation we turn to a different topic in chapter 5. Here a model of the acquisition of a place feature representation is proposed. An interesting picture emerges when it is assumed that consonants and vowels share the same set of place features; it turns out that there is a systematic development of the child's lexical representations, which can be captured in terms of non-segmental units carrying a feature specification, and constraints on output representations.

Up to this point the study has focused exclusively on the representation of Place of Articulation features. In chapter 6 the other aspect of Place, height , will be addressed. In this area too, there have been recent developments in the theory. Clements (1989a), for example, has proposed to replace the familiar features [±high] [±low] with a single feature [±open] in combination with a set of tiers. The question posed in this chapter is how the height dimension of vowels develops, a neglected topic in the field of phonological development. It turns out that it is a complicated topic, since different kinds of influences affect the children's production of vowels, which obscure the phonological development of height.

Chapter 7, finally, contains a summary of the main findings and concluding remarks.

2 The database

Setting-up the data collection was a joint enterprise with Paula Fikkert (see Fikkert 1994). The data were partly collected in Groningen (by Paula Fikkert and an assistant) and partly in Leiden (by myself and an assistant). However, similar methods have been used and the data are stored in a collective database.

Since the original phrasing of the research project was in very general terms, the method of data collection was not directed towards recording any specific types of utterances. The main goal was to make high-quality recordings of spontaneous speech. The advantage of this method has been that both the recordings and the transcriptions have not been biased by any preconceived opinions. The disadvantage, in retrospect, lies in the fact that sometimes crucial information for one account or another turned out to be underrepresented in the database.

2.1 Subjects

The database contains data from twelve children, six boys and six girls. These children all come from middle-class, Dutch-speaking homes. They were recruited via the university newspaper and by announcements pinned up at several day-care centers.[1] The children all appeared to have a normal hearing acuity and normal cognitive and motor development. This assessment is based on intuition and not on quantifiable tests, however. The ages of the children varied between 1;1.14 (one year; one month, fourteen days) and 1;11.8 at the outset of the data-collecting period. The idea behind the selection of children varying in age was to collect a cross-sectional set of data. A year of data collecting would mean that ultimately the phonological developments of one to three year olds would be captured. This idea has partially succeeded; as can be expected, the picture is distorted by the well-

[1] Of the original twelve children, six were recorded in Groningen, and six were recorded in Leiden.

known fact that not all children correlate age and degree of phonological development in the same way.

2.2 Data collection

The data-base contains material that falls under the heading of 'naturalistic longitudinal observations'. From 11 children, data were collected every two weeks — unless circumstances prevented it — for a 7 to 15-month period at the children's homes. One child has been recorded every week for only two months.[2] The recordings were usually made in the presence of a caretaker, although the children appeared to feel completely comfortable with us. Spontaneous speech was elicited mostly by 'reading' picture books, and sometimes while playing. A set of picture books remained constant across subjects and during the whole data-collecting period. These included *Sesamstraat* and a picture dictionary by Richard Scarry.

Both the relatively frequent recordings and the longer period over which the subjects were followed in their phonological development are important aspects of the database. In the course of time, different stages in the way children produced words can be observed, which makes it possible to spot genuine developments in the phonological system. The relatively frequent recording rate can, on the one hand, provide confirmation about the existence of some stage — when evidence for a certain production strategy is found in two or more recordings in a row, for example. On the other hand, given that developments can occur in quick succession, the frequent recordings also guarantees that not too many important changes occurred unnoticed.

Recordings were made using a Sennheiser MD 421N microphone and either a Casio or Sony DAT-recorder. Recordings of the children in Groningen were made on cassette audio tapes during the first two months, using a Sony cassette tape deck and a Sony microphone. The microphone was put in front of the children, which except for the first minute did not distract them at all. A recording session took approximately 25 to 45 minutes, depending on the mood and concentration of the children. In (1) the subjects are listed together with both the ages at which the initial and the final recording were made, and the number of utterances of them in the database.

[2] The data of this child (Leonie) were collected for an earlier study (Levelt 1989) and replaced the data of one of the subjects that originally participated in the recordings in Leiden for the present study.

(1) *Subjects of the present study*

Name	Sex	City	First session	Last session	Nr. of utterances
Enzo	M	Leiden	1;11.8	2;6.11	2088
Robin	M	Leiden	1;4.14	2;4.28	2283
Tirza	F	Leiden	1;6.14	2;6.12	1681
Eva	F	Leiden	1;4.12	1;11.8	895
Catootje	F	Leiden	1;10.12	2;7.4	2210
Leonie	F	Leiden	1;9.15	1;11.18	481
Tom	M	Groningen	1;0.10	2;2.2	1761
Jarmo	M	Groningen	1;4.18	2;4.1	1544
Elke	F	Groningen	1;6.4	2;4.29	1413
Noortje	F	Groningen	1;7.14	2;11.0	1867
Leon	M	Groningen	1;10.1	2;9.2	2566
David	M	Groningen	1;10.25	2;8.19	886[3]

2.3 Transcription of the data

The recorded utterances of the children were phonetically transcribed independently by two people (Levelt/Fikkert and assistant). This procedure was followed both in Leiden and in Groningen. The utterances received a narrow transcription, i.e. detailed phonetic information is provided by the use of diacritics. Initial and secondary stress is marked too. For the phonetic transcriptions the alphabet of the International Phonetic Association (IPA) — as employed for Dutch by Vieregge (1985) and as revised in the report of the Kiel convention (1989) — was used. The phonetic symbols used are listed in the appendix. Subsequently, the transcribers listened to the tapes again together, and compared the transcriptions; in case the two transcriptions of the same utterance differed from each other, an agreement was sought by carefully listening to the utterance again. This joint listening often led to the discovery of more phonetic detail. Also either erroneous interpretations of some utterances, or errors in transcriptions, turned up this way. If no agreement could be reached, the particular utterance was not included in the data-base. In addition, the groups in Leiden and Groningen discussed a subset of each other's transcriptions together to guarantee consistency in the transcription method.

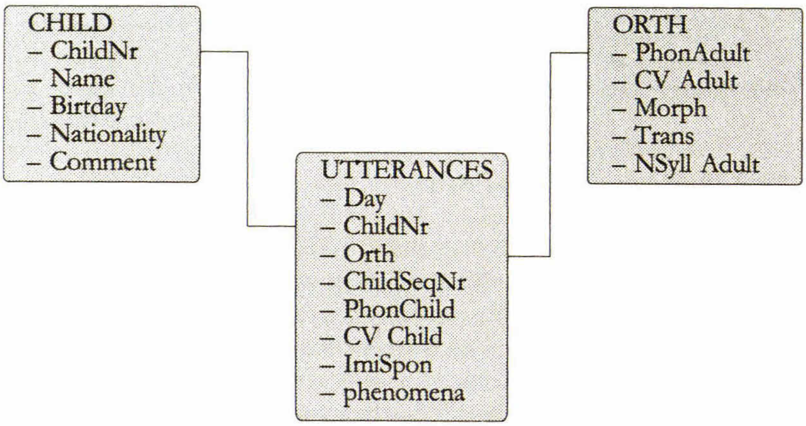
[3] At this point not all the transcriptions of David's utterances have been entered in the database.

2.4 The Database

The data were accommodated in a database called ChildPhon, which was developed at the Max Planck Institute for Psycholinguistics in Nijmegen. The database was devised within the 4th Dimension program for Apple Macintosh.

It contains three independent, though interrelated files: a child file, an adult file and an utterances file. An illustration of the design of the database is in (2):

(2) *Structure of the database*



In the *Child* file, information on the children is stored: name; date of birth; nationality. There is also room for additional comments. The children are automatically numbered.

In the *Adult* file information on the adult forms that are the models for, or the translations of, the child utterances is stored. This file contains a broad phonetic transcription of the form as it could be produced by an adult, next to the orthographic version. The transcriptions are stored in an IPA font (IpaTimes). An English gloss is also provided. Furthermore, there are fields for information on the morphology, the segmental structure and the number of syllables. No morphological information has as yet been included in the database.

The *Utterances* file is linked to the child file by the number of the child, and it is linked to the adult file via the orthographic form of the adult model. Other fields in this file are for: the date of recording; whether it is the first, second, or nth attempt at a particular adult form; the phonetic transcription of the child's production; the segmental structure of the utterance; the number of syllables of the utterance; and whether the utterance was spontaneous or imitated. At a later stage a field was added for 'phenomena'. Since, at the time of putting the data into the database, it was not clear what exactly we were going to explore, any observation that we made in an utterance was provided with a code. Specific codes referred to specific phenomena encountered in the utterances, e.g. assimilations, deletions, additions, substitutions, etc. This coding of the different phenomena made it easy to quickly select a set of data with a particular characteristic.

An example of the output form of the different files in ChildPhon is in (3):

(3) *Example of the output form of files in ChildPhon*

Child file

ChildNr	Name	Birthday	Nationality	Comment
1	Enzo	12/1/87	Dutch	

Adult file

Orth	PhonAdult	CvAdult	Morph	Translation	Nsyll Adult
afbreken toren	ˈɑfˌbʀekə ˈtorə	vcccvvcv cvvcv		down-break tower (break down tower)	5

Utterances file

Day	ChildNr	Orth	ChildSqNr	PhonChild	CvChild	NSyllChil	ImiSpon	phenomena
11/9/89	1	afbreken toren	1	ˈʔɑmʀets̪ ˈt̪oːʁə	vccvvcc cvvcv	4	s	5m, 1m, A
11/9/89	1	afbreken toren	2	ˈʔɑmʀe ˈtoˑʁə	vccvv cvvcv	4	s	5m, 8m, A

ChildPhon has good search facilities, which has been of great value in the organization and analysis of the large amounts of data. At this point, ChildPhon contains approximately 20,000 utterances from 12 children.[4]

[4] ChildPhon will be disclosed for general use in the near future.

2.5 Employment of the data in this thesis

The data used in this thesis are whole utterances. This means that in general single words have not been extracted from longer stretches of speech. The analyses are based on spontaneous utterances, since imitations often reflect the capabilities of the short term memory rather than the state of the child's phonological system.

In the text, child language data appear between square brackets, while broad phonetic transcriptions of the corresponding adult model appear between slashes. In addition, both the orthographic adult form and the English gloss are always provided. An example of how the data are presented is: *vis* 'fish' /ˈvɪs/ [ˈsɪs].

Finally, the data have not been provided with detailed statistical analyses. The generality of a phenomenon studied here has been decided on by simple counting rather than by statistical significance. Percentages are used in the text, but these proportions are always illustrated with the raw numbers.

3 An overview of the history of place feature representations

3.0 Introduction

Since this thesis deals with aspects of place features in the phonological development, we start out here with some considerations of the organization of place features. A term that will be used frequently in this respect is 'natural class'. This term refers to sets of segments that recurrently participate as a group in phonological processes. It can be assumed that it is no accident that a particular set of sounds functions as a natural class in the phonology of a language, but that this is attributable to some shared phonetic property. Phonological theory should be able to formally characterize such natural classes by means of a phonological feature that is phonetically interpretable. An assumption that relates to this is that a natural class should have a simple phonological identification; ideally a single phonological feature should be able to identify a natural class. In the course of this century, ideas about the set of place features and the natural classes they form have been shaped and reshaped. Two sources of information have always played a role: sound inventories of languages, and phonological processes. So, on the one hand a proposed set of place features should be able to characterize all and only the contrasting sounds within each of the world's languages, while on the other hand it should be possible to capture diachronic and synchronic processes of sound change.

Here, we are especially interested in the ideas on the relation between vowels and consonants with respect to Place of Articulation features. The history shows alternately periods of segregation and unification of (certain) place features of vowels and consonants. Lately, and also in this thesis, the tendency has again been to unify vowels and consonants in terms of place features. The arguments for this last position come from vowel-consonant interactions, e.g. coronalization, palatalization, velarization and labialization, in languages of the world. We will see in chapters four and five that in child language too, vowel-consonant interactions are a common phenomenon.

3.1 The Jakobsonian feature system

3.1.1 Jakobson

Jakobson (1938) classifies consonants according to two distinctive qualities, pitch and perceptibility. Consonants are either grave or acute, and either posterior or anterior. Grave sounds, velars and labials, have a low(er) pitch, while acute sounds, dentals and palatals have a high(er) pitch. The pair posterior-anterior, in later publications renamed compact-diffuse, distinguishes the 'louder' velar and palatal sounds from the 'less loud' labial and dental sounds. These distinctions are based primarily on acoustic considerations, but they have an articulatory dimension too: the grave velars and labials have a long undivided oral resonator, while the tongue divides the oral resonator in two smaller chambers in the case of the acute dentals and palatals. Furthermore, anterior (diffuse) consonants have a place of articulation towards the front of the oral resonator, while posterior (compact) consonants have a place of articulation towards the back of the oral resonator. These oppositions, grave versus acute and posterior (compact) versus anterior (diffuse), are the same for vowels. To illustrate this for 'pitch', Jakobson mentions a historical process in Eastern Czech, where /p, b, m/ changed to /t, d, n/ before /i/: here, a grave consonant changes to an acute consonant before the acute vowel /i/, as the examples in (1) show:

(1) *Eastern Czech acute assimilation (from Jakobson & Waugh 1979)*

[pīvo]	→	[tīvo]	'beer'
[tʃepice]	→	[tʃetice]	'cap'
[miɲ]	→	[niɲ]	'less'

Jakobson compares the two fundamental oppositions in sound perception, namely pitch and loudness, to the two fundamental dimensions in visual perception. The opposition posterior-anterior (compact-diffuse) is comparable to the chromatic-achromatic dimension in colors, the opposition grave-acute in sounds is like the dark-light dimension in colors. There exists a conversely proportional relation between these dimensions in both perceptual fields: for a highly chromatic (compact/posterior) sound or color, the opposition between light and dark (grave and acute) is not marked, while in a less chromatic (diffuse/anterior) sound or color, the opposition between light and dark is more pronounced. The 'principle co-ordinates' of sound systems form the triangles in (2):

(2) *Jakobson's sound triangles*

Vowels	Consonants	
A	K	chromatic (compact)
U — I	P — T	
dark (grave) — light (acute)	dark (grave) — light (acute)	achromatic (diffuse)

Chromatism — 'abundance of sound' — is the characteristic feature of vowels, while the opposition light-dark is most pronounced in the achromatic consonants.

3.1.2 Developments in the system

In Jakobson, Fant & Halle (1951) the organization of place features as sketched above is much the same. The terms posterior and anterior are replaced by the terms compact and diffuse respectively, more in accord with their acoustic manifestations. Compact sounds are acoustically characterized by "the relative predominance of one centrally located formant region (or formant)", while in diffuse segments one or more non-central formants or formant regions predominate. With these features, the high-low dimension of vowels is paired with the front-back dimension of consonants: low vowels are paired with velars and palatals, high vowels with labials and dentals. This can also be deduced from the triangles in (2).

The features grave and acute receive a more elaborated acoustic definition than they had before. In grave sounds the lower side of the spectrum predominates, resulting in a low pitch, while in acute sounds the upper side predominates, resulting in a high pitch. The position of the second formant is said to be the most characteristic index of this feature: the phoneme is grave when the second formant lies closer to the first formant, and acute when the second formant lies closer to the third and higher formants.

Two additional features are introduced, flat and sharp, capturing what we would now call 'secondary articulations'. Flat characterizes rounding in vowels and either labialization, velarization or pharyngealization in consonants. Flattening is defined acoustically as a downward shift of a set of formants or even of all the formants in the spectrum. The feature sharp characterizes palatalization in consonants. It is characterized acoustically by a "slight rise of the second formant, and, to some degree, also of the higher formants," which is obtained by raising a part of the tongue against the palate. Both flat and sharp contrast with plain.

The relation between velars and velarization (pharyngealization), labials and labialization and palatals and palatalization is not clear in this model. Both velars and labials are grave, but labialization and velarization are characterized by the feature flat. Palatals are acute, while palatalization is marked by the feature sharp. The relation between front (acute) vowels and palatalization is totally obscure in Jakobson, Fant & Halle (1951), since sharp is a feature limited to consonants.

In Halle (1959) the compact-diffuse opposition is split into two oppositions: [±compact] and [±diffuse]. The reason for this is that as well as [+compact] and [–compact], a [±compact] notation was required in Jakobson's model to represent mid open vowels, like /e/. This is not consistent with the theoretical premise that all oppositions are binary. By splitting the ternary opposition into two binary ones, binarity is, at least technically, observed. Both consonants and vowels are characterized by the feature [±compact]. The feature [±diffuse], however, is now restricted to vowels. The feature system for vowel and consonant place thus becomes a little more segregated.

That there is indeed no intention to refer to a natural class of acute vowels and sharped consonants can be deduced from the formulation of rules that govern the phonetic implementation of unaccented vowels in Russian, and of rules specifying the feature grave/acute, which in Halle (1959) has no distinctive function in vowels. Two examples are in (3):

(3) *Rules from "The sound pattern of Russian"*

a. Rule P 9a (p.70). After all sharped segments [...] unaccented compact vowels become diffuse and of high tonality (i.e. acute) (example: ({žon'a} →) {žan'a}→ {žin'a} 'wife')

b. Rule P 11 (p.72). In position between sharped non-vowels, grave vowels tend to become acute.
(no example presented by Halle)

In this period, then, the primary place features grave/acute and compact/diffuse — later only [±compact] — define both vowels and consonants. Grave characterizes labial and velar consonants and back vowels; acute characterizes dental and palatal consonants and front vowels; compact captures both palatal and velar consonants and low vowels; and finally, diffuse characterizes both labial and dental consonants and high vowels. There is, however, no direct relation, in terms of features, between articulations of vowels and secondary articulations of consonants.

3.2 Chomsky & Halle: SPE

In *The sound pattern of English* (SPE) (Chomsky & Halle 1968), Jakobson's "complete identification of consonants and vowels" with respect to their primary place features, is thought "in retrospect to have been too radical a solution" (p. 303), although no specific arguments for this position are provided. Furthermore, the fact that palatalization, velarization and pharyngealization has to be characterized by a set of independent features that fails to recognize the relation between certain sets of vowels and consonants, is considered to be an inadequacy of the Jakobsonian framework. Accordingly, the place features of vowels and consonants in SPE are accommodated in such a way that identification no longer applies to the primary place features of consonants and vowels, but to the tongue body features of both vowels and consonants, that is, to the primary place features of vowels and the secondary place features of consonants.

The nature of the definitions of features is primarily articulatory in SPE, contrary to the definitions in Jakobsonian work, which were based in the first place on acoustics. Taking the Jakobsonian system as a point of departure, the two sets of features relate to and differ from each other in the following ways:

"Primary articulations"

Jakobsonian	*SPE*
Grave – labial/velar C's – back V's	**[–coronal]** – labial/velar/palatal C's – glides /y/ and /w/ – all non–retroflex V's **[+back]** – back V's – velar/uvular/pharyngeal C's
Acute – dental/alveolar/palatal C's – front V's	**[+coronal]** – dental/alveolar/palato-alveolar C's – retroflex V's **[–back]** – front V's
+Compact – palatal/velar C's – low V's	**[–anterior]** – palatal/velar C's **[+low]** – pharyngeal C's – low V's
+Diffuse – high V's	**[+high]** – high V's – palatal/velar C's
–Compact – labial/dental C's	**[+anterior]** – labial/dental C's

"Secondary articulations"

Sharp	– palatalized C's	**[+high]**	– palatalized C's
			– velarized C's
			– palatal/velar C's
			– high V's
Flat	– labialized C's	**[+round]**	– labialized C's
	– round V's		– round V's
	– velarized C's	**[+back]**	– velarized V's
			– pharyngealized C's
			– velars/uvulars/pharyngeals
			– back V's
	– pharyngealized C's	**[+low]**	– pharyngealized C's
			– pharyngeals
			– low V's

Table I. Jakobsonian versus SPE features

As can be seen, the natural classes that are characterized by the two systems are quite different. Concentrating on the relations between vowels and consonants, we have the natural classes of consonants and vowels in the two systems as depicted in Table II (see next page).

The major changes in natural classes of consonants and vowels in SPE are: (1) front vowels and coronal consonants no longer form a natural class; (2) the class of vowels forming a natural class with velars in SPE is [+high], while in Jakobson's model it is [+low], the opposite; (3) labials and velars no longer form a natural class; (4) palatals no longer form a class with dentals and alveolars in SPE; (5) there is a relation between [+round] vowels and labialized consonants in SPE, not between [+round] and either velarized or pharyngealized consonants.

The rule of Russian above in (3a), raising unstressed non-high vowels before 'sharped' consonants like the alveo-palatals /č/ /š/ /ž/, which are [+high] [–back] in SPE, can now be expressed as an assimilatory phenomenon, whereby a [–high] vowel becomes [+high] following a [–back, +high] consonant:

(4) *Russian raising of unstressed non-high vowels (Kenstowicz & Kisseberth 1979)*

$$\begin{bmatrix} +\text{syll} \\ -\text{high} \\ -\text{stress} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{back} \\ -\text{round} \end{bmatrix} / \begin{bmatrix} -\text{syll} \\ +\text{high} \\ -\text{back} \end{bmatrix} \_\_$$

Jakobsonian		*SPE*			
Consonants	Vowels	Consonants	Vowels	Consonants	Vowels
Acute		**[+coronal]**		**[–coronal]**	
dental	front	dental	retroflex	labial	non-r'flex
alveolar		alveolar		palatal	
palatal		palato-alveolar		velar	
		pharyngeal			
Grave		**[+high]**		**[–high]**	
labial	back	palatal	high	labial	low
velar		velar		dental	mid
		palato-alveolars		uvular	
		palatalized		pharyngeal	
		velarized			
Compact		**[+back]**		**[–back]**	
velar	low	velar	back	labial	front
palatal		uvular		dental	
		pharyngeal		palatal	
		velarized		glottal	
		pharyngealized			
Diffuse		**[+low]**		**[–low]**	
labial	high	pharyngeal	low	labial	high
dental		pharyngealized		dental	mid
		palatal			
		velar			
		uvular			
Flat		**[+round]**			
labialized	round	labialized	round		
velarized					
pharyngealized					

Table II. Natural classes in the Jakobsonian and SPE feature models

The rule in (3b) above, fronting vowels in-between 'sharped' non-vowels can now also be represented as an assimilation rule, whereby a [+back] vowel assimilates to the [–back] characterization of [–back, +high] consonants, as in (5):

(5) *Russian fronting*

$$\begin{bmatrix} +\text{syll} \\ +\text{back} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{syll} \\ -\text{back} \end{bmatrix} \Big/ \begin{bmatrix} -\text{syll} \\ -\text{back} \\ +\text{high} \end{bmatrix} \underline{\qquad} \begin{bmatrix} -\text{syll} \\ -\text{back} \\ -\text{high} \end{bmatrix}$$

Labialization, Velarization and Pharyngealization too can all be expressed as assimilation processes. With Labialization a consonant acquires the feature [+round] preceding — or following — a [+round] vowel; velarized consonants can be said to have acquired a [+back] specification in the environment of a [+back] vowel; pharyngealized consonants receive the vowel feature [+low] by an adjacent [+low] vowel.

However, several processes that appear to be assimilations cannot, or can no longer, be expressed as an assimilation process in the SPE feature system. The process in Eastern Czech, mentioned above in (1), where a labial consonant (grave) becomes coronal (acute) before a front vowel (acute), can no longer be expressed as a natural assimilation process, since [+coronal] refers only to consonants, and all non-retroflex vowels are [–coronal] by definition. Instead, the rule in SPE looks like in (6):

(6) *Eastern Czech assimilation in SPE*

$$\begin{bmatrix}\text{–syll}\\ \text{–coronal}\\ \text{+anterior}\end{bmatrix} \rightarrow \begin{bmatrix}\text{–syll}\\ \text{+coronal}\\ \text{+anterior}\end{bmatrix} / \ \_\_ \ \begin{bmatrix}\text{+syll}\\ \text{–back}\\ \text{–low}\end{bmatrix}$$

Furthermore, it is still not possible to relate round vowels to labial consonants, round vowels being [+round] and labial consonants being [–coronal, +anterior]. Still, there are several processes involving these segments — Campbell (1974) lists 19 processes from different languages involving round vowels and labial consonants. Hyman (1975) points out that in Igbo reduplication, the reduplicated vowel is usually [i], while between labial consonants it is [u]. In SPE the rule would be as in (7):

(7) *Rounding in Igbo reduplication (after Hyman)*

$$\begin{bmatrix}\text{+syll}\\ \text{+high}\end{bmatrix} \rightarrow [\text{+round}] \ / \ \begin{bmatrix}\text{–syll}\\ \text{+ant}\\ \text{–cor}\end{bmatrix} \ \_\_\_ \ \begin{bmatrix}\text{–syll}\\ \text{+ant}\\ \text{–cor}\end{bmatrix}$$

The natural assimilating character of this rule is clearly not expressed.

While on the one hand certain apparent natural classes of sounds have no formal expression in the SPE model, it is on the other hand possible to characterize classes of segments that are not natural just as easily as classes of segments that are natural. This is in part due to the binary character of the features. Lass (1976:168–169), for example, points to the 'naturalness' of the class of sounds [θ ð t d s z], defined by [+ant, +cor], as opposed to the 'unnaturalness' of a class defined by [–ant, -cor], which includes palatals, velars, uvulars, pharyngeals and all non-retroflex vowels. So the feature model of SPE too, expresses too much and too little at the same time.

3.3 Pleas for Jakobsonian and other features

3.3.1 Grave

Campbell (1974) lists examples of processes that apparently refer to a natural class consisting of labials and velars, or labials and uvulars. In English, for example, /x/ changed to /f/ at one point, resulting in forms like *enough*, *tough* and *rough*. He points out that in Jakobson's system this class was neatly captured by the feature [+grave].

Lass (1976) draws attention to lenition facts in Old English that applied to labials and velars but not to dentals, and to a fifteenth century rounding rule in Korean where the back unrounded vowel /ɨ/ became /u/ before /m p ph k kh/. Both phenomena again appeal to the class that can be characterized as [+grave]. He argues that although this class can in principle be defined by the SPE feature [–cor], this would only work in case of a language with no contrasting palatal consonants (or pharyngeals), as they would be included in the [–cor] characterization. Furthermore, Lass argues that although [–cor] might in some cases classify the same segments as [+grave], it fails to explain the existence of this specific class. According to Lass, a class of [+grave] segments, in contrast to a class of [–cor] segments, is explained by the fact that it shares a phonetically identifiable feature, namely a low second formant.

Hyman (1973) argues for the reintroduction of the feature [grave] in phonological theory on the basis of facts from Feʔfeʔ. Historically, the low vowel /a/ from Proto-Feʔfeʔ was backed before syllable final /p/ and /k/, but not before final /t/. The examples he presents are in (8):

(8) *Low vowel backing in Feʔfeʔ (from Hyman 1973)*

Proto-Feʔfeʔ *ab	→	Feʔfeʔ [ɑp]	[vɑp]	'to whip'
Proto Feʔfeʔ *ad	→	Feʔfeʔ [at]	[fat]	'to eat'
Proto Feʔfeʔ *ag	→	Feʔfeʔ [ɑk]	[čɑk]	'to seek'

This argues for [+grave]. Other facts argue for [–grave] (acute). In Feʔfeʔ reduplication, the reduplicated vowel is in general the high back unrounded, i.e. [+grave] vowel [ɯ]. When the stem vowel is [i], [–grave], the reduplicated vowel also becomes [–grave] [i]. When the stem vowel is [e], however, the reduplicated vowel is only [i], instead of [ɯ], before alveolar and palatal, i.e. [–grave] consonants. This is illustrated in (9):

(9) *High vowel reduplication in Feʔfeʔ (Hyman 1973)*

pée	→	pɯpée	'to hate'
tee	→	titee	'to remove'
yee	→	yiyee	'to see'
kée	→	kɯkée	'to refuse'

In this process, as in the process in Eastern Czech mentioned above in (1), front vowels and dentals, alveolars and palatals form a natural class. This class cannot be easily referred to in SPE.

With respect to evidence like the Feʔfeʔ case, which points to the fact that palatals should be grouped with dentals and alveolars rather than with velars and labials, Halle & Stevens (1979) revise the definition of the SPE feature coronal, so as to include the palatals. In SPE the articulatory definition of coronal sounds was: "produced with the blade of the tongue raised from its neutral position." In order to group palatals with dentals and alveolars, the definition is revised to: "produced with the frontal (i.e. tip, blade and/or central) part of the tongue raised, so as to make contact with the palate."[1] Lahiri & Blumstein (1984) note that the new definition of coronal makes this feature identical to [–grave] with respect to consonants. Plain, i.e. non-retroflex, vowels, however, are not included in the new definition.

3.3.2 Labial

Hyman (1975), following Vennemann & Ladefoged (1971), proposes, on the basis of facts like the Igbo reduplication data presented above, to introduce the feature labial.[2] Round vowels, labials and labialized consonants would then all be [+labial]. The rounding of the reduplicated vowel /i/ to /u/ between labial consonants in Igbo can then be expressed as an assimilation process, where the reduplicated vowel acquires the feature

[1] They subsequently introduce the new feature [grooved] to distinguish between the two [+distributed] coronal fricatives /ç/ (palatal) and /š/ (palato-alveolar). However, according to Lahiri and Blumstein (1984) this distinction can be made with the already existing feature [strident], that, moreover, is also able to distinguish bilabial from labiodental continuants.

[2] Or rather 'reintroduce', since for example Trubetzkoy (1939/1969) already used labial as one of his 'equipollent' features for place of articulation in consonants. The re-introduced labial is, however, treated as a privative feature.

[+labial] between [+labial] consonants. Other processes involving [labial] are collected in Campbell (1974). To name two of them, in Cakchiquel /ə/ becomes [+labial] /o/ before a [+labial] consonant, while /i/ becomes [+labial] /u/ before a [+labial] consonant which is followed by a vowel; in Finnish /k/ becomes [+labial] /ʋ/ between two [+labial] ([+high]) vowels.

3.3.3 Lingual

Lass (1976) mentions sixteen processes in the history of English, all assimilations of some kind, that involve high front vowels and dental (alveolar), palatal and velar consonants, a class of segments we have not encountered yet. Two examples of these processes are (1) a 'non-vowel shift' raising of Middle English /a/ to [e] or [æ], 'nearly all of them' before dentals and velars (pp 181–182); (2) diphthongization before dentals, palatals and velars in Modern English. In many US dialects epenthesis of a high vowel shows up before palatals and velars, and (but less commonly) before /n/ + obstruent. On the basis of these facts he proposes to introduce the feature [±lingual].

The feature [±lingual] is defined as follows: [+ling] segments entail a primary activity of either the blade or the body of the tongue. This definition thus captures the range of consonants from dentals up to and including velars. High vowels are [+lingual] too since they group with dentals and velars, and their articulation involves the body of the tongue. Uvulars, pharyngeals and labials are [–lingual].

3.4 Summary

Let us summarize what we have seen so far. The Jakobsonian place features were based primarily on acoustic characteristics. These features, [±grave] (grave/acute), [±compact] (compact/diffuse), [±flat] or [±sharp] (flat or sharp/plain) were replaced by more articulatory based features by Chomsky & Halle (SPE). The primary place distinctions for consonants in SPE were characterized by the features [±anterior, ±coronal], while for finer distinctions and secondary articulations use was made of the vowel place features [±high] [±back] [±low] and [±round].[3] Subsequently, basing themselves on various pieces of evidence (i.e. natural classes of segments in languages),

[3] The features [±distributed] and [±strident] could also be used for finer place distinctions, but we will not go into these features as they do not concern issues in this thesis.

Campbell, Hyman, Lass, and Lahiri & Blumstein argued for re-introduction of the feature grave, and for introduction of the feature labial (Hyman) or of the feature lingual (Lass). Halle & Stevens then redefined the SPE feature coronal in such a way that it became much like [–grave] again, except for the fact that vowels were not included in the definition. The following sets of place features have been proposed:

(10) *Place features proposed in the course of time*

Jakobson Jakobson, Fant & Halle	**SPE**	**Others**
[±grave]	[±coronal]	[±grave]
[±compact]	[±anterior]	[±labial]
([±diffuse])	[±high]	[±lingual]
[±sharp]	[±low]	[±coronal] (new definition)
[±flat]	[±back]	[±round]

3.5 Place features in current phonological theories

Let us now see what has become of the above set of features in three current phonological theories, Dependency Phonology (cf. Anderson & Ewen 1987; Anderson & Jones 1974), 'Radical CV phonology' (van der Hulst 1991, 1993, 1994) and the 'mainstream' Feature Geometries (cf. Clements 1985, 1989b, 1991; Hume 1992; Lahiri & Evers 1991; Sagey 1986; Steriade, 1987b). The focus here lies especially on the classes of consonants and vowels that are predicted to form natural classes in the different theories, and on the way assimilation processes are handled. In discussing these different theories some of the most important changes in the concept of the feature as a 'bundle of features' will be addressed. It is, in the light of this thesis, not fruitful to trace the history of these changes in detail, and the reader interested in this is referred to the literature mentioned in this chapter. A concise overview of the recent history of segmental structure can be found in den Dikken & van der Hulst (1988) and in McCarthy (1988).

What the three theories have in common is that the traditional bundle of unordered features has been replaced by a much more structured feature representation. The claim is that a highly structured feature representation brings out generalizations concerning processes and relationships between processes that would be purely coincidental in SPE-like representations.

One type of structure that has been introduced in the segment, which the theories discussed here have in common, is the grouping of features into sub-groups referring to the relatively independent aspects of the segment. These sub-groups, 'major class features', 'manner features', 'place features' etc. can already be found in SPE and pre-SPE theories, but they had no formal status there. In current phonological theories they do have formal status, i.e. rules can specifically refer to, for example, the class of 'place features' to the exclusion of other classes of features.

Another development that the three theories have undergone to a greater or lesser extent is the abandonment of the binarity premise in favour of monovalency. We have already come across the core of the problem with binarity in Lass' argument for [+grave] instead of [–cor]: if a natural class is characterized by a shared feature, then, in a theory like SPE in which all features are binary, a natural class shares either the plus or the minus value of a feature. However, it is not always the case that both values of a feature identify a natural class of segments, i.e. a class of segments that functions as a unit in phonological processes. Furthermore, a class of segments sharing the fact that they all lack a certain characteristic, so characterized by [–feature], often has no univocal phonetic interpretation. The idea of monovalency is that the phonology is restricted to referring to the presence of a shared, phonetically interpretable property. A feature can, then, only be present or absent in the representation, and if it is absent it is invisible to phonological processes referring to that particular feature.

3.5.1 Dependency Phonology

In Dependency Phonology, all the familiar binary features have been replaced by monovalent 'components'. Segment structure is characterized by the presence or absence of these components,[4] and by the presence or absence of various dependency relations between them. The dependency relations take over part of the function of the binary features of SPE, or, in other words, some distinctive features have been replaced by structural relations. The sub-groups mentioned above are called 'gestures' in Dependency Phonology. One of these gestures is the 'articulatory gesture', which in turn has two subgestures, the 'locational subgesture' and the 'oro-nasal subgesture'. This organization looks like in (11):

[4] Negatively characterized classes of segments do turn up in Dependency Phonology. The class of non-round vowels, for example, can be referred to as {~u}.

(11) *Segmental structure in Dependency Phonology (Anderson & Ewen 1987)*

Segment

articulatory gesture

locational subgesture — oro-nasal subgesture

The actual place components belong to the locational subgesture. Vowels and consonants share components, but the classes of consonants and vowels characterized by a shared component differ from both the classes characterized in Jakobson et al. and those characterized in SPE. In (12) we find the place components of Dependency Phonology.

(12) *Vowel space components*

|i| palatality or acuteness/sharpness
|a| lowness or sonority
|u| roundness or gravity/flatness
|ə| centrality

Articulatory components for consonants

|u| gravity: it defines labials and velars
|l| linguality: characterizes dentals, alveolars, palatals and velars
|i| palatality: distinguishes palatals from dentals/alveolars
|a| lowness: distinguishes uvulars from velars
|t| apicality
|d| dentality: both |d| and the component |t| distinguish between various classes of dental and alveolar consonants.
|r| tongue-root retraction: characterizes pharyngeal consonants, together with |a| and |u|.

A five vowel system is represented by single components, or simple combinations of components, as in (13). We will not be concerned with the exact meaning of the curly brackets and vertical lines.

(13) *Five vowel system (Anderson & Durand 1986)*

{|i|} /i/ {|u|} /u/

{|i,a|} /e/ {|u,a|} /o/

{|a|} /a/

In a seven vowel system, dependency relations come into play in order to distinguish between the mid-vowels. A common seven vowel system, like that of Italian, has the representations in (14), whereby the semi-colon indicates unilateral government (or dependency).

(14) *Seven vowel system (Anderson & Durand 1986)*

{|i|}	/i/	{|u|}	/u/
{|i;a|}	/e/	{|u;a|}	/o/
{|a;i|}	/ɛ/	{|a;u|}	/ɔ/
	{|a|} /a/		

Consonants have the place representations in (15).

(15) *Place structures for consonants in Dependency Phonology (Anderson & Ewen 1987)*

labials	{|u|}
dentals/alveolars	{|l|}
velars	{|l,u|}
uvulars	{|l,u,a|}
palatals	{|l,i|}
pharyngeals	{|r,u,a|}

Palatalized segments acquire an extra component |i|, velarized segments have a dependent |l,u|, labialized segments acquire a dependent |u|, and pharyngealized segments have a dependent |r| component.

In Dependency Phonology we thus encounter the Jakobsonian 'primary' and 'secondary' features [grave] and [flat], collapsed with the secondary SPE feature [+round] in the component |u|; |i| collapses the primary and secondary features [acute] and [sharp]. The component |l| is Lass' [+lingual] (for consonants).

The natural classes of consonants and vowels that can be captured with this system are different from (or: a mixture of) those captured by earlier feature systems (see Table III, next page):

To recapitulate, direct relations between consonants and vowels are limited to certain classes. The Eastern Czech process from (1), for example, whereby /p b m/ → /t d n/ before /i/ cannot be captured in this system, since there is no relation whatsoever between dentals/alveolars (|l|) and front vowels (|i|). On the basis of the component |i|, only relations between front vowels and palatal, or palatalized, consonants are predicted

<table>
<tr><td>|u|</td><td>labials, velars, uvulars, pharyngeals
labialized, velarized segments
round vowels</td><td>grave + flat (Jakobson)

[+round] (SPE)</td></tr>
<tr><td>|i|</td><td>palatals

palatalized segments
front vowels</td><td>acute + sharp
(Jakobson) (except for
plain dentals/alveolars)</td></tr>
<tr><td>|a|</td><td>uvulars, pharyngeals
non-high / low vowels</td><td>[+low] (SPE)
(but also high-mid Vs)</td></tr>
<tr><td>|l|</td><td>dentals, alveolars, velars</td><td>lingual (Lass) (except for
high vowels)</td></tr>
</table>

Table III. Natural classes of consonants and vowels in Dependency Phonology

to exist. Furthermore, while the component |l| is included on the basis of Lass' arguments, this component does not refer to high vowels, although they appear to play a crucial role in the processes that Lass presents as evidence for his feature [lingual].

Dependency Phonology appears to be mainly motivated by the representation of inventories of segments and is apparently not developed in great detail to deal with the representation of phonological processes. This can be shown by the description of Old Norse vowel mutation as presented by Anderson & Ewen (1987:216). In Old Norse a stressed vowel was fronted when the following syllable of the same word contained either an [i] or [j], and rounded when that syllable contained either [u] or [w]. In Dependency Phonology this is accounted for by adding either |i| or |u| to the representation of a vowel. The process is formalized as in (16).

(16) *Old Norse vowel mutation*

<table>
<tr><td colspan="3">fronting</td><td colspan="3">rounding</td></tr>
<tr><td>{|V|}
|
{~i}</td><td>→ |i|
before</td><td>{V;}
|
{|i|}</td><td>{|V|}
|
{~u}</td><td>→ |u|
before</td><td>{V;}
|
{|u|}</td></tr>
</table>

<table>
<tr><td>a.</td><td>{|u|}</td><td>→</td><td>{|i,u|}</td><td>{|i|}</td><td>→</td><td>{|i,u|}</td></tr>
<tr><td>b.</td><td>{u;a}</td><td>→</td><td>{i,u;a}</td><td>{i;a}</td><td>→</td><td>{i,u;a}</td></tr>
<tr><td>c.</td><td>{|a|}</td><td>→</td><td>{a;i}</td><td>{|a|}</td><td>→</td><td>{a;u}</td></tr>
</table>

Although the process itself receives a transparent account, it is not clear how the outcome of the addition of component is derived. As can be seen in (16), the added component enters in different relations with the components already present: in (a) and (b) it is simply combined with the other component(s), but in (c) it ends up in a dependent position. Except for creating exactly the representation for the sound that actually results from the addition of the component this asymmetry in the position for addition of a component does not seem to follow from any general principle, or at least, this is not explained.

3.5.2 Radical CV phonology

Radical CV phonology (van der Hulst 1991, 1993, 1994) pushes the ideas of Dependency Phonology further. Structure plays an even more important role, and the basic building blocks of segments, the components, or, elements, are reduced to only two: |C| and |V|. In isolation, these components have a very global interpretation and they receive specific interpretations only in structure. The global meaning of |C| is 'a relative high degree of stricture' or simply 'more consonant-like'; the global meaning of |V| is 'an unimpeded oral outflow of air' or 'more vowel-like'. The more specific interpretation of the elements depends on whether they occur in a head or in a dependent position in a structure, and on the gesture (cf. class node) they appear in. The head position lends a stronger interpretation to an element than the dependent position. The interpretation of the element in dependent position furthermore depends on what forms the head of the structure: the element in dependent position receives an optimal interpretation within the limits of the articulation space determined by the element(s) in the head position.[5] Elements, or combinations of elements, can enter in two types of dependency relation: (a) direct (daughter dependent) or (b) indirect (sister dependent). In the former dependency relation the head and dependent form a more integrated unit (van der Hulst 1994:9).

The Locational gesture (the Place node) consists of two sub-structures: Primary location and Secondary location. The Primary location node constitutes the head of place. The Secondary location node further refines the place of articulation space. In both location nodes there is a basic distinction between a consonant subspace, where the heads are 'C', and a vowel subspace, where the heads are 'V'. The idea here is not that vowels and consonants literally have distinct place structures, but that certain place features are more specifically 'consonantal', like Coronal and Labial, while certain other features are more specifically vowel-like, like high and low.

[5] This is especially true for the manner structures, which are handled in the same way.

axis was the basic axis for consonants, while the vertical 'chromatism', or 'sonority' axis was the basic axis for vowels. However, both vowels and consonants can combine properties from both axes.

Van der Hulst proposes that the empty locational primary subgesture represents dorsality for consonants and centrality for vowels. The four basic non-empty structures that appear under the Locational node are 'C', 'V', 'C_v', and 'V_c'. The latter two structures include a direct dependency relation; in 'C_v' 'C' is the head of 'V', in V_c 'V' is the head of 'C'. In (17) the interpretation of these elements in either head or dependent position under the Primary location node is shown:

(17) *Interpretation of |C| and |V| structures under the Primary place node*

	Head	Dependent
C	Coronal	front
V	low	posterior
C_v	Labial	round
V_c	high	laminal

In head position, bare C thus represents Coronal — the most unmarked consonantal place structure — and bare V represents low — in this theory considered to be the most unmarked vowel-like place structure. 'C_v' represents Labial, and 'V_c' represents 'high'. In this model, then, a relation between Labial consonants and round vowels and Coronal consonants and front vowels is established by assigning the same structure, C or C_v, to these gestures, in either head (for consonants) or dependent (for vowels) position. 'V_c' — high — and 'V' — low — in dependent position receive the interpretation 'laminal' and 'posterior' respectively. The argument is that in the position for 'high' (vowels), the tongue is relatively more advanced (laminal), while in the position for 'low' it is relatively more retracted (posterior).

Under the Secondary location node, the four non-empty structure have the interpretations in (18), depending on whether the structure under the Primary node is C-headed or V-headed:

(18) *Interpretation of |C| and |V| structures under the Secondary location node*

	C-headed	V-headed
C	palatalization	front
C_v	labialization	round
V	pharyngealization	retracted
V_c	dorsalization	advanced

There are, then, two instances of front and round: under the primary node in dependent position, and under the secondary node when the primary node is V-headed. According to van der Hulst, in secondary position these properties are less integrated with the head property of the primary node.

Assuming that all gestures with identical simple gesture structures regardless of the position — head or dependent, primary or secondary place — form natural classes, the following groupings of sounds can be deduced:

(19) *Natural classes according to Radical CV phonology*

C	Coronal	**C_v**	Labial	**Ø**	Dorsal
	front palatalized		round labialized		
V	low	**V_c**	high	**Ø**	central
	posterior pharyngealized retracted		laminal dorsalized advanced		

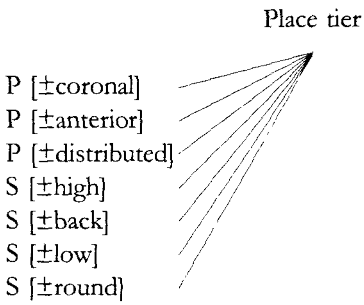
The relationship between consonants and vowels includes a mixture of the natural classes that were found in the systems discussed above. The structure 'C' can be said to correspond to [–grave] (acute) plus 'sharp'; 'C_v' corresponds to Hyman's feature Labial; V groups essentially the same sounds as the SPE feature [+low]; V_c is like the SPE feature [+high] excluding palatalization. There is no relation between back vowels and dorsal consonants. The Jakobsonian grouping of /k/ and /a/, by the feature compact, finds no translation here, with /k/ having an empty locational gesture and /a/ being |V|.

Radical CV-phonology is still in process of being developed and things remain to be empirically tested. As with Dependency Phonology, the way the logic of sound inventories can be built into the actual segmental representations is at this moment the main interest of Radical CV phonology.

3.5.3 Feature Geometrical representations

"Mainstream" phonology, in the meanwhile, focused mainly on representations of features in function of autosegmental processes while the structure of phoneme inventories remained largely unexplained.[6] A complete overview of the history of autosegmental phonology will not be presented here, as this can be found in numerous publications, among others Goldsmith (1976) and van der Hulst & Smith (1982). Instead, we will immediately turn to the place feature organization in the so-called 'feature geometrical representation' presented in Clements (1985).

(20) *Place feature organization (Clements 1985)*



As can be seen in (20), in this first feature geometrical representation the SPE features are grouped integrally under a Place tier node. The major change here is that the term 'place feature' has now become a functional unit in phonological theory.[7] The natural classes of consonants and vowels remain the SPE-classes discussed in 3.2 above. The organizing, non-terminal nodes in the hierarchy are called class nodes, the individual features are called terminal nodes. The Place node is, accordingly, a class node. Every node in the feature hierarchy is supposed to be a functional unit, i.e., each node should be able to function independently of other nodes in phonological processes. Clements recognizes a difference between primary (P) and secondary (S) place features, but he is at this point not sure whether 'Primary' and 'Secondary' should form separate organizing features under the Place node or not. He also notices an asymmetry in assimilation processes between vowels and consonants: in vowel-to-vowel assimilations

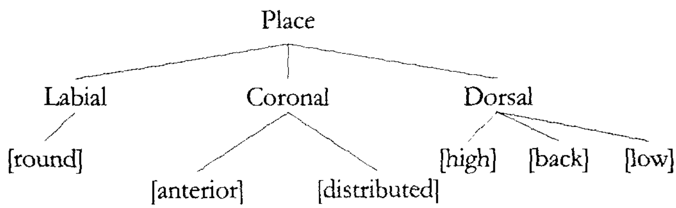
[6] Rice & Avery (1991), do try to build a sound inventory logic into the feature geometry.

[7] The other major change of autosegmental phonology lies of course in the revised outlook of phonological processes in terms of the 'spreading' and 'delinking' of nodes in the feature geometry.

consonants may intervene, while in consonant-to-consonant assimilations it is hardly ever the case that vowels can intervene.

In Sagey (1986) the place node is organized in a different way. First, an extra layer of structure is introduced, which divides the set of place features into hierarchically ordered primary and secondary articulations. Secondly, the primary place features of SPE [±coronal] and [±anterior] are abandoned in favour of the set Labial, Coronal and a feature not encountered before, Dorsal. The representation is then as in (21):

(21) *Place feature organization of Sagey (1986)*



The features Labial, Coronal and Dorsal have become class nodes in this representation.[8] The difference between the two sets of place features, Labial, Coronal and Dorsal versus [±coronal] and [±anterior], is captured in terms of 'place of articulation theory' versus 'articulator theory' (McCarthy, 1988). The SPE set of primary place features is arranged according to the place of articulation of a sound, while the organization we find in Sagey is based on the active articulators involved: the lips (labial), the blade of the tongue (coronal) and the body of the tongue (dorsal). All the vowel features involve activation of the tongue body, and consequently all vowels have a Dorsal node. The feature [anterior] has a different function in Sagey's theory. It is defined as involving the tongue front instead of involving — as it did in SPE — a stricture either in front of, [+anterior], or behind, [–anterior], a certain point in the coronal area. Labial and velar sounds, then, no longer have a specification for [anterior].

Another important deviation from Clements' feature hierarchy is the introduction of non-binary features. According to Sagey, class features can only be either present or absent, and there is no formal notation for the absence of a class feature. Labial, Coronal and Dorsal thus function as monovalent features. Furthermore, contrary to most of the frameworks addressed before, they are totally independent of each other. In the Jakobsonian framework [+grave], like [–coronal] in SPE, grouped together

[8] We will not be concerned with sounds further 'backwards' than Dorsal.

labial and velar, in SPE [+anterior] grouped labial and dental, and Lass' feature lingual, |l| in Dependency Phonology, grouped together dental and velar. We can no longer refer to any of these classes.

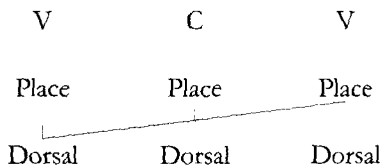
However, because of the fact that the terminal features are still binary, a series of strange groupings of sounds results. For example, [+round] sounds are automatically Labial — as Hyman argued — but [–round] sounds such as [–round] front vowels contrasting with [+round] front vowels, are Labial too. Furthermore, by accommodating [±high], [±back] and [±low] under the Dorsal node, we do not only expect more intimate relations between [+high] vowels and Dorsal consonants — like in SPE — but between vowels of any height, [–high], [+low] or [–low], and Dorsal consonants. Similarly, not only [+back] vowels are predicted to group with Dorsal consonants (below it will be seen that this group can function as a unit in certain assimilation processes) but also [–back] vowels; front vowels and dorsal consonants, however, do not appear to form a natural class in any of the world's languages. In short, all vowels are predicted to have a special relationship with Dorsal consonants. It turns out, however, that this combination of sounds — any vowel plus dorsal consonant — never functions as a natural class in phonological processes. The node Coronal is still reserved for consonants only. Palatalization processes involving front vowels and coronal consonants thus still lack a 'natural' account, front vowels being Dorsal in Sagey's model.

Although in the literature we can still find the feature geometrical representation of place features as it was presented in Sagey's work (cf. Archangeli & Pulleyblank 1992), major changes have been introduced to the place node since.

One of the problems with the grouping of vowels plus dorsal consonants under a single node that people focused on has to do with the requirement for locality in phonological processes. Nodes involved in spreading and delinking processes need to be adjacent to each other in the phonological representation. This is formulated in the well-known condition on crossing association lines on the same plane (cf. Goldsmith 1976, Hammond 1988).[9] As was mentioned above, Clements noticed that in a process like Vowel Harmony, it appears that features can spread from one vowel to another across an intervening consonant. This can occur even if the intervening consonant has a Dorsal node. If both Dorsal consonants and vowels share a Dorsal node, then a vowel harmony process should in principle result in an illformed representation, as in (22):

[9] A plane designates "[...] the unlimited surface defined by two autosegmental tiers" (Clements & Keyser 1983).

(22) *Line-crossing*



Steriade (1987b) proposes to separate tiers for vowels and consonants, by reserving Dorsal for vowels only, while the — formerly — dorsal consonants receive their own class node, Velar.[10] Vowels and consonants thus share the same place node, but have, except for [round] which remains under Labial, separate primary articulator nodes. Vowels and consonants can now operate relatively independently of each other. It is clear, however, that in this model palatalization and velarization processes still have no satisfactory account.

As a further development, Clements (1989b) revises the set of place features and reorganizes the feature model so as to make it possible to account for vowel-consonant interactions like palatalization, while keeping the possibility of representing unblocked vowel-to-vowel processes. The secondary place features [+round], [–back] and [+back] are renamed [+labial], [+coronal] and [+dorsal] respectively.[11] This signifies the special relation between round vowels and labial consonants, front vowels and coronal consonants, and back vowels and dorsal consonants. The actual description of assimilation in this model will be addressed below. This set of features, however, occurs twice in the feature geometry, once under a C-place node, and once under a V-place node. This signifies the relative independence of vowels and consonants. The V-place node also contains two features which the C-place node lacks, namely [open] (Clements' term for [high] and [low], see chapter 6). The asymmetry Clements had observed concerning the behaviour of vowels and consonants in non-local spreading processes is not represented in this model: place features of consonants can spread as easily across vowels as place features of vowels can spread across consonants. In his most recent model (Clements 1991), however, the asymmetry has been incorporated and the sets of features under the C-place and V-place node have been made identical. Examples of a representation for /t/ and /i/ are presented in (23).

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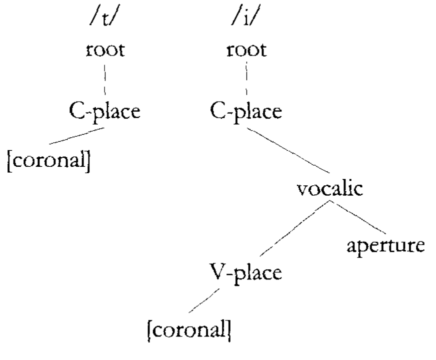
[10] Archangeli & Pulleyblank (1986), basing themselves on Clements (1985), introduce the S-place node as a class node under the Place node, containing the features [high], [low], [back] [ATR] and [round].

[11] For reasons that remain unclear in this article Clements reverts to binary articulator features.

(23) *Place feature representations for /t/ and /i/ (from Clements 1991)*

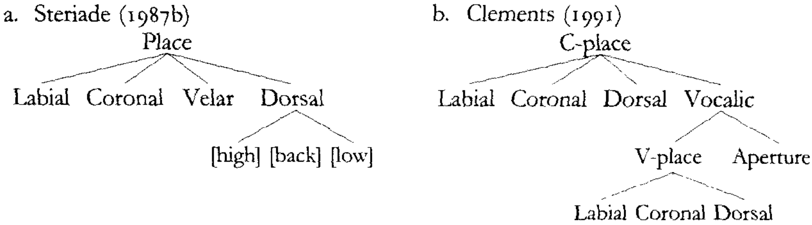


The place feature structure of sounds here looks considerably different from the representations proposed by Sagey, Steriade, and quite different from Clements' earlier proposal as well. Both consonants and vowels now have a C-place node, while only vowels — and consonants with a secondary articulation — have a vocalic node. This is to assure that place features of consonants will not spread easily across vowels: the C-place node of vowels prevents the C-place node of consonants from spreading across them. However, individual place features can in principle spread across non-(place) identical vowels. On the other hand, vowels can spread their place features across plain consonants without any problem since consonants lack the vocalic node that could act as the blocking factor in the spreading process.

The new class node 'vocalic' in fact replaces the former V-place node. The features grouped under the former V-place node are divided into two further classes of features, the actual — and now monovalent — place features [labial], [coronal] and [dorsal] are grouped under the new V-place node, and the height features — Clements calls them aperture features — are grouped under the Aperture node. The introduction of the Aperture node is motivated by the fact that it can function independently from other nodes, such as the V-place node, in phonological processes.

As can be noticed, Clements' feature representation does not contain an actual Place node anymore. The C-place node has taken over this function: consonants and vowels both have a C-place node instead of a Place node. However, if we replace the C-place node with the Place node, Dorsal with Velar, and the Vocalic node with Dorsal, we get a model that is pretty similar to Steriade's (1987b) model mentioned above. (Otherwise, if we replace the C-place node with the Place node again and the Vocalic node with the S-place node, we get almost exactly the feature organization of Archangeli & Pulleyblank (1986) mentioned in footnote 10). This similarity is illustrated in (24):

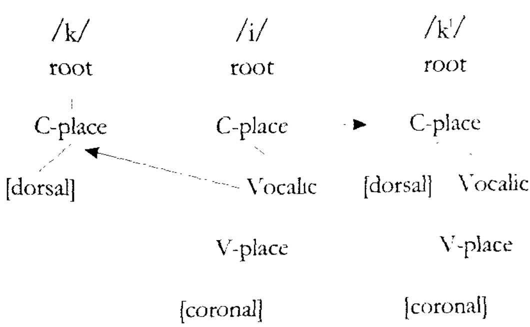
(24)



The changes are thus not so radical as they first appeared. What has changed, mainly, is that relations between consonants and vowels have been made more clear in the model, by redefining [back] as Coronal and Dorsal, and by separating these articulator features for vowels (V-place) from the tongue position features (Aperture).

Let us now consider the actual account of a palatalization, or rather coronalization, process in this model. In Slavic /k, g, x/ become [tʃ, dʒ, ʃ] when followed by front vowels or /j/. We will not be concerned with the affrication of the resulting segments here. Stated simply, the process changes a velar consonant into a coronal consonant, when this consonant is followed by a coronal (front) vowel or glide. It is not possible to spread [coronal] directly from the V-place node vowel or glide to the C-place node of the consonant, because V-place and C-place are on different planes, and spreading cannot occur across planes. According to Clements, then, the process takes place in three steps. In (25) the first stage of the process, involving the sounds /k/ and /i/, is represented. The vocalic node of the vowel /i/ spreads to the consonant /k/, and the sequence /ki/ becomes /kʲi/. At this point the velar consonant has become a velar consonant with secondary palatalization.

(25) *Coronalization in Slavic*



For the second step, the change from a consonant with a secondary coronal articulation to a consonant with a primary coronal articulation, the process of 'tier promotion' is introduced, formalized as in (26):

(26) *Tier Promotion (Clements 1989)*
F_a: V → C (where F_a = any articulator feature, V = V-place and C= C-place)
1. link a copy of F to the C-place node
2. delink F from the V-place node

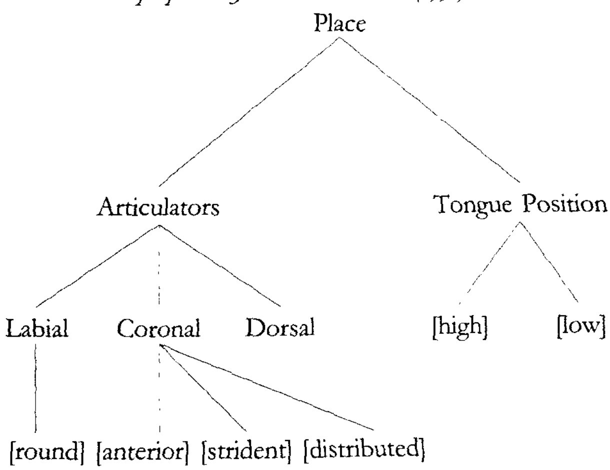
By Tier Promotion, the representation of the palatalized consonant /kʲ/ now turns into the representation for a complex corono-velar segment /kt/, since the representation now contains two primary place, i.e. C-place, features. (It is not clear what happens to the rest of the Vocalic node). Finally, this complex representation feeds a simplification process, Complex Segment Simplification, that delinks the original C-place feature [dorsal].

This seems to be quite a laborious procedure for a relatively common process. A well-taken point of Hume (1992) is that in this account the realization of /k/ as /tʃ/ before a front vowel can only be indirectly attributed to assimilation to this front vowel. The front vowel, in Clements' account, can only palatalize — add a secondary coronal articulation to — the preceding consonant, while other processes take care of the change from palatalized velar to post-alveolar consonant. Hume, then, adopting Clements' representation of place features, assumes that cross-planar spreading can take place (as a marked option). This makes it possible to represent the above assimilation process as a direct change.

The organization of place features as proposed by Clements (1989) receives some criticism from Lahiri & Evers (1991). One point concerns the redundancy introduced in the model by the C-place and V-place nodes; the distinction between vowels and consonants is already incorporated in the model, namely in the sonority features. Furthermore, the model is less revolutionarily different from the model in SPE than it probably appears: the vowel features are kept as separate from the consonant features as before, and the difference is, according to Lahiri & Evers, mainly one of naming. A comment that can be added, applying to the model of Clements (1991), is that the C-place node for vowels has no other function than blocking the spreading of the C-place node of consonants across them. Alternative mechanisms are available to account for the spreading asymmetry between vowels and consonants, like specifying for rules whether they are 'minimal scansion' or 'maximal scansion' rules (Archangeli & Pulleyblank 1987). Minimal rules scan every segment, while maximal rules scan only syllable heads. Vowels, but not consonants, can thus form the relevant tier for spreading processes.

A second point concerns the procedure for palatalization. Tier promotion, the second stage in the change from /k/ to /tʃ/, seems to be an artefact of the way Place is organized by Clements rather than an independently motivated process. The intermediate 'complex segment' stage, resulting from Tier Promotion, does not appear to ever surface diachronically, nor does it appear to be a very natural step to take for a language. As we saw above, Hume (1992) solves this last point by allowing cross-planar spreading. Lahiri & Evers, however, propose a different organization of the place node. Their model is in (27).

(27) *Place node as proposed by Lahiri & Evers (1991)*



In this model vowels and consonants share the same set of features in a more literal sense. Round vowels and labial consonants have a Labial node, front vowels and coronal consonants have a Coronal node and back vowels and velar consonants have a Dorsal node. Round vowels have two Articulator nodes, then, a Labial node plus either a Coronal or Dorsal node. As in Clements (1991),[12] the vowel height features are grouped under a separate node, the Tongue Position (TP) node. The palatalization process of /k/ becoming /tʃ/ before /i/ is accounted for as spreading of the Coronal node of the vowel to the consonant, with a simultaneous delinking of the Dorsal node. This is a far more direct procedure than the one proposed by Clements. Palatalization as a secondary articulation is argued to be the result

[12] The models were developed independently of each other at the same time.

of spreading [+high] from a vowel to a preceding consonant.[13]

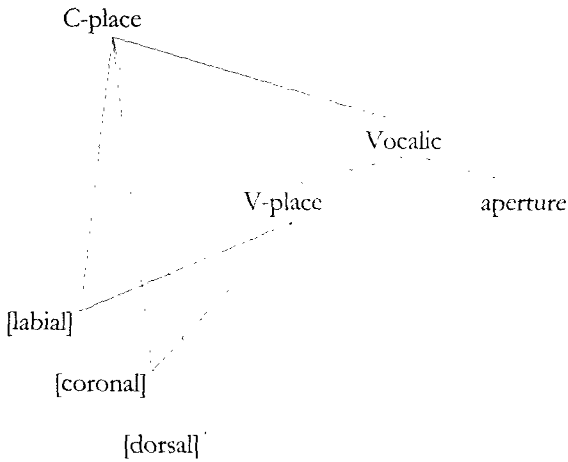
Two types of labialization can be distinguished in the model: primary labialization involves spreading of Labial, while secondary labialization involves spreading of [+round]. It appears to be impossible, however, to represent velarization as a secondary articulation.

In this model, as in Sagey's model, Labial dominates a binary feature [round], which introduces some obscurity. Round vowels are, in this model, actually redundantly specified for [round], since they only have a Labial node when they are [+round]. For vowels, then, a Labial node alone sufficiently specifies the roundness of the vowel. If the feature [round] is discarded, however, an alternative description of secondary labialization needs to be found. Also, a different way to contrast [+round] from [–round] labial consonants, were they ever to contrast only in this feature within a single language, needs to be found. Another problem with the feature [round] arises when a language contrasts, for example, [+round] and [–round] front vowels. The question is if a non-round front vowel should in that case have a [–round], and hence Labial specification. If so, a [–round] front vowel could in principle spread its Labial node to a consonant, inducing primary labialization. This would not be a welcome result. Finally, asymmetric behaviour in vowel harmony processes is predicted: [round] harmony can be defined either as a minimal or as a maximal scansion rule, while for example Dorsal, [back], harmony can only be defined as a maximal scansion rule.

In the most recent version of Clements' model (Clements & Hume 1993, Clements & Wetzels 1993), Hume's proposal to allow cross-tier spreading from V-place nodes to C-place nodes is adopted. The model is, thus, definitively freed from the operations of Tier Promotion and Complex Segment Simplification to represent a simple vowel-to-consonant assimilation. In an illustration of the model, partly copied from Clements & Wetzels (1993) in (28) below, it also appears that there is but one set of place features Labial, Coronal, Dorsal:

[13] The 'palatal' flavour of these palatalized, i.e. [+high], consonants is, according to Lahiri & Evers, a phonetic property, namely the implementation of a j-like off-glide. There is evidence for palatalized consonants being [+high] in Russian. Here, unaccented [–high] vowels are raised after palatalized consonants, but not after non-palatalized consonants.

(28) *Place feature organization (from Clements & Wetzels 1993)*



The features of this set can either be associated with the V-place node or with the C-place node, and they can also associate with both nodes. This would be a quite satisfactory conception of the set of place features. However, the model still contains redundant information and a lot of structure, all just to prevent the assimilation of consonants across vowels. In Clements & Wetzels (1993), the assumption that there are two place feature planes, one dominating the other, even forces them to invoke cross-tier OCP violations, to account for syllable structure constraints in Korean that rule out homorganic consonant-vowel sequences. Another negative point that remains is the unbalanced structure of the place features. The C-place node, for example, dominates, as well as features from the place feature set, a vocalic node that has nothing to do with this place feature set. This is, however, a general problem of feature geometries.

A potentially happy medium between the models of Clements and Lahiri & Evers can be found in a proposal by Selkirk (1991), where dependency relations are introduced under the place node. This makes the double place node structure of Clements no longer necessary, while keeping the possibility to differentiate between primary and secondary articulations, and solving the problem with [±round]. In this model a place feature in dependent position receives a 'secondary' interpretation. A rounded labial, for instance, would look like in (29):

(29) *Representation of a rounded labial in Selkirk's model*

/p^w/
Root
|
Place
|
Labial
|
Labial

The problem with [±round] seems to be solved, since there are no longer any [–round] Labials. Selkirk's model, however, deviates from those of Clements and Lahiri & Evers in that Dorsal represents [+high] rather than [+back] for vowels. Implementation of dependency into Lahiri & Evers' model would probably be the thing to do.

The last table in this chapter compares the major post-Sagey feature geometry features Labial, Coronal and Dorsal — abstracting away from V-place and C-place — to the Jakobsonian, SPE, Dependency and Radical CV-phonology frameworks:

<table>
<tr><th>Feature Geo.</th><th colspan="2">Jakobson</th><th colspan="2">SPE</th><th colspan="2">Dependency</th><th>Radical CV</th></tr>
<tr><th>C/V</th><th>C/V</th><th>V</th><th>C</th><th>V</th><th>C/V</th><th>C</th><th>C/V</th></tr>
<tr><td>Labial</td><td>Grave</td><td>Flat</td><td>[–cor, +ant]</td><td>[+round]</td><td>|u|</td><td></td><td>Cv</td></tr>
<tr><td>Coronal</td><td>Acute</td><td></td><td>[+cor] [–cor, -ant, +high]</td><td>[–back]</td><td>|i|</td><td>|l|</td><td>C</td></tr>
<tr><td>Dorsal</td><td>Grave</td><td></td><td>[–cor, -ant, +back]</td><td>[+back]</td><td>|u|</td><td>|l|</td><td></td></tr>
</table>

Table IV. Labial, Coronal, Dorsal in relation to other models

This ends the journey through some of the history of place feature organization.

3.6 Conclusions

The main changes in the conception of place features and their organization encountered in this chapter can be summarized as follows.

1. The phonetic base which forms the main motivation for the phonological features shifts gradually from mainly acoustic to mainly articulatory, and within the articulatory space from place of articulation to the active articulators.

2. Up until Sagey, primary place features often grouped two primary places into natural classes: Grave and [–coronal] grouped labials and velars, Diffuse and [+anterior] grouped labials and coronals/dentals, while lingual and [–anterior] grouped coronals/alveolars and velars. With the introduction of Dorsal, labials, coronals and velars stopped having natural class relationships among each other.
3. More and more structure is added to the set of (place) features. A mere listing of the relevant phonological elements of segments is not enough: they need to be grouped and ranked so as to reveal natural classes, (group) behaviour in phonological processes, relative markedness in inventories, etc.
4. Place features of vowels and consonants as they are being viewed upon now are very much like they were in the Jakobsonian organization. With the introduction of Dorsal, Grave has been split into Labial and Dorsal.

It is clear that it is not easy to come up with an ideal place configuration, given the high demands on what such a configuration should, and should not be able to represent. Improving the feature organization so as to reflect the build-up of the languages' segment inventories better often leads to a less well-motivated representation of 'group behaviour in phonological processes', and vice versa. Furthermore, concentrating on one set of processes leads to grouping X of features, while concentrating on another set of processes might lead to grouping Y. It might actually not be necessary to lay the whole burden of requirements like on the organization of features per se. For example, the implementation of a logic of segment inventories could probably be dealt with outside of the feature model. Proposals to this effect can be found in Archangeli & Pulleyblank (1992) and in Prince & Smolensky (1993).

3.7 Relevance to present study

Studies in the acquisition of phonology have often concentrated on the development of the segment inventory of a language. The general strategy in these studies is to concentrate on initial consonants of the child's utterance, compare these to the initial consonants of the target adult forms, investigate the matches and substitutions, and finally, list the sequence of appearance of the different segments. In the chapters 4 and 5 of the present study, however, the Place of Articulation feature structure of longer stretches of sound is investigated. It turns out that there are recurrent interactions between vowels and consonants, and quite fixed Place of

Articulation feature patterns for entire words in the early stages of acquisition. A place feature organization that is able to capture these findings then becomes important.

The place feature patterns of vowels and consonants in the child language data provide evidence for the basic place feature organization that is currently gaining ground: labial consonants and round vowels are Labial, coronal consonants and front vowels are Coronal, velar consonants and back vowels are Dorsal. Since up to now these relations have been captured only in current feature geometrical representations of Place, this model of feature structure will be employed in the remainder of the thesis.

4 Consonant Harmony

a reanalysis

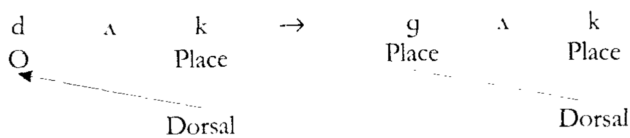
4.0 Introduction

Consonant Harmony is a frequently observed phenomenon in child language. It has been defined as an 'assimilation-at-a-distance' process between consonants (Vihman 1978). In other words, consonants affect other, non-adjacent, consonants. The assimilating features are mostly place features. While in child language this is a frequently observed phenomenon, in adult languages it is not widespread. Moreover, if it occurs in adult languages, the harmonizing features are always secondary place features. Take for example Ponapean, where multiple labial consonants within a morpheme must all be either velarized or plain (Mester 1988). In child language, however, primary place features are affected. A well-known example of a form that could pass for a case of Consonant Harmony is presented in Menn (1978):

(1) *Apparent Consonant Harmony case*
duck → [gʌk]

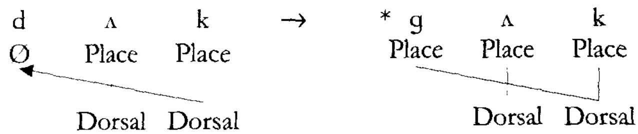
In non-linear phonology, forms like in (1) are accounted for along the following lines (cf. Stemberger & Stoel-Gammon 1989): the consonant targeted by the assimilation process, /d/, is underspecified for Place, in other words, it has no place features in its underlying representation. It receives a place specification from the other consonant in the word, /k/, which is specified for Place, by means of a spreading process. A representation of this account is in (2):

(2) *Procedural representation of Consonant Harmony I*



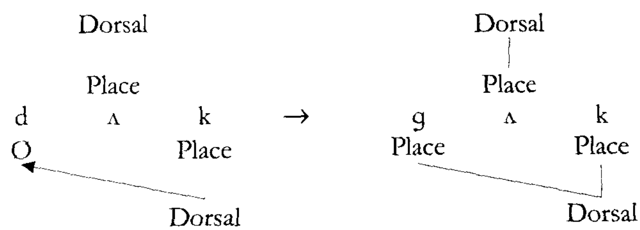
The representation in (2) is actually not complete, and a problem with the account arises as soon as it is supplied with the missing information. The complete representation is in (3).

(3) *Procedural representation of Consonant Harmony II: line crossing*



In (3) the vowel is provided with a place node too, and spreading of the place node from the specified /k/ to the unspecified /d/ now involves a violation of the Line Crossing Prohibition. Different solutions to this problem have been proposed in the literature, one of which involves planar segregation of consonants and vowels (cf. McDonough & Myers 1991). The representation is then looks as in (4):

(4) *Procedural representation of Consonant Harmony III: planar segregation*



Details of this proposal will be discussed below. The problem of crossing association lines is solved, but we will argue that the child language data are not accounted for.

In this chapter, the phenomenon will be approached from a rather different angle. It will be argued that the assimilation process does not take place as in (4) between two non-adjacent consonants, but between adjacent vowels and consonants. The process is thus like (5b) and not like (5a):

(5) *Nature of the assimilation process*

a. $C_i\ V\ C_j \rightarrow C_j\ V\ C_j$

b. $C_i\ V_j\ C_{j/k} \rightarrow C_j\ V_j\ C_{j/k}$

In other words, the consonant that has been argued to be the trigger of the assimilation process is only accidentally present, and the vowel adjacent to the consonant targeted by the assimilation process is the actual trigger of the process.[1]

Some problem cases for former accounts of Consonant Harmony are presented in (6):

(6) *Problem cases for former accounts of Consonant Harmony*

a.	ballon 'balloon' /bɑ'lɔn/	[plɔm]	1;7.9	Tom
b.	schoen 'shoe' /'sχun/	[pum]	1;9.24	Elke

In (6a) it appears that Consonant Harmony has taken place across an intervening consonant: the labial consonant /p/ appears to spread its feature Labial across /l/ to the coronal consonant /n/. This presents a hard case for any account of Consonant Harmony, since even if planar segregation were assumed, /l/ would still be intervening between /p/ and /n/.

The child's production in (6b) appears to be a Consonant Harmony case where, again, Labial is spread. But where from? There is no Labial consonant in the adult word and Elke did not substitute either /s/, /χ/, or /n/ by a labial consonant in other cases. It is clear that the cases in (6) need to be approached from a different angle in order to find an explanation.

For a better understanding of the problems we will have to get an idea about the two important ingredients of current accounts of Consonant Harmony mentioned above, planar segregation and underspecification. In 4.1 these current accounts, especially those presented by Menn (1978), Iverson & Wheeler (1987), Stemberger & Stoel-Gammon (1989, 1991), and McDonough & Myers (1991) will be reviewed. In 4.2 the problems that arise with these approaches are outlined and illustrated with data from the data corpus. The picture that emerges of the actual nature of consonant harmony in child language is elaborated in 4.3 and in 4.4 the phonological representation of the facts is discussed. A summary of the findings and concluding remarks, finally, are in 4.5.

4.1 Former accounts of Consonant Harmony in child language

The first account of Consonant Harmony in an autosegmental framework is by Menn (1978). Menn views assimilation between consonants in child language as one of the child's strategies to comply with a general constraint

[1] It should be clear that what will be called 'process' throughout this chapter is actually the pattern that emerges when comparing a surface adult structure with the corresponding surface child structure, and probably not an actual 'derivation' from some underlying representation of the child to a surface structure (cf. Menn 1978, Iverson & Wheeler 1987).

on his output structure. The output constraint in this case is termed a 'consonant harmony constraint': consonants within a word should be of one place type. If an adult model word contains consonants of different place types, the child can either delete all but one type of consonant, or the child can 'perform' place feature assimilation, rendering all the consonants in his production of the word of one place type. This is actually a nice point of view, since this way Consonant Harmony is integrated in the child's phonological system — of some kind — as a whole, instead of being regarded as some isolated phenomenon. In the next chapter a similar view will be elaborated on. Concerning the formal description of the consonant harmony output constraint, Menn posits the following 'output lexical entry' for the words *stuck, duck* and *truck*, all pronounced [gʌk] by the child Daniel:

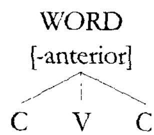
(7) *Output lexical entry for 'stuck' 'duck' 'truck'*

tier 3	stop-position	#		velar		#
tier 2	fricative	#		Ø		#
			C	V	C	
tier 1	word-structure	#	+voice	low-mid	–voice	#

The child has this representation plus a rule of the form: "If an entry in the recognition lexicon contains a velar, then select [velar] as the stop-position specification for the corresponding entry in the output lexicon" (p. 167). In this account neither underspecification, nor planar segregation plays an obvious role, not in the least because these terms were not really worked out yet at the time, and a place node as we know it now also did not exist. The only thing that can be concluded is that the vowel was not involved in the output constraint, and did not present a problem to the account.

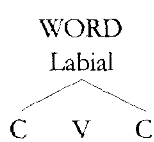
In a more recent paper by Iverson & Wheeler (1987) the idea put forward is that many phonological phenomena in child language are a result of the association of features with certain supra-segmental constituents. This is, again, an interesting idea which will be elaborated on in the next chapter. The child's output representations are viewed here "...as well-formedness templates which characterize, and filter, the set of admissible words in the child's language" (p. 249). For a Consonant Harmony process referred to as Velar Assimilation in the article, the posited well-formedness template that results in the productions [kok] and [gag] for the words *coat* and *dog* respectively is in (8):

(8) *Output template for 'coat' and 'dog'*



For the child in question then, any word that has a back — [–anterior] — consonant will be associated with the word structure in (8), resulting in harmonized forms. This account is in fact exactly parallel to Menn's account presented above: there is a template and a floating place feature that will be linked to the C-slots in the template. Nothing is said about the association line from [–anterior] to the vowel: it does not seem to have any function. For [–anterior] this might not be so problematic, since vowels are not normally specified for [anterior], but Iverson & Wheeler mention that a similar account would be available for labial assimilation. In this case, the template would probably look like in (9):

(9) *Labial output template*



The association line from Labial to the vowel is likely to have an effect here, but no attention is paid to this possibility. It thus seems that segregation of vowel and consonant planes is silently assumed in this account.

In Stemberger & Stoel-Gammon (1989, 1991) a more detailed explanation of Consonant Harmony is presented. They view Consonant Harmony as an 'unconscious' process, caused on the one hand by underspecified consonants in the child's inventory, and on the other hand by a "...tendency for unmarked segments to assimilate to marked segments." The process is thus viewed as a feature filling process, whereby a place feature spreads from a consonant specified for place to a consonant unspecified for place. The case of *duck* becoming [gʌk], viewed from this perspective, was presented in (2) above. The initial consonant was said to be unspecified for place, and the place feature Dorsal, from the final consonant /k/, subsequently spreads to the empty place slot of the initial consonant.

However, in the model of feature representation Stemberger & Stoel-Gammon adopt, the one proposed by Sagey (1986), vowels all have a Dorsal node too. This would mean that spreading Dorsal from /k/ to the initial consonant position would cause association lines to cross, which is forbidden by the Line-Crossing Prohibition. This was shown in (3) above. Stemberger & Stoel-Gammon recognize that this is a problem for their account. They argue that since these intervening vowels do not block harmony they are transparent, i.e. invisible, to the harmony process in one way or another. To achieve this, consonants and vowels should either reside on different planes, or they should have different sets of place features. Planar segregation of consonants and vowels does not appeal to them because, according to them, processes like palatalization, whereby a vowel influences a consonant, would be difficult to account for if consonants and vowels were on different planes. It seems that they have overlooked the fact that these planes will be conflated at a certain point, after which assimilations between adjacent consonants and vowels can be accounted for as usual. In any case, they turn to the feature model suggested by Clements (1985), where consonants and vowels are partially segregated. This was discussed in the previous chapter. Place features are divided into a 'primary' place tier containing consonantal place features and a 'secondary' place tier containing vocalic place features. In this model, rules may spread place features of vowels across consonants, and place features of consonants across vowels. This appeals to Stemberger & Stoel-Gammon: Consonant Harmony can then be characterized as an assimilation process, affecting only the primary place node, and interference with vowels, characterized on the secondary place tier, is avoided. In Clements' later elaboration of this model (Clements 1991), however, a similar account of Consonant Harmony is no longer possible since both vowels and consonants now have a C(onsonant)-place node — the former primary place tier. One of Clements' arguments for this is precisely to exclude the possibility of consonants spreading their place features across vowels.

The most recent account of Consonant Harmony, finally, is from McDonough & Myers (1991). They propose a planar segregation plus underspecification account of Consonant Harmony. Planar segregation of consonants and vowels can only be invoked if the relative order of consonants and vowels is predictable (McCarthy 1989; this will be elaborated on below). According to McDonough and Myers, many children at this stage of development have "...quasi-templatic constraints on the structure of words," and they conclude that children are thus expected to have consonant-vowel planar segregation at this stage of development. Their representation of Consonant Harmony, then, looks just like the example in (4) above, and involves spreading the place node onto an adjacent root node on the consonant plane, unspecified for place.

It can be concluded that in the accounts of Consonant Harmony couched in a non-linear framework either a child output representation with some dominant feature as the only place specification available is posited as the 'cause', or the trigger is thought to be the simultaneous presence of an underspecified consonant and a specified consonant in a word. Furthermore, it is — sometimes silently — assumed that intervening vowels will not interfere with the harmonizing consonants.

A final note here concerns the data. In order to be able to see if the accounts of Consonant Harmony established above are 'correct', a fairly complete data sample of a child needs to be considered, in the sense that one can get a clear idea of context-free substitutions and syllable structure. The data found in the literature on Consonant Harmony in child language cannot be called too representative a sample, however: the actual Consonant Harmony forms that are presented in the literature reviewed above add up to about 15 cases, from 7 different children.[2]

4.2 Outline of the problem

The focus will be on two ingredients of the accounts summarized above: underspecification and planar segregation. Underspecification has to do with the nature of the targets and the triggers in the operation, and therefore with the nature of the operation itself; planar segregation concerns the condition under which the operation can take place. A brief explanation of the two terms from this perspective is presented next.

In theories of underspecification it is assumed that not all features are, or need to be, specified in the underlying representation (cf. Archangeli 1984, 1988; Steriade 1987a). Details of the different proposals do not concern us here. In numerous articles it has been argued that coronal consonants are universally unspecified for Place in their underlying representation (cf. Paradis & Prunet 1991). Underspecified segments can acquire a missing feature specification from a neighbouring segment by means of spreading, or else they receive a default value. The default value for Place is then, universally, Coronal. Regarding Consonant Harmony, it is assumed that the assimilation process will take place if a word contains a combination of a consonant unspecified for place and a consonant specified for place in the child's underlying representation. The underspecified consonant needs a place specification before surfacing, and this can be accomplished, as explained above, by spreading specified material from a neighbouring segment to it. This way, the process applies automatically and can be regarded as unmarked: as soon as the underlying representation of a word

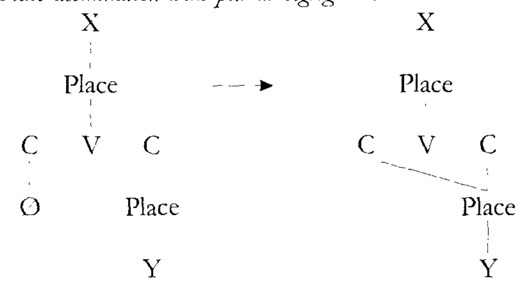
[2] Vihman (1978) presents more forms: about 35 cases of place feature assimilation from 13 different children.

contains a consonant unspecified for place and one specified for place, this last consonant will spread its place node to the underspecified consonant.

An almost inevitable consequence of the assumption that assimilation takes place between non-adjacent consonants is to assume that children have an underlying representation where consonants and vowels reside on different planes. An important principle in current phonological theories is that all phonological processes are local. That is, the elements that are affected in a certain phonological operation have to be adjacent in the representation at that point (cf. Archangeli & Pulleyblank 1987, Steriade 1987b). Locality is enforced by the Line Crossing Prohibition which states that association lines should not cross in spreading processes. Vowels and consonants both have place nodes, and spreading of the place node of one consonant to another consonant across an intervening vowel involves crossing association lines, and therefore a violation of the Locality condition. In (3) above, it could be seen that the place feature Dorsal of the specified Consonant could not reach the underspecified Consonant, because it would cross the association line of the Place node of the intervening vowel.

In order to ensure that consonants are adjacent to consonants at the time where Consonant Harmony takes place — Consonant Harmony then being a local process — the features of consonants and vowels are represented on different planes, as in (10).

(10) *Place assimilation with planar segregation*



An alternative is to separate the set of place features for vowels and consonants into a set of vowel-place features and a set of consonant-place features, as in Clements' (1989b, 1991) feature models, discussed in chapter 3. With this type of feature representation, consonants and vowels are adjacent in all respects except for their place features. This makes communication between consonants with respect to their place features possible. Stemberger & Stoel-Gammon (1989) considered this possibility. In the latter version of Clements' place feature representation (1991), however, this communication between consonants has been made absolutely impossible. We will come back to this below.

Although in principle an account in terms of planar segregation and underspecification seems conceivable, and maybe even quite elegant, we will have to face some problems.

The cornerstone of the account, planar segregation, is not too solid when one takes a closer look at the child language data. Planar segregation is present in a language when the linear order of vowels and consonants in the surface structure of morphemes is predictable. One circumstance that renders linear order predictable is when a language has a sufficiently restrictive root structure constraint (McCarthy 1989). This holds, for example, when the syllable structure of a language is strictly CV. The linear order of consonants and vowels in that language is, then, predictable: every C is followed by a V, which in turn can only be followed by a C, etc. If the linear order of C's and V's on the surface is predictable it should, according to McCarthy, be dispensed with in the lexicon.

In adult Dutch, as in adult English, the sequence of consonants and vowels in words is not predictable, and planar segregation of consonants and vowels, in principle, does not apply. We will have to assume, then, that in Dutch child language there is a sufficiently restrictive root structure that enforces planar segregation. This is what McDonough & Myers (1991) conclude in their account of Consonant Harmony in English child language. However, although children initially do often reduce the syllable structure of adult target words to simple consonant-vowel sequences — by substituting single consonants for consonant clusters, for instance — it is not the case that given a set of consonants and a set of vowels, the child's productions are always predictable. Take for example the words in (11), all part of the early lexicon of children.

(11) *Examples of non-predictable CV-sequences in child language*

a.	eend 'duck' /'ent/	['ɪnt]	1;9.24	Robin
	niet 'not' /'nit/	['nit]		
b.	aap 'monkey' /'ap/	['ap]	1;7.15	Jarmo
	paard 'horse' /'part/	['pa]		

The words in (11a) and the words in (11b) contain the same segmental material, but in a different linear order.

Moreover, not all children have sufficiently restricted consonant-vowel sequences at the time they have apparent Consonant Harmony forms. Jarmo, for example, in a recording session at age 1;10 produced apparent Consonant Harmony forms like in (12):

(12) *Apparent Consonant Harmony forms of Jarmo*

boek 'book' /'buk/	[bup]	1;10.9
Paula (name) /'paula/	['povə]	

In this same session the words in (13) were produced (ignoring vowel length differences):

(13) *CV-sequences in Jarmo's productions*

a.	vc	['ap]	e.	ccvcv	['kʀajə] ['pvova]
b.	cv	['ba:]	f.	cvccv	['tetjə]
c.	vcv	['ɔto]	g.	cvc	['bup]
d.	cvv	['paə] (2σ)	h.	ccv	['tlɛi] ['pvi] ['kʁa]
			i.	cvcv	['kikə]

Considering the 'minimal pairs' vc-cv (13a, b); vcv-cvv (13c, d); ccvcv-cvccv (13e, f); and cvc-ccv (13h, i), one has to conclude that the position of a vowel vis-à-vis a consonant cannot be said to be predictable. The same reasoning applies to Tom, who in two sessions around age 1;6 had the apparent Consonant Harmony forms in (14):

(14) *Apparent Consonant Harmony forms of Tom*

vogel 'bird' /'voχəl/	['χoχo]	1;5.28
pelikaan 'pelican' /ˌpeli'kan/	['kaŋ]	
muis 'mouse' /'mœys/	['mœyΦ]	1;6.10

but produced, in the same sessions, the words in (15):

(15) *CV-sequences in Tom's productions*

a.	vc	['af]	f.	vcv	['oto]
b.	cv	['pɛ:]	g.	cvccc	['kaŋχk]
c.	vcc	['akt]	h.	cvccv	['ka:kʁu]
d.	cvc	['kɩs]	i.	cvvcv	[ˌχu'aχə]
e.	cvcv	['tœkə]			

Here too, 'minimal pairs', in terms of CV ordering, are present: (15a, b); and (15c, d). It is, again, not the case that every C is followed by a V, which is followed by a C, etc.

A final example is provided by Catootje. At age 1;11 she produced the apparent Consonant Harmony forms in (16):

(16) *Apparent Consonant Harmony forms of Catootje*

ballon 'balloon' /bɑˈlɔn/	[ˈbɔmɩ]	1;11.9
kopje 'cup' (dim.) /ˈkɔpə/	[ˈkoχa]	
paddestoel 'mushroom' /ˈpɑdəˌstul/	[ˈpɑmoˈtu]	

while in the same session she produced words like in (17):

(17) *CV-sequences in Catootje's productions*

a.	vc	[ˈap]	f.	vvc	[ˌuˈɑχ]
b.	cv	[ˈku]	g.	cvcc	[ˈmɔnt] [ˈhits]
c.	cvc	[ˈpat]	h.	ccvc	[ˈplan]
d.	vcc	[ˈɩnt]	i.	vccv	[ˈonˌjɑu]
e.	vcv	[ˈɩma]			

It is clear by now that the argument of sufficiently restricted root structures is not sufficiently strong to postulate planar segregation of consonants and vowels; Without planar segregation of vowels and consonants it seems impossible to account for Consonant Harmony while not violating the Locality principle.

Let us turn to the other ingredient, underspecification. The assumption that an underspecified consonant in the underlying representation of a word triggers Consonant Harmony — in order to regard the process as automatic and unmarked — makes sense only if the consonant forming the target of assimilation, being unspecified for place, will not be able to act as a trigger for Consonant Harmony at the same time. The underspecified consonant has no place features underlyingly, and is thus not able to spread a place feature. Unfortunately these things are exactly what we find in the data corpus. The data in (18) below are apparent Consonant Harmony forms of Eva (dorsal consonants did not surface as such at the time):

(18) *Apparent Consonant Harmony forms of Eva: Labial assimilation*

a.	brood 'bread' /ˈbʀot/	[ˈbop]	1;4.12
b.	poes 'cat' /ˈpus/	[ˈpuf]	1;4.12
c.	slof 'slipper' /ˈslɔf/	[ˈpɔf]	1;4.12
d.	verstoppen 'hide' /vəɹˈstɔpə/	[ˈpɔpə]	1;4.26
e.	koffie 'coffee' /ˈkɔfi/	[ˈpɔfi]	1;6.1

Considering the consonants of the adult target forms in (18) leads to the following observations when it is hypothesized that we are dealing here with Consonant Harmony in the child's productions:

I. the assimilated consonant is a coronal (or /k/) in the adult model
II. the trigger consonant is a labial consonant

In an analysis of the type sketched in the introduction above, one would state that the coronal consonants (and /k/) of the adult model words are presumably underspecified for place in the underlying representation of the child. Labial consonants are specified for place, and the labial consonant in the word will thus be able to spread its place feature to the consonant not specified for place.

However, we observe exactly the opposite in the data in (19), also from Eva and produced in the same period:

(19) *Apparent Consonant Harmony forms of Eva: Coronal assimilation*

a.	bed 'bed' /ˈbɛt/	[ˈdɛt]	1;4.12
b.	bijten 'bite' /ˈbɛitə/	[ˈdɛitə]	1;4.26
c.	Bert (name) /ˈbɛɹt/	[ˈdɛt]	1;4.26
d.	vis 'fish' /ˈvɪs/	[ˈdɪs]	1;6.1

I. the assimilated consonant is Labial in the adult model word
II. the trigger consonant is a coronal consonant

The coronal consonants that were supposed to be underspecified with regard to their place features, now trigger place assimilation — this would mean that they are specified for place after all — and labial consonants that were supposed to be specified for place are now ready targets to spread to.

There is one adult word that even triggered both Consonant Harmony-like productions from Eva, in one and the same recording session:

(20) *Apparent Consonant Harmony forms of Eva: either Coronal or Labial assimilation*

buik 'tummy' /ˈbœyk/	[ˈboŭp]	1;6.1
	[ˈdœyt]	

For the production [ˈdœyt], one would have to assume that /k/ in the adult model words collapses with /t/ at this point in Eva's phonological development.

It thus appears that targets of assimilation can be triggers and, vice versa, triggers can be targets, in the production of a single child, in a single recording session, and even within a single word. Ignoring for a moment the planar segregation problem discussed above, an account of Consonant Harmony in terms of a combination of one consonant underspecified and one specified for place in a word, triggering an automatic feature filling process makes the wrong predictions.[3]

In order to show that Eva is not an exceptional case, comparable data from other children are presented in (21):

(21) *Apparent Consonant Harmony forms in the data: Labial, Coronal and Dorsal assimilations*

Jarmo	a.	vis 'fish' /'vɪs/	['sɪʃ]	1;9.9	coronal	R→L
	b.	duif 'pigeon' /'dœyf/	['dœys]	1;9.23	coronal	L→R
	c.	huilt 'cries' /'hœylt/	['jœyt]	1;9.23	coronal	R→L
	d.	monkey /'mɔŋki/	['mɔmu]	1;9.23	labial	L→R
	e.	boek 'book' /'buk/	['bup]	1;10.9	labial	L→R
	f.	Paula (name) /'pɑula/	['porə]	1;10.9	labial	L→R
	g.	tekenen 'draw' /'tekənə/	['tetə]	1;10.9	coronal	L→R
	h.	blokken 'blocks' /'blɔkə/	['kɔko]	1;10.23	dorsal	R→L
	i.	beertje 'bear' (dim.) /'beɹtjə/	['titjə]	1;11.6	coronal	R→L
	j.	Willy (name) /'vɪli/	['lɪli]	1;11.20	coronal	R→L
	k.	zebra 'zebra' /'zebʀa/	['tetat]	1;11.20	coronal	L→R
	l.	kalkoen 'turkey' /ˌkɑl'kun/	['kuŋ]	2;0.4	dorsal	L→R
	m.	schoenen 'shoes' /'sχunə/	['guŋə]	2;0.4	dorsal	L→R
	n.	buiten 'outside' /'bœytə/	['tœytə]	2;0.28	coronal	R→L
	o.	monkey /'mɔŋkɪ/	['kogɪ]	2;0.28	dorsal	R→L
	p.	varken 'pig' /'vɑɹkə/	['kɑkjəs]	2;0.28	dorsal	R→L
	q.	kadootje 'present dim' /ˌka'dotjə/	['koχjə]	2;1.8	dorsal	L→R
	r.	muts 'cap' /'mʉts/	['tʏtst]	2;1.22	coronal	R→L
	s.	zeven 'seven' /'zevə/	['tejə]	2;2.6	coronal	L→R
	t.	borstel 'brush' /'bɔɹstəl/	['pɔfɔŭ]	2;2.27	labial	L→R
	u.	vogel 'bird' /'voχəl/	['koχo]	2;3.9	dorsal	R→L
Noortje	a.	fiets 'bicycle' /fits/	['tɪs]	2;1.17	coronal	R→L
	b.	vogel 'bird' /'voχəl/	['kɔkə]	2;1.17	dorsal	R→L
	c.	pingpongen 'ping-pong' /'pɪŋˌpɔŋə/	['pipɔmə]	2;5.23	labial	L→R
	d.	kast 'closet' /'kɑst/	['kɑχts]	2;6.5	dorsal	L→R
	e.	nog 'another' /'nɔχ/	['ŋɔχ]	2;6.5	dorsal	R→L
	f.	Paula (name) /'pɑula/	['porɑ]	2;6.5	labial	L→R
	g.	poes 'cat' /'pus/	['pufts]	2;6.5	labial	L→R
	h.	toch 'still' /'tɔχ/	['kɑŭχ]	2;6.19	dorsal	R→L
	i.	buiten 'outside' /'bœytə/	['bœyfə]	2;7.2	labial	R→L
	j.	kind 'child' /'kɪnt/	['tɪnts]	2;8.15	coronal	R→L
	k.	kers 'cherry' /'kɛɹs/	['tɛs]	2;8.29	coronal	R→L
	l.	muis 'mouse' /'mœys/	['tœys]	2;8.29	coronal	R→L
	m.	lopen 'walk' /'lopə/	['wopə]	2;9.26	labial	R→L
	n.	tijger 'tiger' /'tɛiχəɹ/	['tɛinɑ]	2;9.26	coronal	L→R
	o.	poes 'cat' /'pus/	['puf]	2;9.26	labial	L→R

[3] Consonant Harmony as an automatic feature-filling process would probably also predict a far higher percentage of 'Consonant Harmony' forms than are actually present in the data. Apparent Consonant Harmony forms are present in about 10% of the utterances of a child in recordings with a peak in such assimilations.

Elke	a.	fiets 'bicycle' /'fits/	['titʃ]	1;7.8	coronal	R→L
	b.	kusje 'kiss' (dim.) /'kʉʃə/	['tɪʃə]	1;9.24	coronal	R→L
	c.	telefoon 'telephone' /ˌtelə'fon/	['pom]	1;10.7	labial	R→L
	d.	vis 'fish' /'vɪs/	['sɪʃ]	1;11.7	coronal	R→L
	e.	vogel 'bird' /'voχəl/	['ΦoΦəɹ]	1;11.7	labial	L→R
	f.	schommel 'swing' /'sχɔməl/	['foΦə]	1;11.28	labial	R→L
	g.	drinken 'drink' /'dʀɪŋkə/	['tjɪnɪ]	2;2.6	coronal	L→R
	h.	dichtbij 'near' /ˌdɪχ'bɛi/	['dɪspɛi]	2;3.27	coronal	L→R
	i.	clown 'clown' /'klaun/	['kʀɑŋ]	2;4.29	dorsal	L→R
	j.	tram 'tram' /'tʀɛm/	['tɛn]	2;4.29	coronal	L→R
	k.	visjes 'fishes' (dim.) /'vɪʃəs/	['sɪsis]	2;4;29	coronal	R→L
	l.	vogel 'bird' /'voχəl/	['foΦjɑ]	2;4.29	labial	L→R
Tirza	a.	sok 'sock' /'sɔk/	['χɔk]	1;9.11	dorsal	R→L
	b.	knoop 'button' /'knop/	['pop]	1;10.22	labial	R→L
	c.	buiten 'outside' /'bœytə/	['nœytə]	1;11.19	coronal	R→L
	d.	varken 'pig' /'vaɹkə/	['χaɹkə]	2;0.18	dorsal	R→L
	e.	vis 'fish' /'vɪs/	['sɪs]	2;0.18	coronal	R→L
	f.	bellen 'bubbles' /'bɛlə/	['dɛlə]	2;2.12	coronal	R→L
Tom	a.	tijger 'tiger' /'tɛɪχəɹ/	['tɛitə]	1;4.14	coronal	L→R
	b.	vogel 'bird' /'voχəl/	['p͜Φɔfɔw]	1;5.14	labial	L→R
	c.	pelikaan 'pelican' /ˌpeli'kan/	['kaŋ]	1;5.28	dorsal	L→R
	d.	vogel 'bird' /'voχəl/	['χɔχɔ]	1;5.28	dorsal	R→L
	e.	boot 'boat' /'bot/	['bof]	1;6.11	labial	L→R
	f.	konijn 'rabbit' /ˌko'nɛin/	[ˌkuŋ'gaŋ]	1;7.9	dorsal	L→R
	g.	cassette 'cassette' /ˌka'sɛtə/	['kaχ'sɛtə] i	1;10.8	dorsal	L→R
	h.	juf 'Miss' /'jʉf/	['ʋy̯uf]	1;10.8	labial	R→L
	i.	muis 'mouse' /'mœys/	['tøys]	1;8.10	coronal	R→L
	j.	verfdoos 'paint box' /'vɛɹfˌdos/	['lɪˌtɒs]	1;8.10	coronal	R→L
	k.	vlag 'flag' /'vlaχ/	['χaχ]	1;8.10	dorsal	R→L
	l.	cijfer 'digit' /'sɛifəɹ/	['sɛisoŭ]	1;11.12	coronal	R→L
	m.	bruin 'brown' /'bʀœyn/	['dɛin]	1;11.26	coronal	R→L
	n.	nog 'again' /'nɔχ/	['ŋɒχ]	1;11.26	dorsal	R→L
Catootje	a.	ballon 'balloon' /ˌba'lɔn/	['bɔmɪ]	1;10.11	labial	L→R
	b.	hoofd 'head' /'hoft/	['bɔft]	1;10.25	labial	R→L
	c.	kopje 'cup' (dim.) /'kɔpjə/	['koχa]	1;11.9	dorsal	L→R
	d.	locomotief 'loc' /ˌlokomo'tif/	['dutə'tis]	2;0.6	coronal	L→R

In the examples above we also see that not only adult model labial or coronal consonants appear to spread their place feature, but also dorsal consonants.

In Stemberger & Stoel-Gammon (1989) data like the above are said to result from a direction-triggered form of Consonant Harmony. Stemberger and Stoel-Gammon found that when coronals assimilated as readily to velars as velars to coronals, the direction of spreading was always regressive. 'Bidirectional' harmony, as this is termed ambiguously,[4] is thus different

[4] Bidirectional here means that assimilation takes place from e.g. coronals to velars and, vice versa, from velars to coronals. In monodirectional spreading the trigger is always the same.

from 'monodirectional' harmony in the sense that it is triggered by direction rather than by a combination of an empty place feature slot in combination with a specified place feature elsewhere in the word. In short, what assimilates to what in bidirectional harmony depends on the order of consonants in the word. Comparing, in (22), the productions for the words *poes* (18b) and *bed* (19a), which are similar as far as the order of consonants — in terms of place features — is concerned, namely Labial V Coronal, we see that the direction of spreading cannot be the explaining factor for the bidirectionality of assimilation here.

(22) *Apparent bidirectional assimilation from Eva*

pus	bɛt
CVC	CVC
Labial V Coronal	Labial V Coronal
L→R	L←R
pů̊f	dɛt

An even stronger example is provided by Eva's productions for *buik*, namely 'right-to-left' ['dœyt] and 'left-to-right' ['bɔŭp], as could be seen in (20) above. Counter-examples to bidirectional assimilation from other children, except for Tirza, are also numerous in (21). Here all the Place of Articulation features appear to be able to spread in both directions.

A final possibility to account for the data is to abandon the idea that Consonant Harmony involves spreading of the Place node, and to analyze the data in terms of single feature spreading. This captures the fact that in the data of a single child Labial, Coronal and Dorsal can all be triggers of spreading. The Line-Crossing problem remains, however. The data above clearly show that Labial can spread across a round vowel, which is Labial too in all current feature models. Dorsal can spread across vowels, which would be ruled out by a Sagey-type model, and it can spread across back vowels, which would be ruled out by both Clements' and Lahiri & Evers' models. These last two models would also rule out the spreading of Coronal across front, i.e. coronal vowels.

By now the possibilities for calling Consonant Harmony a successful account of the child language data are exhausted, and we will turn to view the matter from a different angle.

4.3 Alternative account

Let us return to the examples in (18)–(20) above, and see under what circumstances triggers become targets and targets become triggers in the assimilation phenomenon. By 'circumstances' here the Place of Articulation feature of the vowel intervening between the two consonants is meant.[5] In (18) and (20), the vowels from the adult model words are /o/, /ɔ/ /œy/ and /u/. These vowels are either front or back, but all are [+round]. In (19) and (20) the vowels are /ɛ/, /ɩ/, /œy/ and /ɛi/. These vowels are all front. It thus appears that a consonant from an adult target word that is originally not Labial surfaces as a labial consonant in the child's production when the adjacent vowel in the adult model is [+round], as can be seen in (18). Alternatively, a non-coronal consonant from an adult model word surfaces as a coronal consonant in the child's production when, in the adult model, the adjacent vowel is front, as can be seen in (19). If the vowel in the adult model is both round and front, assimilation can take place in either direction, that is, the consonant can surface as either a coronal or a labial consonant. This was shown in (20). These same circumstances are found in (21). Furthermore, in (21) we find that dorsal assimilation appears to apply when the intervening vowel is back: take for example the dorsal assimilations of Jarmo in (21m, o, p), where the intervening vowels are /u/, /o/ and /ɑ/ respectively, or the dorsal assimilations of Tom in (21c, f, n), where the intervening vowels are /ɑ/, /u/ and /ɔ/.

The first question now is if this relation between [+round] vowels and labial consonants, front vowels and coronal consonants and back vowels and dorsal consonants, is in any way imaginable or, phonologically speaking, natural. In the previous chapter, dealing with the history of place feature representations, we came across exactly these types of relations in the world's languages. In what in chapter 3 was called Eastern Czech acute assimilation the consonants /p b m/ changed to /t d n/ before /i/; here an originally non-coronal consonant becomes a coronal consonant when followed by a front vowel, just like we saw above in (19). In Finnish, /k/ becomes /ʋ/ between two round vowels; here a dorsal consonant becomes a labial consonant between round vowels, as in (18). Evidence for the relation between back vowels and dorsal consonants is also available in adult languages. Clements & Hume (1993) mention a syllable structure constraint in the Khoisan languages of southern Africa, where only back vowels may occur after velar and uvular consonants. Dell (1993) discusses the Chinese dialect Yongding, where a syllabic nasal is realized as either

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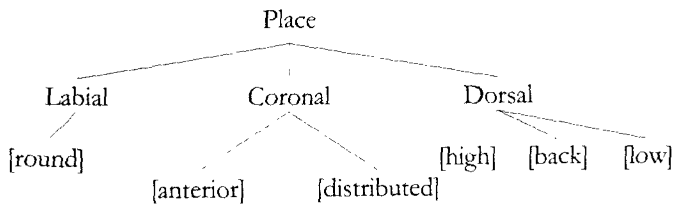
[5] Vowel height features will not be considered here.

/m/, /n/ or /ŋ/, depending on the context. The context for dorsal /ŋ/ to surface is when the following syllable starts with either a dorsal consonant or /a/, /ɔ/, /o/, /u/, i.e. back vowels — the syllabic nasal is realized as /m/ when the following syllable starts with a labial consonant. The classes of front vowels and coronal consonants, labial consonants and round vowels, or dorsal consonants and back vowels are, thus, clearly not specific to child language, but are a universal characteristic of language.

In phonological theory it is assumed that a set of sounds that functions as a natural class should have a simple phonological identification, ideally a single phonological feature. In the previous chapter it was made clear that until recently the representation of place features in the currently most widely used feature model, the feature geometry, did not capture the relation between back vowels and dorsal consonants, nor the relation between front vowels and coronal consonants. The feature model presented in Sagey (1986) is reproduced here in (23):

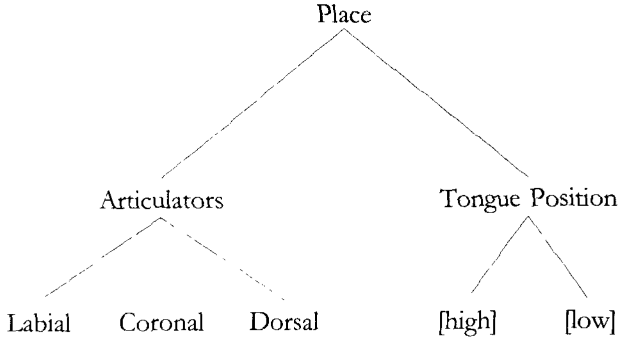
(23) *Place feature organization of Sagey (1986)*



It is clear that while the relation between round vowels and labial consonants can be quite straightforwardly indicated in this representation, the relation between front, i.e. [–back], vowels, situated under the Dorsal node, and coronal consonants cannot. The latter relation does become significant, however, in the most recently proposed feature models (Clements 1991, Clements & Hume 1993, Lahiri & Evers 1991), where one set of place features for consonants and vowels is used in such a way that [+round] vowels are Labial, the front, [–back], vowels are Coronal and the [+back] vowels remain Dorsal. Vowels that are back and round, like /o/, /u/ etc., are in principle 'complex', i.e. they are both Labial and Dorsal. As a working model we will use a simplified version of the representation of place features presented in Lahiri & Evers (1991), illustrated in (24) (see next page), the most crucial aspect of which is that front vowels are under the Coronal node.

If we now return to the data in (18) and (19), we see that Labial assimilation takes place when the vowel in the target word is labial and Coronal assimilation takes place when the vowel in the target word is coronal, for example (25).

(24) *Feature model used here (adapted from Lahiri & Evers 1991)*



(25) *Consonant-Vowel assimilations: Labial and Coronal*

poes /'pus/	Lab Lab Cor	→	Lab Lab Lab	['puf]
slof /'slɔf/	Cor (Cor) Lab Lab	→	Lab Lab Lab	['pɔf]
bed /'bɛt/	Lab Cor Cor	→	Cor Cor Cor	['dɛt]
vis /'vɪs/	Lab Cor Cor	→	Cor Cor Cor	['dɪs]

In (21) we saw that Dorsal assimilation occurred when the vowel in the target word was dorsal:

(26) *Consonant-Vowel assimilations: Dorsal*

nog /'nɔχ/	Cor Dors Dors	→	Dors Dors Dors	['ŋɒχ]
schoenen /'sχunə/	(Cor) Dors Dors Cor	→	Dors Dors Dors	['guŋə]

The obvious question to ask now is whether it is still necessary to view the process as an assimilation process between consonants. The vowel appears to be an important factor in the direction of spreading. Could it not be the only factor? One type of data that would strengthen this hypothesis would be cases where a consonant X from the adult model is substituted by a consonant Y in the child's production, when the adjacent vowel is Y too and there is no consonant of type Y present in the adult model word. This would strongly suggest that vowels are triggers of place harmony in child language. Indeed, quite a few such cases are present in the data. In (27) some of these vowel-consonant assimilations, found in Eva's data, are presented. The harmonized parts of the child's production are underlined:

(27) *Clear Vowel-Consonant assimilations in Eva's data*

a	schoenen 'shoes' /'sχunə/	→	['umə]	1;4.12
b.	toren 'tower' /'torə/	→	['bowə]	1;6.1
c.	doen 'do' /'dun/	→	['bun]	1;7.15
d.	(naar) toe 'to' (prep) /'tu/	→	['pu]	1;7.15
e.	klok 'clock' /'klɔk/	→	['pɔt]	1;7.15
f.	beer 'bear' /'beɹ/	→	['dɛ]	1;4.12
g.	weg 'gone' /'ʋɛχ/	→	['dɛχ]	1;4.26
cf.	water 'water' /'ʋatəɹ/	→	['pɑdə]	1;4.26
cf.	was 'laundry' /'ʋɑs/	→	['hɑs]	1;4.26

The round vowels /u/ and /o/ in (27a–d) are the only Labial elements present in the adult model words, and thus the only possible cause of the labial substitution — /m/ for /n/ in (27a), /b/ for /t/ in (27b), /b/ for /d/ in (27c) and /p/ for /t/ in (27d) — that appear in the child's productions. In (27f–g) the front vowels /e/ and /ɛ/ are the only Coronal elements present in the adult model words, and thus likely to be the cause of the coronal substitute /d/ that emerges instead of the labial model sounds /b/ and /ʋ/ in the child's production. These uncontroversial cases of vowel-consonant assimilation occur regularly in the data of all the children in the data corpus. The puzzling cases in (6) in the introduction are now solved too: in both *ballon* → ['plɔm] and *schoen* → ['pum], the labial vowel in the model word, adjacent to the 'targeted' consonants in the adult models, is the designated 'trigger' of Labial assimilation.

Examples of vowel-consonant assimilations from other children are given in (28):

(28) *Vowel-Consonant assimilations in the data*

Jarmo	a.	kikker 'frog' /'kɪkəɹ/	['tika]	1;9.9	coronal
		klaar 'ready' /'klaɹ/	['ka]	1;9 9	no change
	b.	auto 'car' /'oto/	['kotɔ]	1;10.23	dorsal
	c.	beer 'bear' /'beɹ/	['tɪə]	1;10.23	coronal
	d.	poppetje 'little figure' /'pɔpətjə/	['kɔkɔ]	1;10.23	dorsal
	e.	bij 'bee' /'bɛi/	['tɛi]	1;11.20	coronal
	f.	bloemetje 'flower dim' /'blumətjə/	['kutə]	1;11.20	dorsal
	g.	kip 'chicken' /'kɪp/	['tɪt]	2;0 4	coronal
	h.	poes 'cat' /'pus/	['kus]	2;0.4	dorsal
	i.	wipwap 'see-saw' /'ʋɪp,ʋɑp/	['tiʋɑp]	2;0 4	coronal
	j.	vallen 'fall' /'vɑlə/	['kɑlə]	2;0.28	dorsal
	k.	hoedje 'hat dim' /'hutjə/	['huχjə]	2;0.28	dorsal
	l.	schoenen 'shoes' /'sχunə/	['kumɑ]	2;0.28	labial
	m.	zoetjes 'sweetener' /'zutjə/	['kucəs]	2,0.28	dorsal
	n.	groot 'big' /'χʀot/	['po]	2;1.22	labial
	o.	kameel 'camel' /,kɑ'mel/	['teŭw]	2;1.22	coronal

	p.	wipwap 'see-saw' /ˈʋɪpˌʋɑp/	[ˈtɪnˌdɑp]	2;2.6	coronal
	q.	kip 'chicken' /ˈkɪp/	[ˈtɪp]	2;2.27	coronal
	r.	klok 'clock' /ˈklɔk/	[ˈpɔk]	2;2.27	labial
	s.	poesje 'cat' (dim.) /ˈpusjə/	[ˈpuχjə]	2;2.27	dorsal
	t.	ballon 'balloon' /ˌbɑˈlɔn/	[ˈlɔm]	2;3.9	labial
	u.	weg 'gone' /ˈʋɛχ/	[ˈnɛχ]	2;3.9	coronal
	v.	kip 'chicken' /ˈkɪp/	[ˈkɛt]	2;3.9	coronal
	w.	nog keer 'once again' /ˈnɔχ ˈkeɹ/	[ˈnɔp ˈteə]	2;3.9	labial & c'nal
	x.	Rollo (name) /ˈʀɔlo/	[ˈbɔlo]	2;3.9	labial
	y.	stoel 'chair' /ˈstul/	[ˈtufə]	2;3.9	labial
	z.	olifant 'elephant' /ˈoliˌfɑnt/	[ˈhɔŋiˌkɑtjə]	2;4.1	dorsal
Noortje	a.	beer 'bear' /ˈbeɹ/	[ˈteə]	2;1.17	coronal
	b.	stoel 'chair' /ˈstul/	[ˈtuχ]	2;2.21	dorsal
	c.	konijn 'rabbit' /ˌkoˈnɛin/	[ˈpɔtɛin]	2;5.23	labial
	d.	nog 'another' /ˈnɔχ/	[ˈmɔχ]	2;5.23	labial
	e.	zon 'sun' /ˈzɔn/	[ˈhɔŋ]	2;6.19	dorsal
	f.	hond 'dog' /ˈhɔnt/	[ˈhɔf]	2;7.17	labial
	g.	schoenen 'shoes' /ˈsχunə/	[ˈhumə]	2;7.17	labial
	h.	zon 'sun' /ˈzɔn/	[ˈpɔmɑ]	2;7.17	labial
	i.	ballonnen 'balloons' /ˌbɑˈlɔnə/	[ˈpɑŋˈtɔmə]	2;8.1	dorsal & labial
	j.	knoeien 'spill' /ˈknujə/	[ˈmuja]	2;8.1	labial
	k.	Noor (name) /ˈnoɹ/	[ˈnuʋɑ]	2;8.1	labial
	l.	kip 'chicken' /ˈkɪp/	[ˈtɪp]	2;8.29	coronal
	m.	vijf 'five' /ˈvɛif/	[ˈsɛif]	2;8.29	coronal
	n.	vegen 'sweep' /ˈveχə/	[ˈneiχə]	2;11.0	coronal
Elke	a.	koek 'cake' /ˈkuk/	[ˈpuk]	1;9.10	labial
	b.	schoenen 'shoes' /ˈsχunə/	[ˈpumə]	1;9.24	labial
	c.	kikker 'frog' /ˈkɪkəɹ/	[ˈtɪtɑ]	1;10.21	coronal
		koe 'cow' /ˈku/	[ˈku]	1;10.21	no change
	d.	bloem 'flower' /ˈblum/	[ˈpɔŋ]	1;11.28	dorsal
	e.	kip 'chicken' /ˈkɪp/	[ˈtɪpt]	1;11.28	coronal
	f.	kijk 'look' /ˈkɛik/	[ˈtɛik]	2;1.16	coronal
		klok 'clock' /ˈklɔk/	[ˈkɔk]	2;1.16	no change
	g.	weg 'gone' /ˈʋɛχ/	[ˈlɛχ]	2;1.16	coronal
		water 'water' /ˈʋatəɹ/	[ˈʋatə]	2;1.16	no change
	h.	ballonnen 'balloons' /ˌbɑˈlɔnə/	[ˈlɔmə]	2;4.29	labial
Tirza	a.	kijken 'watch' /ˈkɛikə/	[ˈtykə]	1;8.5	coronal
		klok 'clock' /ˈklɔk/	[ˈkɔkɛ]	1;8.5	no change
	b.	schoenen 'shoes' /ˈsχunə/	[ˈsumə]	1;8.26	labial
	c.	telefoon 'telephone' /ˌteləˈfon/	[ˈχoŭn]	1;9.11	dorsal
	d.	vallen 'fall' /ˈvɑlə/	[ˈχɑlə]	1;9.11	dorsal
	e.	weg 'gone' /ˈʋɛχ/	[ˈdɪχ] [ˈlɛχ]	1;9.11	coronal
	f.	ballon 'balloon' /ˌbɑˈlɔn/	[ˈlɔm]	1;10.22	labial
	g.	matroos 'sailor' /ˌmɑˈtros/	[ˈŋos]	1;11.19	dorsal
	h.	pruimen 'prunes' /ˈpʀœymə/	[ˈtœymə]	1;11.19	coronal
	i.	zand 'sand' /ˈzɑnt/	[ˈsɑŋ]	1;11.19	dorsal
	j.	zand 'sand' /ˈzɑnt/	[ˈχɑnt]	2;3.27	dorsal
	k.	schoen 'shoe' /ˈsχun/	[ˈpun]	2;5.5	labial

Tom	a.	auto 'car' /'oto/	['topo]	1;0.10	labial
	b.	uit 'out' /'œyt/	['œyΦ]	1;0.10	labial
	c.	koe 'cow' /'ku/	['Φβu]	1;4.14	labial
	d.	bloem 'flower' /'blum/	['χuŋ]	1;5.0	dorsal
	e.	kuiken 'chicken' /'kœykə/	['tœkə]	1;5.28	coronal
	f.	vos 'fox' /'vɔs/	['vɔk]	1;5.28	dorsal
	g.	klok 'clock' /'klɔk/	['kɔp]	1;6.11	labial
	h.	panda 'panda' /'pɑnda/	['pɑŋɑ]	1;6.11	dorsal
	i.	ballon 'balloon' /ˌbɑ'lɔn/	['hɔŋ]	1;6.25	dorsal
	j.	zon 'sun' /'zɔn/	['tʃʉm]	1;7.9	labial
	k.	kikker 'frog' /'kɪkəɹ/	['tɪtɑ]	1;7.9	coronal
	l.	zoemen 'buzz' /'zumə/	['ʃuŋə] (i)	1;7.23	dorsal
	m.	gevallen 'fallen' /χə'vɑlə/	['fɑŋ]	1;8.6	dorsal
	n.	neus 'nose' /'nøs/	['nof]	1;8.20	labial
	o.	zon 'sun' /'zɔn/	['sɔm]	1;11.12	labial
	p.	poes 'cat' /'pus/	['kus]	1;11.26	dorsal
	q.	foei 'pooh!' /'fui/	['χuiç] (i)	1;11.26	dorsal
Catootje	a.	ballon 'balloon' /ˌbɑ'lɔn/	['bɔmɪ]	1;10.11	labial
	b.	kip 'chicken' /'kɪp/	['kit]	1;10.11	coronal
	c.	schoen 'shoe' /'sχun/	['um]	1;10.11	labial
	d.	varken 'pig' /'vɑɹkə/	['hati]	1;10.11	coronal
	e.	klok 'clock' /'klɔk/	['pɔk]	1;10.25	labial
	f.	regen 'rain' /'ʀeχə/	['deχə]	1;10.25	coronal
	g.	giraf 'giraffe' /ʒɪ'ʀɑf/	['u'ɑχ]	1;11.9	dorsal
	h.	kijk 'look' /'kɛɪk/	['ket]	1;11.9	coronal
	i.	olifant 'elephant' /'oliˌfɑnt/	['ɔŋɑm]	1;11.9	dorsal
	j.	telephone 'phone' /ˌtelə'fon/	['hinə'hom]	2;0.6	labial
	k.	doen 'do' /'dun/	['dum]	2;1.25	labial
	l.	rok 'skirt' /'ʀɔk/	['wɔk]	2;2.29	labial
	m.	Roos (name) /'ʀos/	['mʋos]	2;2.29	labial
	n.	T-shirt /'tiʃʌɹt/	['tɪʃɪuk]	2;3.28	dorsal
	o.	handdoek 'towel' /'hɑnˌduk/	['hɑŋˌduk]	2;3.28	dorsal
	p	potlood 'pencil' /'pɔtˌlot/	['bɔkˌhoŭt]	2;4.9	dorsal
	q	weg 'gone' /'ʋɛχ/	['nɛχ]	2;4.23	coronal

Another favourable outcome for the hypothesis would be if there were no apparent cases of Consonant Harmony that contained non-matching vowels, i.e. cases like in (29):

(29)	a.	poes 'cat' /'pus/	→	['tus]
		Lab Lab Cor	→	Cor Lab Cor
	b.	zeep 'soap' /'zep/	→	['fep]
		Cor Cor Lab	→	Lab Cor Lab

At first sight, data of this type do seem to exist. However, apart from the fact that only a small number of such cases is present in our data — in

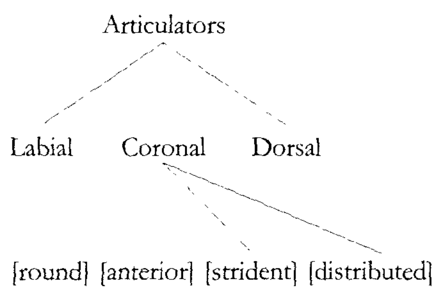
Eva's case, for example, there are only 4 apparent problem cases — it will be shown in the next chapter that these forms, just like the cases re-analyzed in this chapter, do not result from consonant-to-consonant assimilations.

4.4 Representation of place features

The Lahiri & Evers model was used above as a working model, because the relations between labial consonants and round vowels, coronal consonants and front vowels, and dorsal consonants and back vowels is represented in a straightforward way. However, this was not the only currently available model that used this set of place features for consonants and vowels. An alternative model with this characteristic that has been discussed in the previous chapter is the model proposed by Clements (1991) and Clements & Hume (1993). Below, these two models will be compared with respect to the way in which consonant-to-vowel assimilations are represented. It is stressed again that what is described as a process is actually the way we can relate a child surface structure to the attempted adult surface structure.

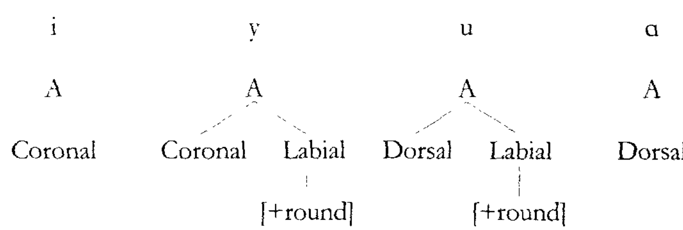
The complete representation of the Articulator node in Lahiri & Evers' (1991) model looks like in (30):

(30) *Articulator node in Lahiri & Evers (1991)*



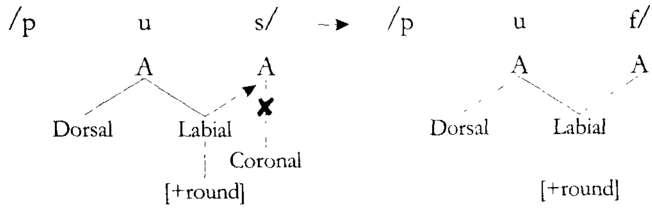
In Lahiri & Evers we find the following representations for vowels — abstracting away here from the tongue position features:

(31) *Vowel representations (adapted from Lahiri & Evers 1991)*



One thing that can be concluded is that consonant-to-vowel assimilation involves single feature spreading, rather than spreading of the entire Articulator node. In the case of round back vowels, what spreads is either the Labial or the Dorsal part of the place specification, and not both — this would probably result in productions with complex segments. The same applies to round front vowels.[6] Another thing that has to be concluded from the representations in (31) is that the representation for round vowels leads to some problems when we want to describe vowel-to-consonant assimilations. In the previous chapter some drawbacks of specifying a round vowel with both [+round] and Labial were already mentioned; here another problem arises. In (32) the change from the adult surface form of *poes* 'cat' /'pus/ to the child's surface form ['puf] is illustrated. We assume that the process involves spreading of the vowel place feature, with simultaneous delinking of the original place feature of the targeted consonant:

(32) *Labial assimilation in the Lahiri & Evers model*



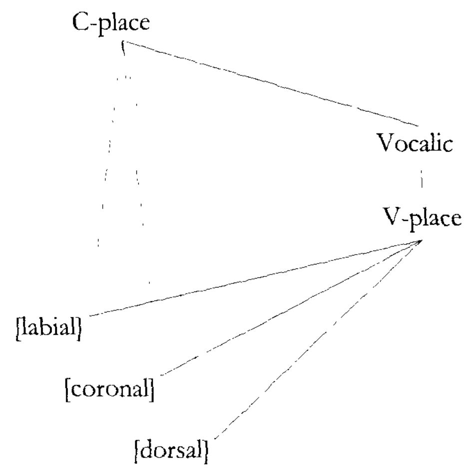
Spreading of Labial from the vowel /u/ automatically spreads [+round] with it, which would result in a rounded /f^w/ in the child's production instead of the produced non-rounded /f/. In other words, the resulting labial consonants would always be labialized labials. It is, obviously, not the case that only [+round] spreads from the vowel, since this would result in labialized coronal and dorsal consonants instead of plain labial ones. We could get around this problem by claiming that since [+round] labial consonants are not part of the Dutch segment inventory the [+round] labial consonants that result from spreading have no independent phonetic interpretation and will therefore be phonetically categorized as the more familiar plain labial consonants. Spreading of both Coronal and Dorsal from vowels can be represented in a straightforward way. It is remarkable, however, that in this model it is, except for 'secondary' labialization which involves spreading of [+round], easier to capture the primary place feature

[6] In the next chapter we will discuss the way the child initially represents these 'complex' vowels.

assimilations of the type we encounter in child language, coronalization and dorsalization, than it is to capture secondary place feature assimilations, like palatalization (which is, in Lahiri & Evers (1991), accounted for in terms of either [–ant] or [+high] spreading) and velarization.

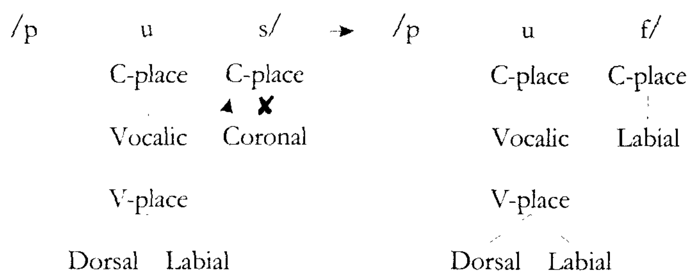
In (33) is the place feature representation of Clements (1991):

(33) *C-place node (adapted from Clements & Wetzels 1993)*



In this model too, round vowels have a 'complex' representation, and the assimilation process consequently again involves single feature spreading. In Clements (1991) vowel-to-consonant assimilation still involved the elaborate procedure of Tier Promotion and Complex Segment Simplification, discussed in the previous chapter. Hume (1992) simplified this procedure by simply allowing for cross-tier spreading, though as a marked option, and in Clements & Hume (1993) this appears to be the accepted way to represent vowel-to-consonant spreading. In (34) the /'pus/ to ['puf] 'derivation' is represented again:

(34) *Labial assimilation in Clements & Hume's model*



Labial thus spreads cross-tier from the V-place node of the vowel to the C-place node of the consonant, while at the same time Coronal is delinked from the C-place node of this consonant. Spreading of Coronal and Dorsal would apply in the same manner. Although this is a quite straightforward representation of the facts, the place feature representation in itself contains a lot of structure that appears to be quite redundant. Clements' argument for providing vowels with both a C-place node and a V-place node was that the consonant-to-consonant assimilation across vowels should be ruled out, while vowel-to-vowel assimilation across consonants should be possible. After all, Consonant Harmony involving primary articulation features does not exist in adult languages; Vowel Harmony involving primary articulation features, however, is a common phenomenon. Since both consonants and vowels have a C-place node, while only vowels — and consonants with a secondary articulation — have a V-place node, spreading of the C-place node from a consonant to a non-adjacent consonant will always result in a violation of the Line Crossing Prohibition when there is an intervening vowel specified for Place. When the vowel spreads its V-place node across a consonant, however, this is not blocked as long as the consonant has no secondary articulation.

Single feature spreading from consonant to non-adjacent consonant, however, is still possible although this does not occur in the languages of the world either. Furthermore, if the non-existence of Consonant Harmony is the argument for a C-place node for vowels, then vowels should also be provided with a specification for [continuant], [consonantal], etc., since non-adjacent consonants do not harmonize in this way either. In the previous chapter it was also suggested that it was probably more fruitful to account for Vowel Harmony in a slightly different way, namely in prosodic terms; vowels, being syllable heads, are adjacent to another on a higher prosodic level than the segmental level, and spreading of Place features can, under this interpretation, take place without problem. The place feature representation can then be kept as simple as possible.

It is clear that at this moment the child language data actually provide no decisive arguments for either of the feature geometrical representations discussed here. What is most important is that Labial groups round vowels and labial consonants, Coronal groups front vowels and coronal consonants, and Dorsal groups back vowels and dorsal consonants. Since we do not have to deal with secondary articulated consonants, the simplified Lahiri & Evers model from (24), repeated here partially in (35), is adequate for our purposes.

(35) *Place of Articulation feature structure assumed here*

Place

Articulators

Labial Coronal Dorsal

4.5 Summary and Concluding remarks

Current principles in phonological theory regarding adjacency force us to assume planar segregation of consonants and vowels in order to be able to account for Consonant Harmony in child language. It was shown, however, that external evidence for the postulation of planar segregation in child language, namely an absolutely predictable consonant-vowel sequencing in syllables, was lacking. Examination of the vowels that intervened between the consonants that were thought to be involved in the phenomenon revealed that these actually had the same articulator feature specification as the harmonized consonant — or as the apparent trigger consonant, for that matter. Numerous data containing consonants that were clearly affected by the adjacent vowel strengthened the hypothesis that Consonant Harmony can better be viewed as Vowel-Consonant Harmony. An account in these terms does not run up against any theoretical problems. Contrary to Consonant Harmony, which would be a phenomenon exclusive to child language, since primary instead of secondary articulators are involved, Vowel-Consonant Harmony finds parallels in the adult languages of the world and provides external evidence for the representation of place features as it is currently conceived.

From the above discussion it might appear that nobody has ever noticed coarticulations of vowels and consonants in the productions of the language acquiring child but this is not totally true. The presence of such interactions between vowels and consonants has been reported in the literature on phonological acquisition by, among others, Jakobson (1941/1968), Ingram (1976), Stoel-Gammon (1983) and Davis & MacNeilage (1990).

Jakobson observed that "...*i* and *u* represent for a one-year old Czech girl a single high vowel phoneme, and similarly *e* and *o* a single mid vowel phoneme: *i* and *e* occurred only after dentals, *u* and *o* only after labials, while before *a* labials as well as dentals occurred" (p. 29).

Stoel-Gammon reports data from a child she studied, Daniel, who produced the words *bubble*, *bottle*, *ball* and *balloon* with a [b], while *pee-pee*, *baby*, *Big Bird* and *beep-beep* were produced with a [d] (p. 456). These data are also consistent with our findings.

Finally, in a study by Davis & MacNeilage on the acquisition of correct vowel productions we find that "[...] the alveolar environment is the only one in which high front vowels are consistently favored[...]" and "High back vowels are most favored in velar environments."

In view of these observations it is surprising that, up until now, no attempt has been made to systematically investigate this issue in the field of the acquisition of phonology.

A few questions remain to be answered. Why should (Dutch) children have Vowel-Consonant Harmony and how systematic is it? Another question is whether the assimilating power is exclusive to vowels in child language, or is there also something like Consonant-Vowel Harmony, i.e. consonants affecting adjacent vowels?

Concerning the 'why' there are two possible answers. One possibility is that the phonological system of the child is, in the course of development, organized in such a way that words can only be produced in one way and not in another. Forms that, compared to the adult models, appear to be cases of Vowel-Consonant Harmony are, in this account, adapted to the child's system. This explanation has been encountered in the discussion of the literature. In the next chapter a proposal along these lines will be worked out in more detail and it will turn out that part of the data presented in this chapter is indeed a product of the developmental state of the child's phonological organization. However, the Vowel-Consonant Harmony data of the majority of the children are not very systematic and often exist next to non-harmonized versions of the adult model. In these cases, the assimilations probably reflect planning problems: as long as the child is not able to fully control the production of combinations of segments with different articulator features, assimilations can occur. The vowel is probably a good anchor to hold on to for the child, since it is both a perceptually salient segment, and an important phonological unit as head of the syllable.

This brings us to the other question, namely whether it is indeed always the vowel that acts as the 'trigger' for assimilation. This is not the case. Vowels do become round next to a labial consonant, front next to a coronal consonant or back next to a dorsal consonant, although not very frequently. In the next chapter it will become clear that, like some of the Vowel-Consonant Harmony cases and the cases that appeared to be real instances of Consonant Harmony, many Consonant-Vowel Harmony cases are due to the developmental state of the child's phonological output system.

5 The developing output system

Place of Articulation

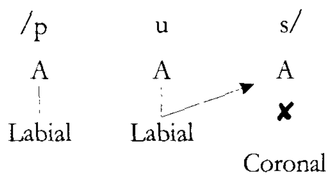
5.0 Introduction

The actual study of (aspects of) the acquisition of place features was launched in the previous chapter with a discussion of the well-known child language phenomenon that in the literature on child phonology is known as Consonant Harmony. Close examination of the Dutch database revealed that previous analyses of this phenomenon were not satisfactory. The crucial finding was that the assimilating place features were spread from the vowel adjacent to the assimilated consonant, rather than from a non-adjacent consonant. This close relation between Place of Articulation (POA) features of consonants and vowels was expressed in the feature geometry, where consonants and vowels shared the same set of POA features. With this in mind, a further step towards a model for the acquisition of a place feature representation is made here.

The acquisition of segmental aspects of phonology does not only involve acquisition of the internal structure of segments. In other words, having acquired a representation for the segment inventory of the language does not guarantee matching productions of adult target words. Jakobson (1941/1968) called the acquisition of the segmental inventory of a language acquisition along the paradigmatic axis. In order to produce a string of segments, like a word, however, it is not enough to know the feature representation of the individual segments. For example, Robin, a child from this study, has apparently acquired the segments /s/ (given ['sɛs], for *zes* 'six' /'zɛs/, /u/ (given ['bumə] for *bloemen* 'flowers' /'blumə/) and /p/ (given ['ap] for *aap* 'monkey' /'ap/). At some point Robin is able to combine these segments in the production ['pus] (for *poes* 'cat' /'pus/), but he is not able to produce ['sup] (for *soep* 'soup' /'sup/), which involves the same set of segments. Instead, for a long time Robin produces ['fup] for target *soep*. Learning to combine the different segments into longer stretches of speech is termed acquisition along the syntagmatic axis (Jakobson 1941/1968). While most studies on the acquisition of phonology have focused on the acquisition of segmental paradigms, this chapter addresses acquisition on the segmental plane focusing on syntagmatic aspects.

The idea, also expressed in Menn (1978) and Iverson & Wheeler (1987), is that child language phenomena are not independent phenomena, but rather the various results of output representations for words that are constrained in one way or another. Taking the familiar VC-Harmony cases again, an issue to be addressed is what the output representation of these forms actually looks like. A word like *poes* 'cat', which becomes ['puf] in the child's production, could on the one hand have a representation like in (1): the different segments are all specified for some Place of Articulation feature. Subsequently, Labial is spread from the vowel and replaces the original Coronal specification.

(1) *Procedural analysis of the production ['puf] for the adult model /pus/*



This is the procedural analysis presented in the previous chapter. On the other hand, there could initially be a limitation on the linking of place features in words, which can be captured by a representation like in (2):

(2) {WORD, Labial}

The intention of this representation is to express that an abstract category WORD, rather than a segment is initially the unit for feature specification in the child's output representation. We will come back to this unit WORD below. The feature Labial will end up being associated to all the elements in a word in the child's production. The output representation of the adult model /'pus/ in (2) thus also results in the production ['puf]. It will be argued that these two representations are, indeed, both available, but at different points in time. Initially, children will have representations like in (2), and a production like ['puf] will result. At a later stage, individual segments, rather than words will be specified for place features, and at this stage spreading of the place feature from the vowel, i.e. VC-Harmony, can be represented. Both (1) and (2), then, characterize Harmony, but for different reasons.

The idea pursued here is that the unit for specification of POA features is initially much larger than the individual segment in the child output representation, namely WORD. The (Dutch) child ultimately needs to be able to specify single segments for POA features. This segmentalization of the unit WORD is not accomplished from one moment to the next. As a first development, certain POA features appear to be assigned to specific locations in the word. This results, among other things, in productions that in the child language literature are called instances of 'Fronting' — like the '['pus] but *no* ['sup]' case of Robin mentioned above. Fronting has been analyzed as a phenomenon due to a cooccurrence restriction on consonants in a word to the effect that the first consonant in a word must be more front in terms of place of articulation than the second one (Ingram 1974, 1989; Menn 1975, 1978). Here, Fronting will not be taken to be a result of a cooccurrence constraint on consonants, but rather of edge constraints on the linking of place features in a word.

The development of a place feature representation in words, then, is viewed here both in terms of limitations on the units with which output representations are built — like WORD, instead of segment-sized units — and in terms of constraints on these output representations.

The chapter is organized as follows. Below in 5.1 a selection of the literature concerning the word as initial unit of acquisition is discussed. In 5.2 some basic assumptions concerning the assumed feature model and the sound inventory of Dutch are introduced. Then, in 5.3, a grammar — a model for the developing output representation with respect to POA features — is presented. The working of this model is discussed in detail in 5.4 on the basis of extensive data from Robin. These data are compared to the data of other children of the Fikkert/Levelt corpus in 5.5. In 5.6, finally, a summary of the findings is presented.

5.1 The word as a basic unit of acquisition: literature

The idea that features are initially associated with a unit larger than the segment is not new. Remarks and proposals to this effect can be found in, among others, Jakobson (1971), Waterson (1971), Moscowitz (1973), Chiat (1979), Macken (1979) and Iverson & Wheeler (1987).

In his work on child language, Jakobson concentrated mainly on the paradigmatic relations between sounds, i.e. phonematic contrasts. A remark from Jakobson (1971) is, however, worth mentioning in the light of this chapter and can be translated to the idea that initial units for feature specification are larger than the segment: "At first child's language is devoid of any hierarchy of linguistic units and obeys the equation: one utterance-one sentence-one word-one morpheme-one phoneme-one distinctive feature" (p. 25).

Waterson (1971), working in the Firthian prosodic phonology framework, presented a non-segmental analysis for child language, which would give "[...] greater freedom to express various correlations between child's and adult's forms and structures." When analyzed segmentally, certain forms of her subject P appeared to have no correlation at all with the corresponding adult forms. The child forms did, however, share a large number of features with the corresponding adult forms, but they were distributed over the word in a different way. Waterson found that the productions of P all fitted into one of five basic word structures, each of them containing a specific selection of prosodic and articulatory features. According to Waterson, these selections of features form schemata which facilitate both the production of forms — less planning of articulatory programs needs to be done — and the acquisition of new forms — through pattern recognition. Development consists in providing these schemata with more and more phonetic detail, and finally, in the abolishment of the schemata.

The actual analysis of P's utterances is, however, difficult to generalize as a model of acquisition. First of all, Waterson recognizes two types of features: (1) Segmental features, associated with places within the syllable, like manner features and place features (labial, apical, dorsal); (2) Syllable features. These features are said to associate with "[...]the whole or part of the syllable but not with place within the syllable, e.g., frontness, backness, centrality, lip-rounding, lip-spreading, nasality, voicing, voicelessness." Waterson clearly recognizes the fact that features are associated to larger units than the segment in child language. However, the syllable features and segmental features are disjoint sets. There is, for example, 'frontness', which can affect a whole utterance, and there is 'apical', which affects individual segments. There is, however, no instance of frontness associating to segments, or of apical affecting the whole utterance. In contrast, the idea pursued here is that it is the same set of features which is initially associated to a structure larger than the segments, and in a later stage will be associated to single segments.

The actual word structures proposed by Waterson are quite hard to interpret. For example, a word scheme called 'Labial structure' refers to forms that share the following features: labiality at the onset of each syllable, continuance, voiced onset of every syllable, voiced ending of every syllable, broad degree of openness of the vowel, prominence of one syllable, and syllable structure CV. Another word scheme is called 'Stop structure,' and contains the basic features: oral stop at syllable onset, voiced ending of syllables, prominence of first syllable, disyllabic word structure. The words that belong to these structures are the following:

(3) *Word structures proposed by Waterson (1971)*

Labial structure		Stop structure	
fly	[βæ] [væ] [bβæ]	biscuit	[beːbeː]
barrow	[bʌwu]	Bobby	[bæbuː]
flower	[væwæ]	pudding	[pupu]
		Kitty	[tɪtɪ]
		dirty	[dətɪ]

It is neither immediately obvious that indeed these word schemata are at work in P's phonological system, nor why P's productions for 'fly', 'barrow' and 'flower' are considered to be so different from his productions for 'biscuit' and 'Bobby'.

As a first non-linear approach to child language data, however, and the only one for many years, the work has considerable merit.

Moscowitz (1973) hypothesized that children initially concentrate on intonation, and therefore focus on intonation-carrying units. At first, the child will focus on a sentence-unit. Then, the child will narrow down this sentence-unit to a smaller intonation-carrying unit, the syllable. This unit helps the child to develop the semantic notion of 'word', and 'word' and 'syllable' become equated at this point. Only then is a phonological system in terms of phonemes and phoneme oppositions construed. The hypothesis is not worked out empirically.

The role of the word in phonological development is also stressed in a paper by Chiat (1979). Her claim is that in the early stages of phonological development the child is not ready to focus on phonemes differentiating meaning, since the child's primary task at this stage is to break up the speech chain and isolate meaningful units, i.e. words. In other words, the child needs to know what the form is before it can focus on the details of the content of these forms.

Macken (1979) presented an account of the data of a subject Si, acquiring Spanish as a first language, in terms of 'preferred output patterns' for words. The 'word', rather than the phoneme is taken to be the organizing unit of the child's early phonology. Only at a later stage can the phonological system of the child be described in terms of phonemic contrasts. The way in which Macken uses the 'word-as-unit' is different from the way it will be used in the proposal below: as an unanalyzed unit for, among other things, feature specification. The word here is more like it is used in Waterson, as a demarcated domain in which constraints in the form of word patterns determine the type and ordering of consonants. As an illustration, examples of word patterns presented in Macken are in (4):

(4) *Word patterns in Macken (1979)*
word pattern [m_n_]
adult words selected for this pattern in stage I are *manzana* 'apple' and *mano* 'hand'
Si produces [mənna] and [waɪnno] respectively.

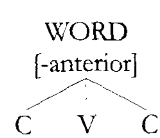
word pattern [p/b_t/d_]
adult words selected for this pattern in stage II are, among others, *zapato* 'shoe' and *sopa* 'soup'
Si produces [pwatto] and [pwæta] respectively

Iverson & Wheeler's (1987) idea comes close to the proposal that will be accounted for in this chapter, as the quotation below shows:

> "...the child learning a language such as English [...] has to discover that features like [voice], [anterior], [nasal], etc. are not properties of words, syllables, or other suprasegmental constituents" (p. 249).

An important element of the proposal that will be worked out in this chapter, which is ignored in Iverson & Wheeler and therefore detracts from the impact of their idea, is the fact that both consonants and vowels are ultimately affected by the feature which is taken, by the child, to be a property of the word. Take once more the well-formedness template, discussed already in the previous chapter, that the child may posit according to Iverson & Wheeler:

(5) *Child's word template as proposed by Iverson & Wheeler (1987)*



They state: "Any word that has a back consonant will be associated with this *word structure*, yielding the effects of the otherwise curious process of Velar Assimilation, where all *consonants in a word* are velar if there are any". (p. 251, italics added). They proceed: "Similar accounts are available for processes like labial [...] assimilation." In the previous chapter it was argued that in the case of a Labial word template an effect on the vowel would certainly be expected, also in Iverson and Wheeler's theory of feature organization.

Wijnen (1990), finally, concludes an overview of child phonology literature that partly overlaps the works discussed here as follows: "The conclusion that can be drawn from these and similar studies is that children's early word form representations do not contain phonemic segments. Rather, they seem to consist of a set of articulatory features, integrated in a prosodic 'carrier'." (p. 117)

Although the issue has received quite some attention in the literature, it has not been thoroughly investigated. In the single-subject studies of Waterson and especially Macken, the word is viewed as an organizing unit rather than as a unit, as yet not further analyzed, for feature specification. Furthermore, the word patterns that in these studies are found to be active in the child's phonological system are quite idiosyncratic and can be generalized only to a certain extent. Iverson & Wheeler, who do assume that in the early stages of phonological acquisition features are a property of words, rather than of segments, ignore the effect these feature specifications for words will ultimately have on the produced vowels. The findings in the previous chapter already gave an indication that both vowels and consonants will be affected by POA feature specifications for words. It is therefore worthwhile to elaborate on the issue, making use of the extensive amount of data collected for this study. This way it will be possible to consolidate the previous findings and to formulate a proposal that is at the same time more detailed and more generally valid.

5.2 Background assumptions

In the previous chapter it turned out that in child language there are relations between round vowels and labial consonants, front vowels and coronal consonants, and back vowels and dorsal consonants, just as in the (adult) languages of the world. These relations are best captured in a feature model that can refer directly to these groupings, with a single set of place features for consonants and vowels. A simplified Lahiri & Evers (1991) model, where a familiar geometrical organization is combined with a restricted set of monovalent features, turned out to be the most suitable model for this purpose. This feature organization will function as a working model here. Again, the focus will be on the Articulator node only. The height features are the focus of the next chapter.

The POA features refer to the following segments in Dutch:

Labial:	round vowels:	/y, ø, ʉ, u, o, ɔ, œy/
	labial consonants:	/p, b, f, v, m, ʋ/
Coronal:	front vowels	/i, e, ɛ, ɪ, y, ø, ʉ, ɛi, œy/
	coronal consonants:	/t, d, s, z, n, j, l/
Dorsal:	back vowels:	/u, o, ɔ, ɑ, a, ɑu/
	dorsal consonants:	/k, χ, x, ŋ, ʀ/

In the data, the Dorsal fricative has in general been transcribed as /χ/, a uvular (voiceless) fricative. In Dutch the Dorsal fricative is pronounced either as the velar /x/ or the uvular /χ/, depending on the part of the country. Phonologically there is no contrast between these two fricatives. In general, the parents and children of this study produced uvular fricatives. They also produced the dorsal, rather than the coronal, version of the 'r', transcribed as /ʀ/. Post-vocalically 'r' is far more sonorant, and is transcribed /ɹ/.

The full POA feature specification of front round vowels like /y/, and back round vowels like /u/, is complex, as in (6):

(6) *Full POA specification of round vowels*

It will be assumed here, however, that initially these vowels have a non-complex representation. Children often do not produce dorsal consonants in the earliest stages of phonological acquisition. The claim is that at this stage there is a constraint on Dorsal specifications in the output representation. Consequently, the hypothesis being that there is only a single set of Place features for consonants and vowels, the feature Dorsal is assumed to be banned from the output representation for vowels too. As long as there are no dorsal consonants in the data of a child, then, the back round vowels will be referred to as Labial. The question then is how to distinguish the front round vowels from the plain front vowels. It turns out that it is not yet necessary to distinguish these two classes by means of the feature Labial, since most of the children do not consistently distinguish between them in their productions. Robin, for example, produces on the one hand the non-round variants [ɛi], [ɛ] and [a] for the adult round model /œy/, alongside the round variants [œ] and [œy]. On the other hand, he produces either non-round [ɛi] or round [œy] for the non-round adult model /ɛi/, either non-round [ɛi] or round [œy] for the non-round adult model /ɛi/, independent of context. From these facts it can be concluded that the target front round vowel /œy/ is only incidentally, and maybe even accidentally, rounded in the child's production. Accordingly it is assumed that in general Labial is not distinctive for front vowels at this stage. Both round and non-round front vowels are therefore referred to as Coronal.

To summarize: as long as there are no dorsal consonants in the child's productions, there will be two species of sounds in the child's productions with regard to POA feature structure: Coronals and non-Coronals. The non-Coronals are captured by the feature Labial. If the constraint on Dorsal specifications loses importance in the child's system, it is still assumed that the representation for a back round vowel need not be complex. In this case either a specification Labial or a specification Dorsal will be assumed to result in a back round vowel production.[1]

A final and more familiar assumption is that Coronal is the default value for Place of Articulation. It is therefore not necessary to specify Coronal in the output representations.[2]

5.3 A model for the acquisition of POA features in word productions

The following interesting observations were made in the Fikkert/Levelt corpus of child language:

— at first no combinations of different POA features are found in words produced by the children
— combinations of a Coronal consonant and a Labial (Dorsal) vowel in CV sequences, like /to/, are not found in the data for some time.
— C_1VC_2 sequences where C_2 is a Labial consonant and C_1 is a non-Labial consonant do not occur in the data for a long time.
— $C_1V(C_2)$ sequences where C_1 is Dorsal either do not occur in the data at all, or occur in the data only if V (and C_2) are Dorsal too.

[1] In Jakobsonian terms, the opposition is Acute versus Grave, where for consonants the phonetic interpretation of Grave is initially restricted to labial.
[2] There is a large body of literature on this topic (see Paradis & Prunet 1991, and the short discussion of underspecification in the previous chapter.

These observations on what is not found in the data, in combination with observations on what does occur in the data of the children, will be accounted for by gradual developments in the phonological output system of the language learner. Before turning to these developments, however, a general outline of the phonological output system assumed here is presented.

The phonological output system consists of three components: (1) Phonological features that need to become associated to some higher organizing unit in the output representation. In the present discussion these are limited to the Place of Articulation features Labial and Dorsal (Coronal is presumably not specified in the output representation). This component will be called F; (2) The phonological units that carry a feature specification (or: higher organizing units) available to the system that generates output representations. This component will be called U; (3) Constraints on the output representations. This component is called C. In the present discussion only constraints regarding the association of POA features will be concerned.

The output system formally looks like (7):[3]

(7) *Output System*
Output System = (U, F, C)[4]

Output representations generated by this system are thus fully dependent on the contents of the components U, F and C. Developments in these components concomitantly lead to developments in the output representations. In the model proposed here developments only take place in the components U and C.

In (8), then, a model of the developments that concern the POA feature representation in words is presented:

[3] Cf. Levelt (1974) for this format of representation.

[4] A grammar that closely resembles this model is the one recently proposed in Optimality Theory (Prince & Smolensky 1993, McCarthy & Prince 1993). Although the analyses presented in this chapter are to some extent interpretable in terms of this theory, the full impact of Optimality Theory on the issues discussed here is, at the moment of writing this thesis, not clear. In accordance with this theory it will be assumed that the constraints form a hierarchically ordered set and are minimally violable. These assumptions play no crucial role in this chapter, although the spirit of this aspect of Optimality Theory is apparent in formulations like constraints being 'dominantly present', or 'losing importance'.

(8) *Model of the acquisition of a place feature representation for words*

A. Developments in U:

I. In the child's output system the category WORD is initially the only available unit for Place feature specification. Only the WORD as a whole can be referred to. It is thus assumed that at this stage the segment is not an actively manipulatable unit yet.

A Labial specification will be represented as {word, Labial} and results in a production whereby all the segments of the word have a Labial specification. A Dorsal specification is captured by {WORD, Dorsal}. The representation {WORD} stands for an unspecified member of the category WORD, which will consist of Coronal segments in the production.

II. As a first development, the left edge of WORD becomes available as a unit for POA feature specification. The 'edge' refers to either a consonant or a vowel in the production of the child.

Representations whereby reference is made to the left edge of WORD have the form {[WORD, POA feature}.

III. In the phonological system of the child it subsequently becomes possible to refer to the vowel, independent of an edge. At this stage the vowel will be referred to as WORD-Peak (i.e., the sonority peak of WORD) in order to indicate that consonants and vowels are still dependent on their encapsulation in the WORD with respect to aspects of a POA feature specification. From this stage on assimilation procedures like VC-Harmony can be represented in the phonological system of the child.

Representations whereby reference is made to the sonority peak of WORD have the form {WORD-P, POA feature}.

IV. Next, the right edge becomes available as a unit of POA feature specification.

Representations whereby reference is made to the right edge of WORD have the form {WORD], POA-feature}.

B. Developments in C:

I. There is a preference for Labial specifications over Dorsal specifications in the output representation. This is captured by a constraint on Dorsal specifications.

II. As soon as WORD-edges become available as specifiable units in U, the general pattern is that Labial is specifically assigned to the left edge, while Dorsal can only be assigned to the right edge (or WORD-Peak). This patterns is captured by

> so-called edge-constraints. The constraint on Dorsal specifications gives way to a constraint excluding Dorsal specification of the left edge. In contrast, Labial is specifically directed towards this left edge.
>
> Finally, the WORD is abandoned as unit of place feature specification and the edge constraints are no longer dominantly present in the phonological system of the child. From then on segments specified for any POA feature can occur anywhere in the produced word.

The acquisition of adult-like POA feature representations for words is, then, partly a process of gradual atomization, or segmentalization of the unit of specification, from a whole unanalyzed WORD, to the left edge of WORD, to the sonority peak of WORD, to the right edge of WORD, and finally to individual segments. The other part of the acquisition process lies in the effect the constraints have on output representations.

It will be seen that the children of this study are to a high degree consistent with the model in (8). Differences among the children are mostly in terms of timing of the proposed stages: while in the data of some children the different stages can all be distinguished, in the data of others this is not possible. Since the recordings were made every other week this could well be an artefact of the recording procedure. The order of the developments in III and IV will, however, turn out to be variable: for some children stage IV precedes stage III. Furthermore, although a preference for Labial specifications over Dorsal specifications in output representations is found for all the children in this study, the extent to which Dorsal specifications are banned in the output representations of the different children varies.

Before turning to the data a little more needs to be said about the category termed WORD. First of all, WORD instead of plain 'word' is employed in the text to denote an abstract category, a unit for a place feature specification. The assumption is that universal sonority templates take care of the sequencing of segments in the WORD (cf. Fikkert 1994 for details on this aspect of acquisition).

The unit that will be considered in connection with place features does not always correspond to the whole uttered word. The part of the word produced by the child that is taken into account is the stressed syllable plus, in case of a bisyllabic word, the consonant of the following unstressed syllable. In general this amounts to the initial VC or CVC part of the uttered word. As such the unit WORD can be equalled to the minimal Prosodic Word, a Foot-long stretch of sound (Itô 1986, McCarthy & Prince

1986, McCarthy & Prince 1990). In a produced form like ['pus] for *poes* 'cat' all the segments are taken into account, while in a form ['lopə] for *lopen* 'walk' the sequence /lop/ will be taken into account, ignoring the unstressed /ə/. In these early stages of phonological acquisition, words are usually not longer than two syllables (Fikkert 1994).

5.4 The data

5.4.1 The nature of the data

The data that will be discussed here come from six children. Five of them are children of the Fikkert/Levelt corpus that were recorded from the earliest stages of meaningful speech. From the sixth subject the first meaningful words were not recorded, but the initial stages of the proposed model are still clearly discernible.

From these children the POA feature make-up of every single spontaneous and interpretable utterance was taken into consideration, up until the point that segments in any position in the word could be specified for any POA feature. Obvious onomatopoeic forms were left out of consideration because in these forms sounds are often used that at that moment do not occur anywhere else in the data of the particular child. Children that will always produce /t/ for adult model /k/ will nevertheless imitate the crowing of (Dutch) roosters as ['kykələ'ky], and not as ['tytələ'ty].[5]

As will be seen, there are striking similarities between the children in the light of the proposed model of development, but also some differences. Therefore, the model will first be illustrated in detail with data of one child, Robin. Then we will turn to the data of the other children, which are presented in less detail and in comparison with Robin.

5.4.2 The initial stage: WORD specifications and *Dorsal

The hypothesized initial state of affairs is that the child has as yet no notion 'phoneme' in its output representation. Instead, features are associated to the larger unit WORD. Ignoring for the moment the component C, the output representations that can be generated in this stage are in (9):

---

[5] This, by the way, shows that the child has no articulatory-phonetic problem with sounds like /k/.

(9) a. {WORD}
b. {WORD, Labial}
c. {WORD, Dorsal}

The representation in (9a) is the unspecified representation and results in productions that have a Coronal place of articulation throughout, i.e. Coronal consonants and front vowels. In (9b) the WORD is specified Labial, which will result in a production with Labial consonants and round (& back) vowels. A production with Dorsal consonants and back vowels is represented by (9c).

If (9) indeed captures the varieties of POA feature make-up of the child's initial lexicon, a quite restricted set of produced words is expected. Robin's first 11 words, produced at age 1;5.11, presented in (10), are a clear illustration of this stage.

(10) *Robin's initial set of produced words*

{WORD}	a.	die 'that one' /ˈdi/	[ˈti]	1;5.11
	b.	huis 'house' /ˈhœys/	[ˈhœys]	
	c.	niet 'not' /ˈnit/	[ˈnt]	
	d.	thuis 'home' /ˈtœys/	[ˈtœs]	
	e.	zes 'six' /ˈzɛs/	[ˈsɛs]	
	f.	tiktak 'tick-tock' /ˈtɪkˌtɑk/	[ˈtita]	
	g.	aan 'on' /ˈan/	[ˈan]	
	h.	daar 'there' /ˈdaɹ/	[ˈta]	
{WORD, Labial}	i.	pop 'doll' /ˈpɔp/	[ˈpɔ]	
	j.	mama 'mommy' /ˈmɑma/	[ˈmɑma]	
	k.	aap 'monkey' /ˈap/	[ˈap]	

The forms produced by Robin in (10a–f) consist of coronal consonants in combination with a front vowel, which can be captured by the representation {WORD}. The form in (10i) has a labial consonant and a round (& back) vowel, and is an instance of {WORD, Labial}. In (10g, h) and in (10j, k) we encounter forms which at first sight do not conform to the representations since the vowels /ɑ/ and /a/ are considered to be neither front nor round. It is assumed, however, that these vowels do not need a POA feature specification Dorsal, since they can be uniquely referred to by the feature [+low]. The complete representation of the forms in (10g, h) and the forms in (10j, k), then, is {WORD, low} and {WORD, Labial, low} respectively. It is assumed that the feature [+low] will automatically associate to the sonority peak of the word, i.e. the vowel position. The association of Labial in (10j, k) with the entire word might have some effect of rounding on the [+low] vowel, but since no Labial [+low] vowel contrasts with a plain [+low] vowel in Dutch, it is not relevant to the phonology.

The feature [low], however, is not a POA feature but a Tongue Position feature, which does not concern us here. In this chapter [low] will therefore not be included in the representations. Leaving [low] out, the representations are identical to the two POA representations in (9a) and (9b).

Robin produces one word, ['bibi], for *baby* 'baby' /'bebi/, that does not comply with any of the representations in (9) since it contains a combination of a labial consonant and a coronal vowel. This could be disposed of as an exception. However, ['bibi] could also be the first word whereby reference is made to the left edge of WORD in the representation, stage II in the proposal. For the moment the issue will be left open.

There are at this stage no Dorsal segments in Robin's productions. Above in 5.3 it was already mentioned that this situation would be captured by an output constraint on Dorsal specifications. The first constraint on output representations to be encountered, then, is in (11):

(11) *Constraint on Dorsal specifications*
*Dorsal

It is also worthwhile contemplating the adult models in (10): they can be represented by {WORD} and {WORD, Labial} almost as readily as the child's renditions of them. Except for *tiktak*, the words in (10a, b) — *die, niet, thuis, huis, zes, aan, daar* — all comply with the representation {WORD}, while the models in (10c, d) — *pop, mamma, aap* — fit the representation {WORD, Labial}.

It thus appears that Robin specifically selects words from the adult language that fit his phonological output system. Words from the language that deviate too much are avoided. This is an interesting phenomenon since it provides evidence for the child's awareness of phonological properties of words and sounds: he is apparently able to phonologically analyze the adult form to some extent. The reader is referred to Ferguson & Farwell (1975), Kiparsky & Menn (1977), Schwartz & Leonard (1982) and references therein for further observations on this matter.

In the next two recording sessions, Robin produces the following new words:

(12) *New words produced by Robin*

a.	{WORD}	deze 'this one' /'dezə/	['tis]	1;5.21
		televisie 'television' /ˌteləˈvisi/	['zizi]	
		trein 'train' /'tʀɛin/	['tɛin]	
		ijs 'ice' /'ɛis/	['æis]	1;6.9
		Sesamstraat 'Sesame Street' /'sesɑm'strat/	['zisa]	
		uit 'off' /'œyt/	['œyt]	
b.	{WORD, Labial}	boom 'tree' /'bom/	['bom]	
		mooi 'pretty' /'moi/	['boːi]	
		bal 'ball' /'bɑl/	['bɑo]	

These new words all fall within the existing categories, and again the adult models appear to be selected for their compliance with Robin's phonological system. The discrepancies between the adult models and Robin's renditions of them are mostly in terms of syllable structure.

In these recordings we also encounter two forms that are similar to the production ['bibi] of the previous recording:

(13)	meer 'more' /'meɹ/	['mi]	1;5.21
	mij 'me' /'mɛi/	['mi]	1;6.9

It is less likely that these forms too are exceptions, and it thus seems that the left edge of WORD has become available as a unit for POA feature specification in Robin's output system. We will turn to this development in the next section.

The first sets of words produced by Robin thus clearly reflect the proposed initial state of the developing phonological system: a whole WORD, rather than individual phonemes in a word, is the unit for a POA feature specification (or is left unspecified) in the child's phonological output representation. Furthermore, it appears that this unit can only be specified for the POA feature Labial. This is thought to result from the constraint *Dorsal, which does not allow Dorsal specifications in output representations. Otherwise, the unit WORD is left unspecified, which results in a Coronal specification by default. The two output representations that can be generated with this material are (9a) {WORD} and (9b) {WORD, Labial}.

5.4.3 Attempting non-fitting adult models and the WORD edge

One way for the child to cope with the limitations of its output system is the selection strategy encountered above. In this case, the child will only produce words from the language it is acquiring that are in conformity with the possibilities of his phonological output system. A conceivable alternative is that an adult form that does not comply with the limitations of the child's system already is nevertheless provided with one of the output representations that the system is able to generate. In that case, the child's production will deviate from the adult's surface representation. The main strategy initially, of Robin at least, is lexical selection.

In the following recordings of Robin, however, around age 1;7, adult words that are not in accordance with the representations {WORD} and {WORD, Labial} are produced. These words are in (14):

(14) *Developments in Robin's productions*

a.	auto 'car' /ˈoto/	[ˈotə] [ˈbʷotə]	1;6.22
b.	stoel 'chair' /ˈstul/	[ˈdy] [ˈdys]	
c.	bad 'bath' /ˈbɑt/	[ˈpɑpə]	
d.	boot 'boat' /ˈbot/	[ˈbɔit]	1;7.13

The adult model words in (14a, b) contain a non-homorganic vowel-consonant sequence (the opposite of the sequences in [ˈbibi] and in [ˈmi] (13): in (14a, b) the vowel is Labial, the consonant is Coronal). The words in (14c, d) contain two non-homorganic consonants. Compared to the initial three recordings two things have changed. On the one hand the *attitude towards phonological material* from the model adult words has slightly changed: the non-fitting forms are not merely avoided. In Robin's productions in (14b, c), the adult models are simply represented as {WORD} and {WORD, Labial} respectively, and the child's productions accordingly deviate from the adult models. On the other hand, the so-called *non-fitting forms start to become fitting*. The productions in (14a, d) match the POA feature make-up of the adult models: for both the productions of the model *auto*, [ˈotə] and [ˈbʷotə], and the production of the model *boot*, [ˈbɔit], Labial is not associated to every segment of the word, which means that WORD is definitely no longer the only available unit for a Labial specification. Like in the productions for *baby* and *meer* and *mij* (13), Labial has retracted to the left edge of WORD, while the remainder of the word is left unspecified. This unspecified residue will end up with the default Coronal specification in production. The representation of this state is in (15):

(15) {[WORD, Labial}

At this stage, the representations {WORD, Labial} and {[WORD, Labial} can both be generated, i.e. the representation in (15) does not replace the representation {WORD, Labial}. The forms in (14) already showed this. No productions occur in Robin's data that require reference to the right edge of WORD.

Up until this moment the *Dorsal constraint is still dominantly present in the output system: Robin has not attempted any adult word containing Dorsal segments.

5.4.4 Dorsal

At age 1;7.13 Robin attempts two adult words that contain Dorsal segments: *koekje* /'kukjə/ 'cookie' pronounced ['χɔχa] and *klaar* /'klaɹ/ 'ready' pronounced ['tai]. The adult form *klaar* has apparently been provided with the output representation {WORD} in the child's system, which results in the production ['tai] with a Coronal consonant. Like the adult model word, the child's production ['χɔχa] contains a Dorsal consonant, and a back & round vowel. Up until this point, the back & round vowels were captured by the specification Labial. Assuming that these vowels can now be represented as either Labial or Dorsal, a new output representation can be postulated:

(16) {WORD, Dorsal}

Apparently, the constraint on Dorsal specifications no longer affects the output representations, and again the entire WORD is the unit for specification.

In the next recording session, two new adult models containing Dorsal consonants are used:

(17) *Robin's productions of adult models containing Dorsal consonants*

a.	{WORD, Dorsal}	kikker 'frog' /'kɩkəɹ/	['kʌχa]	1;7.27
b.	{WORD}	kijk 'look' /'kɛik/	['tɛi]	

As it turns out, however, Dorsal is not a popular POA feature: only for the model word *kikker* (17a) has Dorsal been retained in the child's output representation. This representation, {WORD, Dorsal}, results in the fact that the stressed front vowel /ɩ/ from the adult model is produced as back, Dorsal, /ʌ/ by Robin. The model word *kijk* is in Robin's system provided with the unspecified output representation, {WORD}, and is pronounced ['tɛi]. In the following month Dorsal is almost completely inert again: no new words containing Dorsal consonants are acquired and the word *kijk* is not produced any more for several weeks. Only the production [ˈχaχa] or [ˈχɔχa], for *koekje* 'cookie' is maintained.

5.4.5 The WORD-peak

Above it was seen that in the first three recording sessions Robin did not produce any adult model word that contained a Labial vowel to the right of a Coronal consonant. From the fourth session on, adult forms of this type were attempted but no such sequence was matched in Robin's production. Examples are in (18).

(18) *Robin's productions of $C_{Cor}V_{Lab}$ -sequences I*

a.	stoel 'chair' /ˈstul/	[ˈdy]	1;6.22
b.	douche 'shower' /ˈduʃ/	[ˈtys]	1;7.13
c.	ballon 'balloon' /ˌbɑˈlɔn/	[ˈbɔmə]	1;7.13
d.	zo 'right' /ˈzo/	[ˈsɑ]	1;7.13

All the adult models in (18) have received one of the possible output representations of that stage in Robin's phonological system, {WORD} or {WORD, Labial}. In contrast, Robin did attempt the adult model *auto* /ˈoto/, which he produced as [ˈotə] in general, from age 1;6.22 on. In this case, the Labial vowel /o/ is situated at the left edge, the only other unit available for specification at this point except WORD. The fact that the unit WORD-edge (left) applies to both vowels and consonants shows that this unit WORD-edge is at this stage not just a term for consonant.

At age 1;8.10, however, the production [ˈtu] is recorded for *stoel* 'chair', and two sessions later, at age 1;9.10, the productions in (19) are recorded:

(19) *Robin's productions of $C_{Cor}V_{Lab}$ -sequences II*

a.	stoel 'chair' /ˈstul/	[ˈtul]	1;9.10
b.	groot 'big' /ˈχrot/	[ˈzot]	
c.	school 'school' /sχol/	[ˈzo]	

In these cases, the round & back vowels are not situated at the left edge of WORD, and except for (19c), nor at the right edge. In the model in (8) it was proposed that as a next stage the POA feature can be linked to the sonority peak of the unit WORD. This is represented as {WORD-P, POA feature}, where P stands for 'sonority peak'. At this stage, then, the units 'left edge' and 'sonority peak' are recognized within the unit WORD. In combination with the supposition that back & round vowels can be referred to as either Labial or Dorsal from the moment that the constraint on Dorsal specifications is no longer dominantly present in the output system, the forms ['tu] and ['zot] have either of the following two output representations: {WORD-P, Labial} or {WORD-P, Dorsal}. It was also stated in (8), that at this point Vowel Consonant Harmony cases could be represented, which would entail spreading a POA feature from the WORD-P to the edge of WORD. This will be addressed below in 5.4.8.

5.4.6 The right WORD edge and Dorsal

Around age 1;10, Dorsal consonants appear in Robin's productions again in an interesting fashion. While the left edge of the unit WORD can become specified for Labial, the right edge of WORD becomes available as a specifiable unit for Dorsal. This is represented in (20):

(20) {WORD], Dorsal}

The remainder of the WORD can *either* be left unspecified, resulting in Coronal segments to the left of the Dorsal segment in a produced word, or the left edge can be specified as in (15). The produced word then starts with a Labial segment and ends with Dorsal segment.

Robin's productions containing Dorsal consonants illustrate these possibilities.

(21) *Dorsal consonants in Robin's productions*

a.	drinken 'drink' /'drɪŋkə/	['tɪŋkə]	1;9.24
b.	dicht 'close' /'dɪχt/	['dɪk]	
c.	brug 'bridge' /'bʀʉχ/	['pʉχ]	
d.	weg 'gone' /'ʋɛχ/	['fɛχ]	
e.	lekker 'good' /'lɛkəɹ/	['tɛkə]	

The developments in the component U of the output system, i.e. the gradual maturation of different units that are able to carry a feature specification — WORD, [WORD, WORD-P, WORD] — has now been illustrated. This not all there is to it, however. As soon as both edges are specifiable units, constraints on output representations come to light which profoundly affect Robin's productions for quite some time. Before we turn to these constraints, a summary of the findings so far is presented.

5.4.7 Summary of the findings so far

The components U and F and C in Robin's phonological output system as discussed up until now contain the material listed in (19):

(22) *The sets U , F and C in Robin's output system*
U: {WORD, [WORD, WORD-P, WORD]}
F: {Labial, Dorsal}
C: {*Dorsal}

In (23) the developments concerning the components U and C are placed in time. As soon as a constraint is no longer dominantly present in the system — in that it bans all output representations violating it — it is crossed out in the table.

(23) *Summary of the developments over time*

Age	units in U	Constraints
1;5.11	WORD	*Dorsal
1;6.22	WORD-edge (left)	
1;7.13		~~*Dorsal~~
1;8.7	WORD-P	
1;9.24	WORD-edge (right)	

5.4.8 Edge constraints on representations

Although from age 1;9.24 on reference can be made to both the left edge and the right edge, and both Labial and Dorsal are available features, Dorsal cannot be assigned to the left edge for quite some time, while Labial cannot be assigned to the right edge without being assigned to the left edge too. It thus appears that the left edge is specifically reserved for a specification Labial. Somewhere along the line, then, the representation {[WORD, Labial} has become the preferred state in Robin's system when a Labial specification is involved. The constraint on Dorsal specifications in the output representations appears to have a more limited range, and now refers to specifications of the left edge of WORD. Dorsal is therefore bound to the right edge (or the WORD-Peak); the right edge, however, is not specifically reserved for Dorsal.

This special relation between Labial and the left edge of WORD is captured here by two constraints:

(24) *Edge constraints on POA feature specifications*
a. Labial → [WORD
Labial should be associated to the left edge of WORD
b. *Dorsal → [WORD[6]
Dorsal should not be associated with the left edge of WORD

Coronal is unspecified in the output representations. Assuming WORD to have a segmental structure CVC(v) in Robin's production, the hypothesis is that the CVC sequences in (25), with regard to the sequence of POA features, will not be encountered in the data. As the constraints apply to the entire word (CVC), they have to apply to the sequences C͜VC or CV͜C, where the vowel goes with the specification of either of the two edge consonants, and to $CV_{Coronal}C$, where the vowel is left unspecified.

(25) *Feature make-up of words hypothesized not to appear in Robin's data*

	C	V	C	examples
a.	Coronal	irr.[7]	Labial	soep 'soup', slapen 'sleep'
b.	Dorsal	irr.	Coronal	kaas 'cheese', geit 'goat'
c.	Dorsal	irr.	Labial	kop 'cup', kamer 'room'
d.	Coronal	Labial	Coronal	zoen 'kiss', goed 'good'

In (25a) Labial is at the right edge without being at the left edge, violating (24a); in (25b) Dorsal is at the left edge, violating (24b); in (25c) both (24a) and (24b) are violated; in (25d) the constraint in (24a) is violated again: Labial is not associated to the left edge. Were the WORD-Peak specified Dorsal, however, no constraint would be violated (by the WORD-Peak).

The influence of the constraints on Robin's output representations and consequently on his productions becomes obvious when Robin's productions of adult model words with the POA feature make-up of the forms in (25) are considered. In succession adult model words with the following types of CVC-sequences will be discussed: (25a) Coronal Consonant, any Vowel, Labial consonant, which will be abbreviated as C_CVC_L; (25b) Dorsal Consonant, any Vowel, Coronal consonant — C_DVC_C — ; (25c) Dorsal Consonant, any Vowel, Labial Consonant — C_DVC_L — ; (25d) Coronal Consonant, Labial Vowel, Coronal Consonant — $C_CV_LC_C$.

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[6] In Dutch (and in many other languages for that matter) this constraint still applies at some level: the Dorsal nasal consonant /ŋ/ only occurs word-medially and word-finally, and never in word-initial position.
[7] By 'irr' it is indicated that the feature make-up of the vowel is irrelevant.

C_CVC_L adult model words

Adult words of this type are initially hardly ever attempted by Robin. Until age 1;9 only the word *slapen* 'sleep' is produced:

(26) *Robin's first attempts to produce C_CVC_L adult model words*

a.	slapen 'sleep' /ˈslapə/	[ˈpatə]	1;7.27
b.		[ˈpapə]	1;8.24

At this point, the absence of attempts to produce adult model words of this type can be explained by the fact that the right edge is not available for specification yet. In both (26a) and (26b) the POA features of the adult target word have been reorganized according to the available possibilities. The production in (26a) appears to be a metathesized form: the Labial and the Coronal consonant have switched places. An explanation suiting the state of Robin's phonological system at this point is that the production has resulted from the fact that only the left edge of WORD is available for specification. The output representation assigned to the target *slapen* is {[WORD, Labial}: the left edge is specified for Labial while the remainder of the word is left unspecified, resulting in Coronal segments. For the production in (26b), the account is that Labial linked to the entire WORD, represented as {WORD, Labial}.

Above in 5.4.6 it was seen that from age 1;9.21 on, the right edge has become an available unit for specification and more target C_CVC_L words are attempted. Matching productions, however, do not occur in Robin's data, as the examples in (27) show.

(27) *Robin's further attempts to produce C_CVC_L adult model words*

a.	stoep 'side walk' /ˈstup/	[ˈpop]	1;9.21
b.	"	[ˈfup]	1;10.7
c.	trap 'stairs' /ˈtʀɑp/	[ˈpap]	1;9.21
d.	sop 'suds' /ˈsɔp/	[ˈfɔp]	1;10.7
e.	sloffen 'slippers' /ˈslɔfə/	[ˈbɔfə]	1;10.7
f.	tafel 'table' /ˈtafəl/	[ˈpafy]	1;10.7
g.	neef 'cousin' /ˈnef/	[ˈmef]	1;10.7
h.	zeep 'soap' /ˈzep/	[ˈfep]	1;10.7
i.	sap 'juice' /ˈsɑp/	[ˈfɑp]	1;10.21
j.	dammen 'play checkers' /ˈdɑmə/	[ˈbɑmə]	1;10.21
k.	soep 'soup' /ˈsup/	[ˈfup]	1;10.21
l.	snoepje 'candy' /ˈsnupjə/	[ˈfupi]	1;10.21

m.	zebra 'zebra' /'zebʀa/	['ɒipɑ]	1;10.21
n.	zeven 'seven' /'zevə/	['fɩfɩ]	2;0.4
o.	chipjes 'chips' (dim.) /'ʃɩpjəs/	['fɩpɩs]	2;0.18
p.	verstopt 'hidden' /vəɹ'stɔpt/	['fa'puft]	2;0.18
q.	locomotief 'locomotive' /ˌlokomo'tif/	['pif]	2;1.7
r.	niemand 'nobody' /'niˌmɑnt /	['mimat]	2;1.7

At this stage it is absolutely predictable what Robin's productions will be of target C_CVC_L words: for every C_CVC_L adult model a C_LVC_L form is produced. The examples in (27g, h, m) show that the adult models have not simply all been represented as {WORD, Labial}: the vowel in these forms is Coronal instead of Labial. Here we have instances of the forms that in the previous chapter were presented as potential counter-examples to Vowel-Consonant Harmony and, as such, real instances of Consonant Harmony. It can be argued, however, that these forms are not instances of Consonant Harmony either, because they are neither the result of a preference for homorganic consonants in a word, nor of a constraint on combinations of non-homorganic consonants in words. They result because of the constraint that an instance of Labial should be associated with the left edge of the WORD. The components U and F of the output system could in principle generate either of the two output representations in (28):

(28) *Possible output representations generated by the components U and F*
 a. {WORD], Labial}
 b. {[WORD], Labial}[8]

The output representation that will result in a production matching an adult model word like *zeep* 'soap' is as in (28a). This violates (24a), because Labial is associated to the right edge without being associated to the left edge of WORD. The alternative representation, in (28b), deviates minimally from the representation in (28a) (and will thus distort the form of the adult model minimally) but now the highly valued left edge of WORD as association site for Labial is included in the representation. The constraint in (24a) is satisfied this way, and the production of forms with this representation will contain a Labial consonant at both edges of the word.

At age 1;11 Robin produces some C_CVC_L adult models as either C_CVC_L or C_LVC_L:

[8] The difference between a representation {WORD, Labial} and {[WORD], Labial} lies in the fact that the first representation leads to a production where all segments are Labial, while in the second representation only the segments at the edges are Labial. Everything between these edges is unspecified, and thus Coronal in the production.

(29) *Robin's more succesful attempts to produce $C_C V C_L$ adult models*

a.	zeepsop 'soap suds' /'zep'sɔp/	['sep'fup]	1;11.6
b.	slepen 'drag' /'slepə/	['tipə]	1;11.20
c.	"	['ʋepə]	1;11.20

It is not before the age of 2;2.27, however, that the POA feature make-up of $C_C V C_L$ adult models is always matched in Robin's renditions of them.

$C_D V C_C$ adult model words

The 9 examples in (30) are the only target words of this type that Robin attempts to produce before age 2;2.7, the age where the constraints on POA features will turn out to have lost their importance. None of the produced forms matches the POA feature structure of the adult model word.

(30) *Robin's attempts to produce $C_D V C_C$ adult models*

a.	clown (idem) /'klaun/	['dan]	1;7.13
b.	schoen 'shoe' /'sχun/	['pun]	1;8.10
c.	gooien 'throw' /'χojə/	['ʋojə]	1;8.24
d.	groot 'big' /'χʀot/	['zot]	1;9.7
e.	kaas 'cheese' /'kas/	['tas]	1;10.7
f.	kan niet 'not possible' /'kanit/	['tanit]	1;10.21
g.	koud 'cold' /'kaut/	['taut]	2;0.4
h.	goed 'good' /'χut/	['fut]	2;1.6
i.	katten 'cats' /'katə/	['taka]	2;2.25

Most of the produced forms contain no Dorsal consonant at all. The matching output representation of the $C_D V C_C$ adult models, which would be {[WORD, Dorsal}, violates the constraint in (24b). In these cases the solution can not be sought in a representation {[WORD], Dorsal}, where the "right" (right) edge is added in the representation — as was done in (28b) for Labial — resulting in productions of the type ['kauk], instead of ['taut] in (30g) for *koud* 'cold'. Such a representation would still violate (24b). In (30a, e, f, g) the solution appears to be to represent the adult models as {WORD}, with no POA feature specification at all.

The production in (30i) is like the production in (26a) above: a form that appears to be metathesized. Here, as the mirror-image of the representation for (26a), the output representation that has been selected for the model *katten* 'cats', is {WORD], Dorsal}: Dorsal is associated at the right edge while the remainder of the WORD remains unspecified.

Three interesting productions are ['pun] for *schoen* 'shoe' in (30b), ['ʋojə] for *gooien* 'throw' (30c), and ['fut] for *goed* 'good' in (30h). The account is that Dorsal is ignored altogether, and the output representation is based on the feature Labial of the adult model vowel. The representation {WORD-P, Labial}, however, violates the constraint 'Labial → [WORD', just as in (28a), where the representation was {WORD], Labial}. In (28) the solution was found in a representation {[WORD], Labial}, which resulted in apparent Consonant Harmony forms. The representation for the productions in (30b, c, h) is proposed to be {[WORD-P, Labial}, which satisfies 'Labial → [WORD'. This results in productions that are instances of Vowel Consonant Harmony as discussed in the previous chapter. For the production ['zot] for *groot* 'big' in (30d), finally, the representation is based on the feature Dorsal of the back & round vowel, {WORD-P, Dorsal}, and as such does not violate any constraint. We will come back to the forms in (30b, c, h) below.

The feature make-up of the adult models *schoen* and *goed*, which is predominantly Dorsal when the vowels are also considered to be Dorsal, is worth a small excursion as to why the representation {WORD, Dorsal}, which would result in productions more like ['χuŋ] and ['χuk] respectively, has not been selected. A significant coincidence is that the possibility to refer to the left edge in the output representations entered Robin's phonological system simultaneously with the possibility to refer to Dorsal, at age 1;7.13. It appears that at this point Labial and Dorsal are competing for the left edge. We saw above that the representation {WORD, Dorsal}, which implies that the left edge is specified Dorsal too, hardly ever surfaced and it can be concluded that the constraint that a specified left edge of WORD can only be Labial, (24b), has become compelling at this stage. The left edge is from then on reserved for Labial, and accordingly the Dorsal WORD representation can no longer be active. When the right edge becomes available, at age 1;9.24, Dorsal finds an association site at this edge of WORD. The constraint in (24b) becomes less forceful from age 1;11.21, and is from age 2;2.27 no longer important. From then on word initial Dorsal consonants of adult model words are always present in Robin's productions too.

The examples in (30) were illustrations of the fact that Dorsal cannot appear as the initial consonant in Robin's productions, since there is a strong constraint on the representation {[WORD, Dorsal}. The small number of attempts to produce adult model words that have an initial Dorsal consonant show that Robin's strategy here is mainly one of avoidance. The productions of this type of adult model are scattered over several recordings, and, apart from the fact that they will not have an initial Dorsal consonant, the form of these productions is not really predictable.

C_DVC_L adult models

Given the facts about initial Dorsal consonants and final Labial consonants encountered above, it is not surprising that matching C_DVC_L adult models are not found in Robin's productions for a long time. Adult model words with an initial Dorsal consonant are initially avoided in Robin's speech, and these include, obviously, adult models of the type C_DVC_L. It is not until around age 1;10 that a word with such a structure is attempted. For some time then, Robin's productions of C_DVC_L adult models are absolutely predictable, just like his productions of adult models of the type C_CVC_L. Examples are in (31).

(31) *Robin's attempts to produce C_DVC_L adult model words*

a.	schommelen 'swing' /'sχɔmələ/	['vomə]	1;9.21
b.	Grover (name) /'χʀovəɹ/	['fofə]	1;9.21
c.	klimmen 'climb' /'klɪmə/	['pɪmə]	1;10.7
d.	koffie 'coffee' /'kɔfi/	['pofi]	1;11.7
e.	kamer 'room' /'kaməɹ/	['bamɑɹ]	1;11.21
f.	kopen 'buy' /'kopə/	['popə]	2;0.18
g.	kiepauto 'dump truck' /'kip'oto/	['pip'oto]	2;1.7
h.	knopje 'button' (dim.) /'knɔpjə/	['mɔpjə]	2;1.7
i.	kapitein 'captain' /ˌkɑpi'tɛin/	['pɑpiˌtɛin]	2;1.26

The output representations assigned to the adult models here are the same as the ones assigned to the adult models in (27): either {WORD, Labial} or {[WORD], Labial}. The fact that Dorsal is completely ignored in these cases cannot be traced back to some principle of single specification — a preference for one POA feature specification per WORD — since as soon as Labial and Dorsal are located at their appropriate edges there is no problem at all. Examples of such forms are repeated from (21):

(32) *Examples of Robin's productions containing both Labial and Dorsal segments*

a.	brug 'bridge' /'bʀʉχ/	['pʉχ]	1;9.21
b.	weg 'gone' /'ʋɛχ/	['fɛχ]	

The question might be raised why we do not find metathesized productions, like ['pokə] for *kopen* 'to buy', where both Dorsal and Labial from the adult model would be retained. A possible explanation is the following. Unlike the two other metathesized forms we encountered, where the representation contained only one POA feature specification, the forms here have two feature specifications, Dorsal and Labial. Assuming that in the phonological material of the input has a linear ordering, linking Labial from the input representation to the left edge of WORD in the output representation and Dorsal to the right edge will in these cases probably result in crossing association lines. In that case, the constraint on crossing association lines is more compelling than the ambition ascribed to language acquiring children like Robin to retain all the phonological material from the adult target word in their production.

Up until now the effect of the constraints in (24) was illustrated by comparing the POA feature make-up of adult models and Robin's renditions of them, with respect to the consonants in the word. Adult models of the types C_CVC_L, C_DVC_C and C_DVC_L, are for a long time not matched in Robin's production, but appear as either C_CVC_C, C_LVC_C, C_CVC_D or C_LVC_L. Described in terms of the consonants in a word, in the adult models the initial consonant is articulated more towards the back than the final consonant, while in the child's production the initial consonant is either articulated more towards the front than the final consonant or the two consonants are homorganic. In Ingram (1974) these child productions are said to result from a strategy he terms 'fronting'.[9] Consonants in a word are, according to Ingram, subject to the following constraint: "[...] whatever the first consonant may be, the following one(s) must be articulated either at the same point of articulation or a more posterior one." The fronting strategy states that "[...] the order of appearance of consonants in a word coincides with the direction of articulation from front to back" (p. 235). While this formulation captures essentially the same set of data as the constraints in (21), the two accounts are basically different. Ingram's account is in terms of the relation between consonants in a word, which is a relation between non-adjacent consonants, while the relations discussed here are between specific POA features and specific edges of WORD. The specific sequences of consonants within the words produced by the child are the ultimate result, and not the focus, of the available units and their interaction with the WORD-edge constraints. Furthermore, the WORD-edge constraints have evolved from an earlier stage where edges did not play a role: the unit for POA feature specification evolves from WORD to WORD edge. Ingram relates the fronting strategy to a previous stage where the dominant syllable is CV, and refers to Jakobson's claim that the first consonants acquired are those produced at the front of the mouth: first /p/, /b/, or /m/ followed by /t/, /d/, and /n/ (Jakobson, 1941/1968). As a residue of this stage, an unmarked relationship between consonants in a

[9] The term 'fronting' originally refers to the childrens substitution of Dorsal segments like /k/ for Coronal segments like /t/.

C_1VC_2 structure exists for the child when C_1 is more fronted than C_2.

The fronting strategy is separately, and tentatively, formulated for relations between vowels in words. The strategy here is: "if a word has more than one high vowel, the following constraint is operative: V[–back]$_0$ V[+back]$_0$, or i-i; u-u; but not *u-i" (p. 236). The predictions regarding sequences of vowels and consonants in a word are different in the two approaches. Unlike the two fronting strategies, the proposed units initially available in the phonological output system have the same effect on these sequences as they have on sequences of consonants: while according to the fronting strategies the form ['tutu] would be a possible production — the sequences taken into account being t-t and u-u — in the approach here the child would not be able to represent this form since the unit for a Labial specification in an output representation resulting in ['tutu] is neither the left WORD-edge, nor the entire WORD. An illustration of this was presented in (18) where it was shown that the initial productions of adult targets structured like /'tutu/ never matched this sequence of POA features.

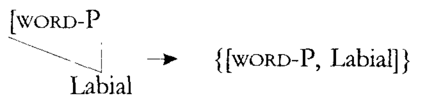
Another adult model that should be contemplated in this respect is $V_CC_L(V)$, which is initially predicted to be impossible because of the fact that there is no right edge available for the Labial specification, while in a later stage the representation of such forms would violate the edge constraint for Labial in (24a). The 'Fronting' account would not exclude the possibility of such productions. Unfortunately there are very few words in Dutch that have such a sequence, and it is not likely that children will produce them. The choice is between words like *immigratie, imam, ipso facto, evasief* and *emeritus*, all rather difficult concepts for a two year old.
In Robin's data there are productions of two, conceptually more evident, adult models of this type: *even* /'evə/ 'just for a moment' and *emmer* /'ɛməɹ/ 'bucket'. The word *even* was recorded for the first time at age 1;11.6, and was produced ['esə], reflecting the output representation {WORD}, rather than {WORD], Labial}. The word *emmer* was recorded at the time where the unit WORD-edge and the WORD-edge constraints had lost their importance in Robin's phonological system, at age 2;5, and was produced ['hɛma]. This evidence, limited as it may be, further supports the proposal.

Finally, we will return to the claim in (8) that VC Harmony cases could be represented as soon as WORD-P had become a unit of specification, and to the forms in (30b, c, h), which apparently involved VC Harmony.

$C_C V_L C_C$[10] adult models

In combination with the supposition that back round vowels can be referred to as either Labial or Dorsal from the moment that Dorsal has entered the output system, representations where reference is made to the WORD-Peak are either {WORD-P, Labial} or {WORD-P, Dorsal}. In the period where the edge-constraints affect the output representations generated in Robin's phonological system, two situations can arise: (1) WORD-Peaks that are not situated at the left edge of WORD are specified for Dorsal: no constraint is violated; (2) WORD-Peaks that are not situated at the left edge of WORD are specified Labial, and violate the constraint that Labial should be linked to the left edge. A representation where both the WORD-P and the left edge are specified Labial does not violate any constraint. This last situation is, procedurally speaking, Vowel-Consonant Harmony: the vowel (sonority peak) is specified for Labial, and this feature is spread from the vowel towards an edge. A rough sketch of the resulting representation is in (33):

(33) *Vowel-Consonant Harmony*



A representation where the WORD-P is specified for Labial will only surface if the left edge is specified for Labial as well, and this leads to productions like ['pun] for *schoen* 'shoe' and ['fut] for *goed* 'good' (from (30)). A representation where the WORD-P is specified Dorsal, however, has no problem surfacing. In Robin's productions we indeed find these two possibilities alongside each other:

(34) *Robin: word-P is either specified Labial or Dorsal*

a.	{[WORD-P, Labial}	schoen 'shoe' /'sχun/	['pun]	1;8.10
b.	{WORD-P, Dorsal}	stoel 'chair' /'stul/	['tu]	1;8.10
c.	{[WORD-P, Labial}	goed 'good' /'χut/	['fut]	2;1.6
d.	{WORD-P, Dorsal}	doen 'do' /'dun/	['dun]	2;1.6

The stages that precede the final stage, where adult-like output representations, on the one hand, can be generated and, on the other hand, will also

[10] An adult model of the type $C_C V_L$ obviously causes the same violation of the 'Labial-at-left-edge' constraint, and the presence of a Coronal consonant following the vowel is thus not crucial.

be able to surface, have all been discussed and Robin's acquisition data are a clear illustration of these different phases. The proposed edge constraints for Labial and Dorsal, together with the assumption that Coronal is unspecified in the output representation, are strongly confirmed. With regard to the POA feature structure of his productions, whether they match the adult models or not, they can be accounted for in terms of the phonological units that are utilized in the output representations, and the constraints on these output representations. In the next section the various developments in Robin's phonological system are summarized and placed in time again.

5.4.9 The developments over time

There are two main sources of developments in Robin's productions: (1) developments in the phonological units available for specification in the component U of the output system; (2) developments in the importance of constraints on output representations. The phonological units that become available in the course of time is repeated from (22), The constraints that we encountered are repeated from (11) and (24):

(35) *The sets U, F and C in Robins output system*
U: {WORD, [WORD, WORD-P, WORD]}
F: {Labial, Dorsal}
C: {*Dorsal, *Dorsal → [WORD, Labial → [WORD}

In (36) the developments in these two components of the phonological output system are placed in time (see next page).

In (36a) the one element in U is WORD, and there is a constraint on Dorsal specifications. The set of output representations that can be generated by this output system is {WORD} and {WORD, Labial}. Except for the productions ['bibi] and ['mi], the first two recordings of Robin only contain productions that reflect these output representations. In (36b) the left edge of WORD has become available as a unit for specification in output representations. More or less matching productions like ['bɔit] for *boot* 'boat' (14d) and ['otə] for *auto* 'car' (14a) are encountered, but *stoel* 'chair' is not matched since this would involve an output structure where Labial is linked neither to WORD nor to the left edge of WORD. Instead, ['dys] (14b) is produced.

(36) *Developments in the components U and C of the output system over time*

	Age	elements in U	constraints
a.	1;5.11	WORD	*Dorsal
b.	1;5.29 / 1;6.22	[WORD	
c.	1;7.13		~~*Dorsal~~
d.	1;7.27		*Dorsal → [WORD
e.	1;8.7	WORD-P	Labial → [WORD
f.	1;9.21	WORD]	
g.	1;11.7		~~Labial → [WORD~~
h.	1;11.21		~~*Dorsal → [WORD~~

At age 1;7.13 it appears that the constraint on Dorsal specifications no longer has an effect on Robin's output representations. At the same time, or a little later, however, an edge constraint becomes apparent that again involves Dorsal specifications: '*Dorsal → [WORD'. Probably as a consequence of this constraint, only two {WORD, Dorsal} output representations surface in Robin's production.

A subsequent development (36e) is that the sonority peak of the WORD can be specified for a POA feature: the adult model *stoel* is produced ['tu], instead of ['dy], in the recording at age 1;8.7.

At age 1;9.24 the right edge of WORD becomes available for specification too. It turns out that the representation {[WORD, Labial} has become a constraint: in order for a representation containing Labial to surface, Labial needs to be assigned to this edge. Vowel-Consonant Harmony cases occur in Robin's data when the WORD-P has been specified Labial: the edge constraint 'Labial → [WORD' is satisfied when the left edge of WORD is specified too.

At age 1;11.7 there is a first sign that the constraint 'Labial → [WORD' becomes less forceful: the adult form *zeep* /'zep/ 'soap', which had up until that moment been produced ['fep], for the first time surfaces as ['sep]. It is not until age 2;3, however, that the constraint systematically fails to prevent representations violating it from surfacing. The same applies to the constraint '*Dorsal → [WORD': in a recording at age 1;11.21 *kijk* /'kɛik/ 'look' is for the first time produced ['kɛik] instead of ['tɛik]. Again it is not until age 2;3 that such forms are encountered systematically in Robin's productions.

The proposed stages, furthermore, do not occur strictly one after another, but overlap for some time. The new possibilities are at first hesitantly utilized, as if it needs getting used to the new situation, and then slowly invade the productions. This is illustrated by the tables below.

In Table I the distribution of four types of CV-sequences in Robin's data over time is presented both in percentages and numbers. Here we see the gradual development of POA feature specification in CV-sequences: from specifying (or leaving unspecified) the entire unit {WORD}, to specifying the left edge, [WORD, to specifying the WORD-P independent of an edge. The four types of CV-sequences are: Labial C Labial V (PO); Coronal C Coronal V (TI); Labial C Coronal V (PI); and Coronal C Dorsal (Labial) V (TO).

Age / Type	1;5.11	1;6.9	1;7.27	1;8.24	1;9.24	1;10.21	1;11.21	2;4.8
PO	28.6 (2)	21.4 (3)	27.3 (6)	41.2 (14)	30.6 (11)	32.7 (16)	25.4 (15)	19.4 (13)
TI	57.1 (4)	64.3 (9)	65 (13)	29.4(10)	36.1 (13)	28.6 (14)	32.2 (19)	29.9 (20)
PI	14.3 (1)	14.3 (2)	13.6 (3)	23.5 (8)	25 (9)	30.6 (15)	27.1 (16)	25.4 (17)
TO	0	0	0	5.9 (2)	8.3 (3)	8.1 (4)	15.25 (9)	25.4 (17)
N=	7	14	22	34	36	49	59	67

Table I. Distribution of four types of CV-sequences over Robin's data in percentages

In the first three consecutive periods that are taken into account in the table, the entire WORD is clearly the basic unit for specification and leaving this unit unspecified is the most popular option. The representation {[WORD, Labial} surfaces from the beginning, but the share of productions in Robin's data that reflect this representation is small at first: this reflects the suggested transition period. The WORD-P is initially not available as a unit for specification, and no productions starting with a sequence TO are encountered. At age 1;8.24 only two of the thirty-four different word productions starting with a CV-sequence reflect an output representation {WORD-P, Dorsal}. This number slowly increases in the next couple of months, until as many as 25.4% of the CV-sequences have this combination at age 2;4.8.

In Table II the different stages and developments in the system are illustrated on the basis of consonants that surface in CVC(V) sequences in Robin's productions.

Type \ Age	1;5.11	1;6.9	1;7.27	1;8.24	1;9.24	1;10.21	1;11.21	2;4.8
TT	66.7 (4)	80 (8)	45.5 (10)	32.4 (12)	25 (10)	16.7 (10)	21.7 (14)	16.5 (17)
PP	33.3 (2)	20 (2)	13.6 (3)	24.3 (9)	20 (8)	35 (21)	15.9 (11)	2.9 (3)
PT	0	0	31.8 (7)	40.5 (15)	32.5 (13)	26.7 (16)	29 (20)	26.2 (27)
TK	0	0	0	0	10 (4)	11.7 (7)	14.5 (10)	15.5 (16)
PK	0	0	0	0	10 (4)	8.3 (5)	17.4 (12)	7.8 (8)
KK	0	0	9.1 (2)	2.7 (1)	2.5 (1)	0	1.4 (1)	3.9 (4)
TP	0	0	0	0	0	1.6 (1)	1.4 (1)	8.7 (9)
KP	0	0	0	0	0	0	0	4.9 (5)
N=	6	10	22	37	40	60	69	103

Table II. Feature make-up of consonants in Robin's CVC(V) word productions

In the first two recordings that are taken into account only non-Dorsal homorganic consonants surface in Robin's productions. This reflects the stage where WORD is the unit for specification, and Dorsal is banned from the output representations by the constraint *Dorsal. Again it is clear that the unspecified unit is the most popular output representation. Then, in the recording at age 1;7.27, the left edge has become an available unit for specification. There appears to be no transition period here. At the same time Dorsal tentatively appears as a specification for WORD. It was suggested that the representation {WORD, Dorsal} was subsequently overruled by the preference for Labial at the left edge. In the meantime the right edge has become available too, and Dorsal then re-appears in the representations at this edge of WORD in the recording of 1;9.24. The edge constraints remain important until age 2;3, and almost without exception ban output representations that would surface with consonant sequences T(V)P or K(V)P. The high number of PP forms at age 1;10.21 is a result of the edge constraints that preferred {[WORD], Labial} representations over {WORD], Labial} representations.

As a final step in the development, it will be assumed that the sonority peak becomes equated with the concept 'vowel', and the edges of WORD that are not sonority peaks with the concept 'consonant'. The WORD is from then on phonemicized. The edge constraints lose their grip on the output representations — probably because 'edge' has been replaced by 'consonant' as a unit for specification in the representations — and we will find any combination of consonants and vowels in the child's productions.

Now that the model of developments in the output system has been addressed extensively on the basis of Robin's data, the general validity of the findings will be illustrated by data of other children.

5.5 The model and other children

For ease of exposition the main aspects of the model are repeated here. Four stages are recognized in the development of the component U:

I. The unit for specification in the output representation of the child is the WORD. The WORD can be specified with the Place of Articulation features Labial or Dorsal, or can be left unspecified. A representation {WORD, Labial} results in a production with Labial consonants and vowels, a representation {WORD, Dorsal} in a production with Dorsal consonants and vowels. An unspecified representation {WORD} results in a production with Coronal consonants and vowels.

II. A new unit for specification is the left edge of WORD, represented as [WORD.

III. The sonority peak of WORD, i.e. the vowel, can be specified independently of an edge. This new unit for specification is represented as WORD-P.

IV. The right edge of WORD becomes available for specification.

In the component C, the developments were the following:

I. Dorsal specifications are banned from the output representation: *Dorsal. This general constraint on Dorsal specifications later gives way to a more specific edge-constraint.

II. Two constraints influence the specification of the left edge of WORD: 'Labial → [WORD', i.e. Labial is associated to the left edge, and '*Dorsal → [WORD', which amounts to the fact that the left edge can only be specified for Labial.

5.5.1 WORD specifications and *Dorsal

The earliest data from four of the five other children investigated contain clear evidence for WORD being the initial unit for specification in the developing output representation. This is illustrated below by the initial sets of words produced by Jarmo, Tom, Noortje and Eva, respectively.

Jarmo starts out with the following set of words in the first two recording sessions:

(37) *Jarmo's first set of word productions*

{WORD}	die 'that one' /ˈdi/	[ˈdi]	1;4.18 – 1;5.2
	dit 'this one' /ˈdɪt/	[ˈtɪ]	
	daar 'there' /ˈdaɹ/	[ˈdɑ]	
	aaien 'stroke' /ˈajə/	[ˈajə]	
{WORD, Labial}	koe 'cow' /ˈku/	[ˈbu]	
	klaar 'ready' /ˈklaɹ/	[ˈʋɑ]	
{WORD, Dorsal}	"	[ˈkɑ]	

Although the choice of words is much simpler than Robin's, the structure of this initial lexicon is very much the same. Contrary to Robin, Dorsal specifications are not completely banned from output representations, although except for an instance of *kijken* 'watch' in a later session, until age 1;7.29 only the form [ˈkɑ] or [ˈka], for *klaar* 'ready' occurs in the data. The target word *klaar* is also produced [ˈʋɑ], resulting from a {WORD, Labial} representation rather than from a {WORD, Dorsal} representation. This probably indicates that the constraint on Dorsal specifications does have some effect in the child's output system.

Tom was recorded from the very young age of 1;0.24 on. In the period from age 1;3.10 until 1;4.14 the first varied set of words was produced:

(38) *Tom's first varied set of word productions*

{WORD}	uit 'out' /ˈœyt/	[ˈhœyt]	1;3.10
	dat 'that' /ˈdɑt/	[ˈtɛt]	1;3.10
	auto 'car' /ˈoto/	[ˈɑtɑŭ]	1;4.14
	tijger 'tiger' /ˈtɛiχəɹ/	[ˈtat]	1;4.14
{WORD, Labial}	koe 'cow' /ˈku/	[ˈΦβu]	1;4.14
	op 'all-gone' /ˈɔp/	[ˈɔp]	1;4.14
	mam 'mom' /ˈmɑm/	[ˈmɔm]	1;3.10
	aap 'monkey' /ˈap/	[ˈbap]	1;4.14
	paard 'horse' /ˈpaɹt/	[ˈpap]	1;4.14
{WORD, Dorsal}	oog 'eye' /ˈoχ/	[ˈɔχ]	1;4.14
	ook 'also' /ˈok/	[ˈhok]	1;4.14
{[WORD, Labial}	paard 'horse' /ˈpaɹt/	[ˈpœyt]	1;3.10
		[ˈpɑt]	1;4.14
{WORD-P, Labial}	auto 'car' /ˈoto/	[ˈtoŭtoŭ]	1;3.10

Although most of the productions can be regarded as resulting from an output representation where the WORD is the unit for specification, the productions ['pɑt] and ['pœyt] for *paard* 'horse', in Tom's set require the unit WORD-edge. The production ['tɑ̆ʊtɑ̆ʊ] even reflects the availability of the unit WORD-P. This last unit was acquired in a later stage by Robin. However, until age 1;5.14 only the words *auto* and *paard* appeal to the presence of the units left WORD-edge and WORD-P in Tom's output representations. The constraint on Dorsal specifications does not appear to affect the output representations.

The first recording of Noortje that contained more forms than 'mommy' ['mɑma] and 'yes' ['ja] occurred at age 2;1.17. Except for the presence of Dorsal segments, her initial set of productions is structured very much like Robin's.

(39) *Noortje's first set of word productions*

{WORD}	beer 'bear' /'beɹ/	['teɔ]	2;1.17
	die 'that one' /'di/	['ti]	
	fiets 'bike' /'fits/	['tis]	
	thee 'tea' /'te/	['teĭ]	
	trein 'train' /'tʀɛin/	['tɛi]	
	trui 'sweater' /'tʀœy/	['tœy]	
	twee 'two' /'tʋe/	['te]	
	huis 'house' /'hœys/	['hei] ['hɑus]	
	Willy (name) /'ʋɪli/	['hɛji]	
	daar 'there' /'daɹ/	['da]	
{WORD, Labial}	boom 'tree' /'bom/	['pu]	
	bal 'ball' /'bɑl/	['pɑu]	
	Paula (name) /'paula/	['pɑpa]	
{WORD, Dorsal}	vogel 'bird' /'voχəl/	['kɔkɔ]	
	stoel 'chair' /'stul/	['ku]	
	konijn 'rabbit' /ˌko'nɛin/	['ku]	
{[WORD, Labial}	poes 'cat' /'pus/	['pus]	
	beer 'bear' /'beɹ/	['pi]	
	Willy (name) /'ʋɪli/	['ʋɪhi]	

Two forms that require reference to the left WORD-edge, *beer* ['pi] and *Willy* ['ʋɪhi], are also produced as [teə] and ['hɛji], which probably shows that that this WORD edge is still less well established in the system as a unit for specification.

Eva, finally, was not recorded from the very start of meaningful speech, but most of the forms she produced in the first recording, listed in (40), still reflect the initial stage where WORD is the unit for specification. Only one representation contains a Dorsal specification, for the right edge, and it can thus be concluded that the constraint on Dorsal specifications is actively present in the output system.

(40) *Eva's first set of word productions*

{WORD}	bed 'bed' /'bɛt/	['dɛt]	1;4.12
	beer 'bear' /'beɹ/	['dɛ]	
	dicht 'closed' /'dɪχt/	['dɪə]	
	eend 'duck' /'ent/	['eĭn]	
	eten 'eat' /'etə/	['eĭtɪ]	
	kijk 'watch' /'kɛik/	['tæit]	
	trein 'train' /'tʀɛin/	['tæin]	
	neus 'nose' /'nøs/	['nɛs]	
	prik 'injection' /'pʀɪk/	['tɪt]	
	sleutel 'key' /'sløtəl/	['høtœy]	
	konijn 'rabbit' /ˌko'nɛin/	['tæin]	
	teen 'toe' /'ten/	['ten]	
	vlinder 'butterfly' /'vlɪndəɹ/	['ɪnə]	
	auto 'car' /'oto/	['aŭtau]	
	daar 'there' /'daɹ/	['da]	
	patat 'french fries' /ˌpɑ'tɑt/	['tɑt]	
	staart 'tail' /'staɹt/	['tat]	
{WORD, Labial}	brood 'bread' /'bʀot/	['mop]	
	buik 'tummy' /'bœyk/	['bœup]	
	oma 'granny' /'oma/	['oma]	
	op 'all-gone' /'ɔp/	['ɔp]	
	open 'open' /'opə/	['opə]	
	poes 'cat' /'pus/	['puf]	
	schoenen 'shoes' /'sχunə/	['umə]	
	sloffen 'slippers' /'slɔfə/	['pɔfə]	
	aap 'monkey' /'ap/	['ap]	
{[WORD, Labial}	fiets 'bike' /'fits/	['pit]	
	maan 'moon' /'man/	['man]	
{WORD], Dorsal}	weg 'gone' /'ʋɛχ/	['d̆ɪχ]	

Lexical selection is clearly not Eva's strategy: adult model words are recklessly represented as either {WORD} or {WORD, Labial}, resulting in a most interesting series of productions. Some of these featured in the previous chapter because they clearly show that the POA feature of the vowel in the adult target word guides the child's production. It is obvious now that in this stage the forms result from the combination of this POA feature and the undifferentiated unit for specification WORD.

Only in Elke's data no evidence for an initial stage with a preponderant role for WORD is found. Her first set of words recorded contains productions like:

(41) *Elke's first set of word productions*

poes 'cat' /ˈpus/	[ˈpus]	1;6.25
bad 'bath' /ˈbɑt/	[ˈbɑʃ]	
schoen 'shoe' /ˈsχun/	[ˈtuʃ]	
kindje 'child' (dim) /ˈkɪntjə/	[ˈkɪʃ]	

However, in the next section it will be seen that the WORD edge does play a role in Elke's productions. Considering this in addition to the obvious presence of WORD as a unit for POA feature specification in the phonological system of the other children, it is concluded here that stage I is a generally valid stage in the acquisition of phonology.

5.5.2 The dismantlement of WORD

Above, the first productions requiring a partial specification of WORD were already encountered in the data from Tom (38), Noortje (39) and Eva (40). Indeed, in these data the left edge was singled out for specification, and was specified for Labial, just as we found for Robin. Only in the data of Eva, in (40), did a production occur that required a specification of the right edge of WORD.

A slightly deviating pattern is found in Jarmo's data. His first production requiring a non-WORD specification is [ˈkɛikə], for *kijken* 'watch', in a recording at age 1;6.13, which requires not only a right edge specification but also a Dorsal specification for the left edge. Until age 1;10.23, however, only one other such production is found. From age 1;7.15 until 1;8.26 the only other productions that cannot be represented by referring to the entire WORD are [ˈpas] for *paard* 'horse' /ˈpaːt/, [ˈoto] for *auto* 'car /ˈoto/, and [ˈpus] for *poes* 'cat' /ˈpus/. These forms indicate that the general pattern for Jarmo's second stage too is the possibility to refer to [WORD in his output representations.

While the appearance of the left edge of WORD as unit for specification can thus be regarded as the generally valid second stage in the development of output representations for words, the children do not all follow the proposed stages with regard to the other units for specification, WORD] and WORD-P.

In (42) the ages of the children are listed at which the different units for specification appear to start playing a role in their phonological output system.

(42) *Ages at which the different units for specification become available*

	[WORD	WORD-P	WORD]
Jarmo	1;7.15	1;11.20 (1;9.9)	1;8.26
Noortje	2;1.17	2;3.21 (2;2.21)	2;2.21
Tom	1;3.10	1;5.14	1;5.14
Elke	1;6.25	1;6.25	1;8.13
Eva	1;4.12	1;7.15	1;4.12

For Jarmo, Noortje and Eva, measured by the appearance of $C_CV_LC_C$ productions in the data, WORD-P becomes available as a unit for specification only after the right edge has become available. The ages between parentheses indicate the recording where an instance of VC Harmony gives rise to the suspicion that WORD-P has been a unit for specification for a longer time. In Jarmo's data we find the production ['boχ], for *boom* 'tree', in Noortje's data we find ['tuχ] for *stoel* 'chair', both indicating a {WORD-P], Dorsal} representation. Only Elke clearly refers to WORD-P before referring to the right edge. This means that stage III and stage IV as proposed do not necessarily occur in this order: some children apparently first delimit the WORD by referring to its edges, others turn their attention from the left edge to the sonority peak and only then concern themselves with the right edge. Most importantly, however, the left edge becomes available as a unit for specification before the right edge.

5.5.3 The edge constraints

In Robin's data two output constraints affected the form of his productions as soon as both edges had come into play. It turns out that the constraint 'Labial → [WORD' is active in the phonological system of all the other children of this study. The other constraint, '*Dorsal → [WORD', which bans Dorsal specifications from the left edge, is obviously present only in Eva's system. The data of the other children point to a slightly different attitude towards Dorsal in their output representations.

First the generality of the output constraint 'Labial → [WORD' is illustrated by considering the way adult targets that are not in conformity with this edge-constraint are handled. This means that, as in section 5.4.8 above, adult targets with the following types of CVC(V)-sequences will be discussed: $C_C VC_L$ (Coronal Consonant, any Vowel, Labial Consonant) and $C_D VC_L$ (Dorsal Consonant, any Vowel, Labial Consonant).

$C_C VC_L$ adult targets

It can be observed for all the children that matching productions of this type of target do not occur in their data for some time. In (43) the ages at which productions of the type $C_C VC_L$ are recorded for the first time are listed, compared to productions of the types $C_L VC_C$ and the availability of the right edge for specification.

(43) *Availability of right edge vs. first recording of $C_C VC_L$ and $C_L VC_C$ productions*

	$C_L VC_C$	$C_C VC_L$	WORD]
Noortje	2;1.17	2;5.23	2;2.21
Jarmo	1;7.15	1;11.20	1;8.26
Elke	1;6.25	1;10.21	1;8.13
Tom	1;1.7	1;6.11	1;5.14
Eva	1;4.12	1;8.12	1;4.12

As can be seen, even when the right edge of WORD is an available unit in the output representation it is apparently not possible for {WORD], Labial} representations to surface for some time.

In general, the children simply avoid using target words of this type, so the large number of adapted productions present in Robin's data is not paralleled in the data considered here. In Noortje's data three target words of this type are found until age 2;8.15; Jarmo's data contain five such target words until age 1;11.20; both Elke and Tom totally avoid this type of words until age 1;10.21 and age 1;6.11 respectively. Above, in (40), we saw that Eva does not avoid producing adult target words that cannot be provided with matching representations in her phonological output system, but merely represents them according to the possibilities. In (44) the resulting productions of the few $C_C VC_L$ adult model words attempted by the other children are presented.

(44) *Attempts to produce $C_C VC_L$ adult model words*

a.	Dribbel (name) /ˈdʀɪbəl/	[ˈdɛɸɔ]	1;7.15	Jarmo
b.	trommel 'drum' /ˈtʀɔməl/	[ˈpɑbɑ]	1;7.15	
c.	duif 'dove' /ˈdœyf/	[ˈdœys]	1;9.23	
d.	slapen 'sleep' /ˈslapə/	[ˈpapə]	1;10.23	
e.	tafel 'table' /ˈtafəl/	[ˈtahɔ]	1;10.23	
f.	lamp 'lamp' /ˈlɑmp/	[ˈmɑm] [ˈɑm]	2;3.7	Noortje
g.	tafel 'table' /ˈtʌfəl/	[ˈpaf]	2;6.5	

The form ['dɛΦɔ] in (44a), is the only production found in Jarmo's data until age 1;11.20 and can be considered a chance hit. The other forms in (44) are all in accordance with one of the approved representations {WORD} {WORD, Labial} or {[WORD, Labial}. In Eva's data, furthermore, some VC Harmony cases are found that can be thought to result from the preference for output representations where Labial is linked to the left edge. These are in (45):

(45) *Eva's productions reflecting the 'Labial → [WORD' constraint*

a.	doen 'do' /'dun/	['bun]	1;7.15
b.	schoenen 'shoes' /'sχunə/	['bunə]	1;7.15

Forms of the type C_LVC_C, in the meantime, occur frequently in the children's productions.

C_DVC_L adult targets

In (46) the ages at which productions of the type C_LVC_D are recorded for the first time are listed, compared to productions of the types C_DVC_L.

(46) *Availability of right edge and first recording of C_LVC_D and C_DVC_L productions*

	C_LVC_D	C_DVC_L	WORD]
Noortje	2;3.7	2;7.2	2;2.21
Jarmo	1;9.9	2;0.28	1;8.26
Elke	1;8.13	2;3.27	1;8.13
Tom	1;5.14	1;6.11	1;5.14
Eva	1;6.1	1;11.8	1;4.12

Again some period lies between the appearance of productions of forms requiring an unproblematic representation and the appearance of productions which require a representation that is not in accord with the edge constraint.

Given the avoidance strategy for C_CVC_L adult model words, it is not surprising that in this case too, adult targets requiring the constrained representation are not much produced much. Target forms of this type that were apparently assigned non-problematic output representations in the child's phonological system are given in (47):

(47) *Attempts to produce C_CVC_L adult model words*

a.	kip 'chicken' /'kɪp/	['kɪt]	1;11.6	Jarmo
b.	"	['tɪt]	2;0.4	
c.	koffie 'coffee' /'kɔfi/	['kɔsi]	1;11.6	
d.	kip 'chicken' /'kɪp/	['kuk]	2;2.21	Noortje

e.	”	['pɪp]	2;3.7	
f.	”	['pik]	2;3.21	
g.	kamer ‘room’ /'kaməɹ/	['pamə]	2;5.23	
h.	kop ‘cup’ /'kɔp/	['pɔp]	2;6.5	
i.	kip ‘chicken’ /'kɪp/	['ɪt]	1;10.21	Elke
j.	”	['pɪp]	1;11.28	
k.	”	['pɪk]	1;11.28	

Both Noortje and Elke show the whole array of alternative output representations that are preferred over a representation that will result in /'kɪp/: {WORD, Dorsal} ['kuk] (47d), {[WORD], Labial} ['pɪp] (47e, j), {WORD} ['ɪt] (47i). The forms in (47f, k) have an output representation which is in accord with ‘Labial → [WORD’. In Jarmo's data we find forms referring to an output representation that, while not violating ‘Labial → [WORD’, do violate the other constraint, ‘*Dorsal → [WORD’, namely the forms ['kɔsi] and ['kɪt] in (47a, c). In the next section the relation between Dorsal and the WORD-edge is considered.

With regard to adult targets of the type C_CVC_L and C_DVC_L then, the data show that the constraint ‘Labial → [WORD’ appears to be dominantly present in the developing phonological output system of all the children in this study.

Dorsal and the WORD-edge: C_DVC_C and $C_DV_CC_D$ forms

Productions of forms of the types C_DVC_C (like *kaas* ‘cheese’ /'kas/) and $C_DV_CC_D$ (like *kijken* ‘watch, look’ /'kɛikə/) are not expected in the child language data if the constraint, ‘*Dorsal → [WORD’ affects the output representations. For Robin it was suggested that, indirectly, even {WORD, Dorsal} representations (like for *koekje* ‘cookie’ /'kukjə/) no longer surfaced because of this constraint. Except for Eva, however, the other children apparently do not completely ban words that can be represented as {WORD, Dorsal}.

Eva's data, then, are similar to Robin's, and clearly reflect a mutual bond between left edge and Labial. The events concerning Dorsal move swiftly with Noortje and Tom, although their data do not contradict a short presence of the constraint. Both Elke's and Jarmo's data appeal to a different course of developments for Dorsal. Elke's data, however, indicate a role for ‘*Dorsal → [WORD’ in the second instance. First the data of Eva, Noortje and Tom will be discussed, then, in the next section, the deviating pattern that is found in the data from Elke and Jarmo is addressed.

In (48) the ages are listed at which productions of the type C_CVC_D and productions of the types C_DVC_C and $C_DV_CC_D$ are recorded for the first time:

(48) *First recordings of C_CVC_D, C_DVC_C and $C_DV_CC_D$ productions*

	C_CVC_D	C_DVC_C	$C_DV_CC_D$
Tom	1;5.14	1;5.28	1;5.28
Noortje	2;2.21	2;3.7	2;3.21
Eva	1;4.26	1;11.8	1;11.8

In Tom's case no forms with an initial Dorsal consonant are attempted spontaneously until age 1;5.28, except for adult targets like *konijn* 'rabbit' /ko'nεin/, *kameel* 'camel' /ka'mel/ and *kadootje* 'present' (dim.) /ka'dotjə/, which all carry main stress on the syllable that does not contain the Dorsal consonant. Only the syllable carrying main stress is produced. At age 1;5.14 both C_CVC_D and C_LVC_D productions are present in the data for the first time, matching the adult models:

(49) *Tom's first matching productions of C_CVC_D and C_LVC_D adult model words*

biggetje 'piglet' /'bɪχətjə/	['pεχkɪ]	1;5.14
tijger 'tiger' /'tεiχəɹ/	['taχŋ]	
varken 'pig' /'vaɹkə/	['fɑkə]	

In the next recording, at age 1;5.28, matching C_DVC_C and $C_DV_CC_D$ forms appear next to deviating productions:

(50) *Tom's productions of C_DVC_C and $C_DV_CC_D$ adult model words*

geit 'goat' /'χεit/	['kεit]	1;5.28
	['tε]	
pelikaan 'pelican' /ˌpeli'kan/	['ki'kɑn]	
	['kɑŋ]	
kikker 'frog' /'kɪkəɹ/	['kykɑ]	
kuiken 'chicken' /'kœykə/	['tœkə]	

Above it was seen that one session later, at age 1;6.11, matching C_DVC_C forms are recorded. Adult targets with an initial Dorsal consonant, however, are not attempted much until age 1;7.9.

Noortje, from age 1;7.14 until age 2;3.7, only produces initial Dorsal consonants in forms that can be represented as {WORD, Dorsal}. Except for an attempt at the word *duck* 'duck', adult model words that cannot be represented as {WORD, Dorsal} are avoided. The first production of a word requiring an edge-specification for Dorsal is ['tik], for *dik* 'fat' /'dɪk/, recorded at age 2;2.21. A matching production of an adult target of the form $C_DV_CC_D$ occurs at age 2;4.4, and a matching production of the form C_DVC_C appears only at age 2;5.23. However, Noortje produces ['kεin] for *konijn* 'rabbit' at age 2;3.7. At least in the short period between age 2;2.21 and 2;3.7 then, the left edge prefers a Labial specification.

On the whole, not many productions of the types discussed here are found in Noortje's data. Interestingly, however, quite some productions of the type V_CC_D occur, probably indicating that the constraint '*Dorsal → [WORD' is still present at some level.

Eva, finally, produces no instance of an initial Dorsal consonant at all up until the final recording at age 1;11.8. Target adult forms containing an initial Dorsal consonant are not avoided, however, and they surface in Eva's data as in (51):

(51) *Eva's attempts at producing adult model words with an initial Dorsal consonant*

kachel 'heater' /'kaχəl/	['tatɔχ]	1;8.12
kan niet 'can not' /'kanit/	['tanit]	1;9.8
kijk 'look' /'kɛik/	['tɛik]	1;9.22
kikker 'frog' /'kɪkəɹ/	['tɛkəɹ]	1;9.22

Incidentally, while non-initial Dorsal fricatives are produced from age 1;4.12 on, non-initial Dorsal stops are not produced before age 1;9.22. Examples are in (52):

(52) *Eva's attempts at non-initial Dorsal fricatives versus non-initial Dorsal stops*

dicht 'closed' /'dɪχt/	['dɪχ]	1;4.26
drinken 'drink' /'dʀɪŋkə/	['hɪnɛ]	1;4.26
tekenen 'draw' /'tekənə/	['tetə]	1;6.1
deksel 'lid' /'dɛksəl/	['dɪtsa]	1;7.22
nagel 'nail /'naχəl/	['naχɔ]	1;8.12

In sum, the data of Tom, Noortje and Eva show that representations referring to the left edge of WORD, [WORD, do not surface when this edge is specified for Dorsal, for a longer (Eva) or shorter (Noortje, Tom) period. Representations of the form {WORD, Dorsal} do surface in the data of Tom and Noortje, whether the result contains and initial Dorsal consonant or not. The constraint that bans Dorsal specifications from the left edge is operative in the output system of these children for some time, then; in the productions of Tom and Noortje, however, the consequences of this constraint are not as far-reaching as in those of Robin and Eva.

5.5.4 The WORD-edge: a preference for [WORD specifications

The data of Jarmo and Elke show a different pattern. In their case the preference for a Labial specification for the left edge is only apparent in target words with a combination of a Labial and Dorsal consonant. Otherwise, the left edge of WORD appears to be the preferred unit for both POA feature specifications.

Elke produced a single instance of a C_CVC_D form, ['sik] for *muziek* 'music'

/ˌmyˈzik/ in the recording at age 1;6.25. Thereafter no such forms were produced until age 1;10.21. Interestingly, forms of the type C_DVC_C, like [ˈkɑʃ] for *kaas* 'cheese', were produced regularly from age 1;6.25 up until age 1;11.7. Then, for a period of almost five months, until age 2;3.27, these forms totally dissappear from Elke's data. In the period where C_DVC_C but no C_CVC_D forms are produced the target word *tekenen* 'draw' was produced as in (53):

(53) *Elke's attempts at the word 'tekenen'*

tekenen 'draw' /ˈtekənə/	[ˈkɪtə]	1;8.13
	[ˈkakə]	1;8.31
	[ˈkɛikɛi]	1;10.7

It appears that for Elke the left edge of WORD is the preferred location for the association of both Labial and Dorsal. The constraint '*Dorsal → [WORD' cannot be operative, then. In cases where both a Dorsal and a Labial feature are associated to WORD it is the feature Labial that relentlessly ends up at the left edge of WORD. The preferred POA feature for the left edge of WORD is clearly Labial, but if no instance of Labial is present Dorsal is not avoided in this position.

At age 1;10.21 *tekenen* 'draw' is produced [ˈtekə], and from then on gradually more C_CVC_D forms appear in Elke's recordings. Simultaneously, C_CVC_L productions, where Labial is specified for the right edge without being specified for the left edge, appear in the data.

This combination of facts indicates that in Elke's developing output system between 1;6.25 and 1;10.21 the *left* edge of WORD is the preferred unit for POA feature specification, in spite of the fact that the right edge is available for specification from age 1;8.13 on. Not many productions which require a specification of the right edge occur in Elke's data, however. Until 1;10.21 only the production [ˈbuk] for *boek* 'book' occurs regularly. From 1;10.21 on, the preference for specification of the left edge of WORD disappears. For some time then, in the period between the ages 1;10.21 and 2;3.27, Dorsal is preferred at the right edge: C_DVC_C forms drop out of sight, productions of the type C_DVC_L do not occur until 2;3.27, and more C_CVC_D forms are produced. At some level, then, the edge constraint '*Dorsal → [WORD' appears to be operative after all.

Jarmo too prefers representations whereby the left edge is specified even after the age at which the right edge of WORD has become a specifiable unit. The first production requiring reference to the right edge of WORD is the promising form in (54):

(54) *Jarmo's first production requiring reference to right edge*

kikker 'frog' /ˈkɪkəɹ/	[ˈtɪkjə]	1;8.26

Dorsal is not assigned to the left edge but to the right edge, and for a short moment it appears that '*Dorsal → [WORD' is dominantly present in Jarmo's system too. At age 1;9.9, however, a matching production of the form C_DVC_C appears in the data, alongside two C_LVC_D forms:

(55) *Jarmo's productions containing initial and final Dorsal consonants*

kous 'stocking' /'kɑus/	['kɑiʃ]	1;9.9
monkey 'monkey' /'mɔŋki/	['mɔŋ]	
boom 'tree' /'bom/	['boχ]	

Subsequently, C_LVC_D productions disappear from Jarmo's data until age 1;10.23. The attempted word *monkey* is produced ['momu] and *boek* 'book' ends up as ['bup]. Only the C_CVC_D target word *tekenen* is attempted now and then, and is realized as either ['tekə] or ['tetə]. Furthermore, both target forms of the type C_C VC_D and of the type C_LVC_D are not very popular until age 2;0.4.

Forms of the type C_DVC_C, however, occur regularly in Jarmo's data. Just as in Elke's data, C_CVC_L productions appear in Jarmo's data simultaneously with a set of C_CVC_D productions, at age 1;11.20, suggesting that the right edge of WORD has at this point become equally valued for POA feature specifications. In Jarmo's case, however, initial Dorsal consonants do not disappear from his productions at this point. This makes it difficult to account for the fact that productions of the type C_DVC_L do not occur in the data until age 2;0.28. For now the suggestion is that the constraint 'Labial → [WORD' is still effective when reference is made to both edges of WORD in the representation.

In sum, Elke and Jarmo for some time prefer the left edge as a unit for specification, even when the right edge is available as a specifiable unit too. Both Dorsal and Labial can link to this edge, indicating that in their case the left edge is not specifically reserved for Labial. For Elke this appears to become the case, however, as soon as the right edge is no longer put into second place as a unit for POA feature specification. The constraint 'Labial → [WORD' is effective for some time in the output systems of both Jarmo and Elke. For Jarmo the constraint in a later stage only affects representations that refer to [WORD].

5.5.5 The developments over time

To conclude this section, in (56) tables similar to the one in (37) for Robin are presented, where for the different children the developments are arranged over time.

(56) *Developments in the components U and C of the output system over time*

Child	Age	elements in U	constraints
Tom	1;3.10	WORD [WORD	*Dorsal → [WORD
	1;5.14	WORD] WORD-P	Labial → [WORD
	1;5.28		~~Labial → [WORD~~
	1;6.11		~~*Dorsal → [WORD~~
Noortje	2;1.7	WORD [WORD	*Dorsal → [WORD
	2;2.21	WORD] WORD-P	Labial → [WORD
	2;5.23		~~Labial → [WORD~~
	2;7.2		~~*Dorsal → [WORD~~
Eva	1;4.12	WORD [WORD WORD	Labial → [WORD *Dorsal → [WORD
	1;7.15	WORD-P	
	1;8.12		~~Labial → [WORD~~
	1;11.8		~~*Dorsal → [WORD~~
Elke	1;6.25	WORD [WORD WORD-P	
	1;8.13	WORD]	Labial → [WORD
	1;10.21		~~Labial → [WORD~~ *Dorsal → [WORD
	2;3.27		~~*Dorsal → [WORD~~
Jarmo	1;5.2	WORD	
	1;7.15	[WORD	
	1;8.26	WORD]	Labial → [WORD
	1;9.9	WORD-P	
	1;11.20		Labial → [WORD iff [WORD]
	2;0.28		~~Labial → [WORD iff [WORD]~~

5.6 Conclusions

A crucial observation in the previous chapter was that consonants and vowels in words produced by children are closely related to each other with respect to Place of Ariculation. In the present chapter it turned out that, in fact, all the consonants and vowels in a word share the same POA feature at first. This led to the assumption that in the initial stages of the acquisition of phonology, lexical output representations do not contain segment-sized units, but rather word-sized units that carry a POA feature specification. Starting from this assumption, a comprehensive developmental model of a phonological output system that generates lexical output representations for Place of Articulation features was proposed. This output system generated every form the child produced, whether it matched the attempted adult model or not, while it did not generate forms the child did not produce.

The phonological output system assumed in this chapter consists of three components:

(1) a component F, containing the phonological features that need to become associated to some higher organizing unit in the output representation. In this chapter these were limited to the Place of Articulation features Labial and Dorsal while Coronal was assumed to be the default value.

(2) a component U, containing the phonological units to specify (or: higher organizing units). In this chapter it was argued that initially POA features link to a unit much larger than the segment, termed WORD. This unit has the size of a minimal Prosodic Word. The subsequent segmentalization of WORD proceeds step by step; the left edge is the first unit within the unit WORD that can be singled out for specification. An important aspect of the term 'edge' is that it abstracts away from 'consonant' or 'vowel'. Later the sonority peak of WORD and the right edge of WORD become available as well.

(3) a component C, containing constraints. In the present chapter the discussion was limited to constraints on the association of POA features. The constraints that were observed to play a role in the system are: (1) *Dorsal. This constraint entails an absolute ban on Dorsal specifications and was observed in the data of two children; (2) '*Dorsal → [WORD'. This constraint bans Dorsal specifications from the left edge. It is active in the output systems of all but two of the children, and even in their system it appears to be active at some level. (3) 'Labial → [WORD'. This constraint specifically directs Labial specifications to the left edge. It is observed in the data of all the children.

Output representations generated by this system are fully dependent on the contents of the components U, F and C, and developments in these components concomitantly lead to developments in the output representations. Adult model words that require output representations that do not fit this system, either because the unit for specification is not specific enough or because a constraint is violated, are either avoided or are assigned output representations that can be generated by the output system of the children. In the last case productions result that deviate from the adult model. These deviating productions include forms that have been analyzed as instances of fronting, Consonant Harmony, Vowel-Consonant Harmony and metathesis.

Ideally, the model should be able to account for the entire feature structure of lexical outputs. This entails that the acquisition data should be scanned for patterns in other feature areas than place of articulation. The validity of the model as it stands as a universal model is another issue that needs to be addressed. For one thing, the status of the constraints posited here in (child) languages of the world needs to be investigated. The constraint on Dorsal specifications at the left edge appears to be active at some level in different languages, as was mentioned in footnote (6). This is a promising finding. It would be interesting, however, to see what the status of such a constraint is in languages that employ a whole array of dorsal and pharyngeal phonemes, like Arabic. As yet unknown is the effect of the constraint directing Labial to the left edge in adult languages. If we assume, as in Optimality Theory (Prince & Smolensky 1993, McCarthy & Prince 1993, see footnote 4), that in principle the set of constraints in the child's output system is the same as the set of constraints in the adult output system — the difference lying in the relative importance assigned to these constraints — we expect to find evidence for this constraint in adult language too. Finally, the assumed reconciliation of WORD-edge and WORD-peak with 'consonant' and 'vowel' respectively needs to be made more specific. These issues are challenges for future research.

6 Development of vowel height

6.0 Introduction

The previous chapters dealt with the three place of articulation features Labial, Coronal and Dorsal. In the two feature models that corresponded most closely to what we wanted to be expressible, those of Clements (1989, 1991) and Lahiri & Evers (1991), the place of articulation features form a class separate from the 'Tongue position' or 'Aperture' features governing (vowel) height. In the literature several arguments have been presented for a separation of the features governing vowel height from the place of articulation features. One example of a case where vowel height features clearly operate independently of place of articulation features can be found in the Brazilian Portuguese (BP) verb system (Wetzels 1991, as summarized in Clements & Hume 1993). In the 1st person of the present indicative, the mid stem vowels assimilate to the height of the following non-low theme vowel, becoming high mid — BP has a four-height vowel system — before the high mid /e/, and high before the high /i/. The theme vowel does not surface. Wetzels' analysis is that the theme vowel is deleted in hiatus, and concomitantly, the height features of this vowel are relinked on the stem vowel, replacing its original height. An illustration is in (1):

(1) *Brazilian Portuguese 1st person indicative*

mɔr-a-o	→	[mɔro]	'I reside'
mɔv-e-o	→	[movo]	'I move'
sɛrv-i-o	→	[sirvo]	'I serve'

Other arguments for the independence of height features and place of articulation features can be found in Clements (1989a), Clements & Hume (1993), Hyman (1988), and Odden (1991).

To complete this study on aspects of the acquisition of Place then, we will turn to the height branch of the Place node and to the sounds that rely most on it: the vowels.

Virtually no phonological studies deal with the acquisition of vowels in a systematic fashion, probably because the general impression appears to be that vowels do not present much trouble to the language learner (Waterson 1971). Although it turns out that it is not easy to extract systematic patterns with regard to acquisition of a height representation from child language data, the impression that vowels are flawless in children's productions is not justified: in the data corpus under investigation here 'error' rates as high as 70% are found. It is thus worthwhile to start to look for some general patterns.

Three important phonological dimensions of vowels in Dutch are place of articulation (front–back dimension), height, and length. Of these dimensions, the front–back dimension of adult model vowels is in general matched in the child's productions; substitutions along this axis do occur but always under influence of neighbouring segments. Length does present problems and the acquisition of this dimension is addressed, in detail, in Fikkert (1994). For our purpose it is sufficient to know that in the initial stages of acquisition, length is random in the productions of the children. Short vowels can become long, and long vowels can become short, with only a slightly higher percentage of short vowels becoming long. In a later stage the direction of change is dependent on the consonantal environment. In this stage length is still random before obstruents, but short vowels lengthen when an adult target final sonorant is not produced and long vowels shorten when this final sonorant is produced.

The height dimension is problematic too, not only for the children acquiring language but also for the phonologist trying to analyze this developing system. For one thing, unlike the acquisition of place of articulation in words, discussed in the previous chapter, we hardly find 'all or none' patterns of acquisition in the height dimension. Matches and substitutions exist alongside each other most of the time. Also, unlike our findings for the place of articulation dimension, the height dimension appears to be more sensitive to acoustic influences from neighboring segments. Phonologically speaking, these assimilations are not immediately obvious. Adjacent nasals, for example, have an effect on the perception of vowel height, and it turns out that this effect is reflected in the children's productions. Acoustic assimilations like this have to be recognized and separated from the directions vowel height takes in child language because of the developing height system.

Furthermore, in order to find some pattern in the acquisition of vowel height we need to know what the height categorization of vowels is in the adult language. No patterns of raising or lowering can be recognized as long as it is unclear which vowels are considered to be high, mid and low. Unfortunately, in Dutch this categorization is not straightforward. Several different categorizations exist, without there being much phonological evidence for or against any of them, since there are no known synchronic processes that refer to any specific grouping of vowels with regard to height.

A theoretical problem, finally, is the phonological representation of height. If children acquire a phonological representation of height, we want to know what the units of this system are and how they are organized. There are two representations that are currently employed most generally: (a) the familiar [±high] [±low] representation and (b) Clements' (1989) feature [±open] in a multi-tiered system.

Dealing with the phonological development of vowel height thus involves three unstable factors, (1) the child language data; (2) the categorization of vowel height in Dutch; (3) the representation of vowel height in phonological theory. The topic will be tackled in the following way. First, since the model of the acquisition of height proposed by Jakobson (1941/1968) helps to attain some grip on the material, this model is presented in 6.1. Then, in 6.2 we turn to the different categorizations of Dutch vowels that have been proposed. The combination of Jakobson's model and these categorizations leads to different predictions as to what kind of developmental data is likely to be found in child language. These predictions are formulated in 6.3. In 6.4 we turn to the data of several children of the data corpus. Here, as a main goal of this chapter, the developmental events concerning height will be charted as well as checked against the predictions. Different systematic patterns are observed, part of which are found to be due to external circumstances rather than to the developing phonological system. A systematic pattern that is thought to result from an underdeveloped phonological system is the raising of attempted mid vowels in the children's productions. Furthermore, it turns out that the way children categorize vowels does not accord totally with any of the proposed categorizations, and that the vowel /ɛ/ is the odd man out. In 6.5, the two currently employed ways to represent vowel height in a feature geometrical representation are discussed in relation to both the acquisition data and the new perspective on the classification of Dutch vowels. Although both of the height representations have their drawbacks, it will be seen that the developmental data can be regarded to follow, in a probably unexpected way, from a gradual availability of the representation of vowel height that has been proposed by Clements. Finally, also in 6.5 a sketch is presented of how an I A U model would capture the facts.

6.1 Jakobson on the acquisition of vowels

According to Jakobson (1941/1968), the inherent direction of development "[...] obeys a principle of maximal contrast and proceeds from the simple and undifferentiated to the stratified and the differentiated" (p. 68). The first and maximal opposition that children acquire is the one of opening versus closure: a maximally closed segment is opposed to a maximally open segment. The optimal closure is achieved by a labial consonant like /p/, which obstructs the entire oral cavity, while the optimal opening is achieved in the wide vowel /a/. The vowel paradigm is thus launched by the /a/. In chapter 2 we discussed Jakobson's fundamental triangle, formed by a base line U-I indicating 'color' and the A-line indicating 'chromatism', i.e. sonority. Chromatism was said to be the 'specific phenomenal feature' of vowels, and /a/, forming the peak of chromatism, is the optimal vowel. The maximal contrast in the vowel space is then chromatic, i.e. low, versus achromatic, i.e. high. In Jakobson's terms a more narrow vowel is opposed to a more wide vowel. From the 'principle of maximal contrast' it cannot be predicted which of the narrow vowels, /i/ or /u/, will appear in the child's system first, since they are equally narrow, but given the developments on the front-back axis, where Coronal appears to be the default value, the front /i/ is most likely. In the example Jakobson presents the acquired contrast is indeed *papa* versus *pipi*. The next maximal contrast entails one of two things: (I) splitting of the narrow, achromatic vowel into a palatal and a velar vowel, as Jakobson calls them. This establishes the basic vowel triangle /a/ /i/ /u/; (II) introduction of a third, more central degree of vowel height. This establishes the basic linear vowel system /i/ /e/ /a/.[1] Both varieties are also found in the world's languages as minimal vowel systems. The first variety, however, is more common. The vowel system develops further by successively splitting the vowels into velar and palatal ones in the direction from narrow vowels to wide vowels. This model can be pictured as a zipper (2) that is pulled down gradually (see next page).

Accordingly, we will call Jakobson's model the "Zipper model" of vowel development.

The Zipper model predicts that the opposition /e/ - /o/ cannot arise before the opposition /i/ - /u/ is acquired. This is also one of the general implicational laws that are valid for the languages of the world: no language has an opposition e-o without having an opposition i-u. Other parallels

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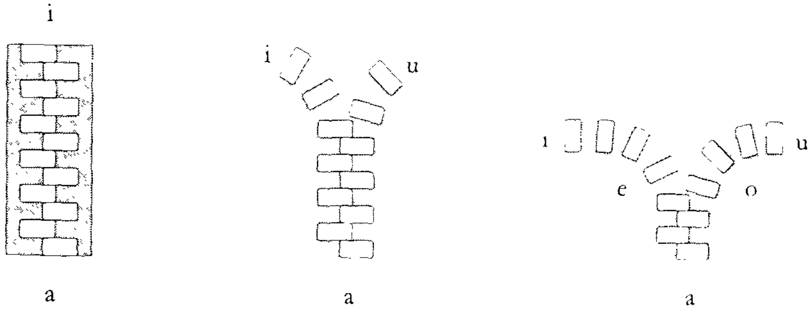
[1] This again points to the fact that /i/ rather than /u/ is the first high vowel to be contrasted to /a/.

(2) *The vowel zipper*



between the order of development and these laws that Jakobson draws attention to are the following: (1) The wider degrees of aperture are never represented by more phonemes than the narrower degrees of aperture; (2) A differentiation of rounded vowels according to degree of aperture cannot arise in child language as long as the same opposition is lacking for the unrounded vowels — the opposition /u/–/o/ can thus not arise as long as the child has no opposition /i/–/e/; (3) Rounded front vowels arise in child language only after the corresponding primary vowels, i.e. the rounded back vowels and the unrounded front vowels, of the same degree of aperture.

What Jakobson, or the model, does not tell us is what the productions of the children will be like in the stage where the system is not complete yet. One interpretation is found in Blache (1978). In this book distinctive feature theory as developed by Jakobson is presented and discussed in the light of phonological acquisition. In order to describe the "[...] thinking process involved in the ordering of these features into a sequence of acquisition" (p. 104), four explanatory models are used, one of which compares the adult model to the child's. This model is termed the "Free Variation Model". The assumption is that children acquire the segment inventory distinctive feature by distinctive feature and that, accordingly, at the stage when only a few distinctive features are acquired, the phonemes of the adult language are hardly phonologically distinguished by the child. Since within an unrestricted space sounds are in free variation, the child will use the adult phonemes interchangeably. Concerning vowels, in the initial stage "[...] the vowels themselves are free-varying, with /a/ being the most probable" (p. 123). The developing system restricts the free variation more and more. At the stage where a 'narrow', i.e. high, vowel is opposed to the wide, i.e. low, vowel, Blache mentions that "The high vowels /i=ɪ=u=U/, and perhaps /e=o/, are contrasted to the low vowels /ɔ=ɛ=a/" (p. 143). Within these two vowel classes the vowels are in free variation, but there will no longer be free variation across the two categories.

An alternative interpretation is that there is no free variation, but that the production possibilities are restricted in a systematic way by the child's phonological system. If the system includes only high (narrow) and low (wide) but nothing in between, a target /e/ which is neither high nor low will either not be attempted by the child, or it is represented according to the restricted possibilities of the child's output system. This is like what we saw in the previous chapter: words from the language that cannot be represented in an adult-like way in the child's output system are represented according to the available possibilities, based on certain characteristics of the adult model. This leads to productions that deviate systematically from the adult model, not randomly as in the 'Free Variation Model'. Although Blache's interpretation seems strange, it turns out that substitutions for vowels can initially be quite random in terms of height, although not in terms of place of articulation. Later, however, systematic deviations from the adult target occur. This will be addressed again below.

In the remainder of this chapter we will not be concerned so much with the acquisition of oppositions, like high *versus* low, as with the acquisition of the different height representations themselves. This gives the Zipper model a slightly different interpretation from the one of Jakobson, who focused on oppositions. The initial state of high versus low, for example, is translated here as: initially only [+high] and [+low] are employed in the child's output representation. The goal here is to investigate the initial state and the subsequent development of the child's output system with respect to the Tongue Position features, and how the adult model vowels are handled in this system. If vowel height in the child's productions is largely determined by a phonological system, it is expected that the child will not represent the height of the adult model vowel in a random way in his output system, but that there is some systematic relation between the adult model and the child's production.

In order to construct a more complete model of the acquisition of vowel height we need to know how vowels, and more specifically, Dutch vowels, are categorized with respect to height. In the next section, the Dutch vowel height system is addressed.

6.2 Classification of Dutch vowel height

Dutch has 12 vowels, ignoring schwa, and 3 diphthongs. The diphthongs will not be considered here. The plain vowels split into a class of long vowels and a class of short vowels and, furthermore, into Coronal (front), central, Dorsal (back) and Labial classes. The long and short sets of vowels are given in (3):

(3) *Long and short vowels in Dutch*
Long: i y u e ø o a
Short: ɩ ʉ ɛ ɔ ɑ

Problems with the height classification arise when the short and the long vowels are lined up in a single picture. In the literature different categorizations are found, which either recognize three or four vowels heights. The most common way is to categorize the short and long vowels as in (4). This three-height categorization for Dutch is adopted by, among others, Cohen et al. (1959), Pulte (1971), and Trommelen & Zonneveld (1982).[2] For now, 'high', 'mid' and 'low' will be used to classify the different vowel heights.

(4) *Three-height categorization I*

	Front	Central	Back
high	i y ɩ ʉ		u
mid	e ø ɛ		o ɔ
low		a	ɑ

A different three-height classification is presented in Booij (to appear):

(5) *Three-height categorization II*

	Front	Central	Back
high	i y		u
mid	e ø ɩ ʉ		o ɔ
low	ɛ	a	ɑ

[2] A similar categorization can be found in van der Hulst (1984). However, since there are more long vowels than short vowels, van der Hulst argues that the front and round vowel /ʉ/ is the short counterpart of both high /y/ and mid /ø/, while the back and round vowel /ɔ/ is the short counterpart of both high /u/ and mid /o/.

In this classification, there is no opposition short-long for the high vowels. The short counterpart of /e/ is /ɩ/ rather than /ɛ/, /ʉ/ is the short counterpart of /ø/, and /ɛ/ is grouped with the low vowels. Unfortunately, Booij neither motivates the differences with the more standard classification in (4), nor why he abandoned the four-height classification discussed next.

A four-height vowel classification, finally, is adopted by among others van Bakel (1976), Moulton (1969) and Booij (1981):

(6) *Four-height classification*

	Front	Central	Back
high	i y		u
high mid	e ø ɩ ʉ		o
low mid	ɛ		ɔ
low		a	ɑ

In this classification only the high mid front vowels have an opposition long-short.

As mentioned before, there is unfortunately no known synchronic phonological evidence in Dutch for assuming either a four-height or a three-height classification for the Dutch vowels. There are, for example, no rules that refer specifically to the vowels /e ɩ ø ʉ o/ to the exclusion of /ɛ ɔ/, which would argue for the categorization in (6). Since specific evidence for four heights is lacking, the less elaborate three-height system should probably be preferred on economic grounds. However, there is also no phonological evidence available that could decide between the two classifications with three vowel heights discussed above. It is in this case helpful to look at the acoustic classification of Dutch vowels.

Figure 1 shows an acoustic vowel triangle based on formant frequencies of F1 and F2 of Dutch vowels. The values are averaged over 25 female speakers of Dutch. The formant frequencies have been transformed to a perceptually relevant scale by the Bark-transformation.

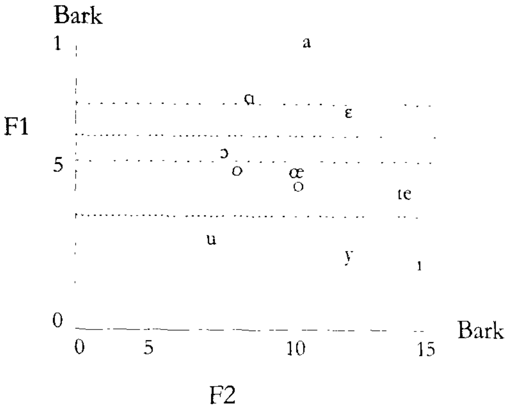


Figure 1 Formant frequencies of Dutch vowels transformed by the Bark-transformation (adapted from van Heuven (1988:87).

The closely dotted lines in the figure indicate the borders of the phonological classes presented in (5). The classification of (4), where /i/ is grouped with /ɪ/, /y/ is grouped with /ʉ/, and /e/ is grouped with /ε/, is acoustically not strongly motivated. The widely spaced dotted lines in the figure indicate the four vowel height classification of Dutch vowels from (6). Although the four-height system appears to be redundant as a phonological system it is motivated acoustically.

There is additional phonetic evidence for the absence of a long-short opposition for the high vowels in Dutch, as assumed in the height systems in (5) and (6). For one thing, these vowels have a shorter duration than the long vowels /e o a ø/. The vowels /i y u/ have the same length as /e o a ø/ only when they are followed by /r/. Also, when the wave-form of /i/ is shortened, the resulting sound remains /i/, and does not become /ɪ/. The same applies to /y/: shortening of the wave form of /y/ does not result in /ʉ/. In contrast, when the wave form of /e/ is shortened, an /ɪ/ results — not /ε/ — , while shortening of the wave form of /o/ results in /ʉ/ (Janssen-Willemse 1981, Slis 1963). The categorizations in (5) and (6), where /e/ and /ɪ/ are grouped together — instead of /e/ with /ε/ and /i/ with /ɪ/ — and where /ʉ/ is grouped with /o/ — instead of with /y/ — is thus grounded in acoustic facts about Dutch. The marked characteristic of the classification in (5) is that /ε/ is grouped with the low vowels /a/ and /ɑ/. In this classification, then, short vowels have only two heights, mid /ɪ/ /ʉ/ and /ɔ/ and low /ɑ/ and /ε/.

It was mentioned already that there is no known synchronic phonological evidence in adult Dutch that can decide on the matter. The way children categorize the adult model vowels, however, probably does shed some synchronic phonological light on the height classification of Dutch vowels. In the remainder of the chapter we will thus compare the three-height system in (4), the acoustically motivated partial three-height system in (5), and the acoustically motivated though probably more redundant four-height system in (6). Together with the Zipper model of the acquisition of height these classifications make different predictions concerning the order of acquisition and the substitution patterns that are likely to be found in child language. These predictions are formulated in the next section. We will then turn to the acquisition data to check the different hypotheses. It will be seen that none of the three classifications makes the right predictions. The child language data point to a classification of Dutch vowel height as in (7). This classification is a combination of the classification in (5), for the back vowels, and the one in (6), for the front vowels:

(7) *Three-Four-height classification proposed here*

	Front	Central	Back
high	i y		u
high mid	e ø ɪ ʉ		o ɔ
low mid	ɛ		
low		a	ɑ

6.3 Hypotheses

The categorization in (4) will now be called Model I, the categorization in (5) is Model II and the one in (6) is Model III. In (8) the models are presented once again (next page).

According to the Zipper model, the representations for height available in the initial stage are limited to [+high] and [+low]. Subsequently, more heights can be represented, starting with the higher regions. In the three-height models this simply means that in stage I [+ high] and [+low] are active representations in the output system, while in stage II a representation for mid vowels is acquired. In the four-height model stage I is identical to stage I for the three-height model. In stage II a representation for the

(8) *The three categorizations of Dutch vowel height*

(8) *The three categorizations of Dutch vowel height*

		Model I	Model II	Model III
high		i ι y ʉ u	i y u	i y u
mid	high mid	e ɛ o ɔ o	e ι ɔ ʉ o ɔ	e ι ø ʉ o
	low mid			ɛ ɔ
low		ɑ a	ɛ ɑ a	ɑ a

high mid vowels is acquired. Finally, in stage III, low mid vowels can be represented too. With respect to actual vowels that can be represented in the different stages, the three models clearly predict different things. In (9) the vowels that are predicted by the three models to be representable in the developmental stages are listed. From now on we will not be concerned with the front & round vowels. The rounding presents a complicating factor to acquisition — this was also mentioned by Jakobson — which obscures the view on the development of height. Also, and this supports the preceding statement, they occur late in the children's productions and are not attempted very frequently.

(9) *Vowels that are predicted to be representable with regard to vowel height*

	Model I	Model II	Model III
Stage I	i ι u	i u	i u
	a ɑ	a ɛ ɑ	a ɑ
Stage II	e ɛ	e ι	e ι
	o ɔ	o ɔ	o
Stage III			ɛ ɔ

The predictions concerning the vowels /i u a ɑ e o/ are the same according to the three models but the predictions concerning /ɛ ι ɔ/, focusing on height, are different:

/ι/ In Model I the vowel /ι/ is considered to be [+high]. In principle, then, /ι/ should be representable as such from the start. In the models II and III, however, /ι/ is considered to be mid or high-mid. The representation for (high) mid vowels becomes available in the second stage. According to the models II and III, then, /ι/ /e/ and /o/ should occur simultaneously in the child's production.

/ɔ/ The vowel /ɔ/ is considered to be mid in the models I and II, and is thus representable as such in the second stage. In these models the vowels /ɔ/ /e/ and /o/ are expected to occur in the child's productions at the same time. In Model III /ɔ/ is considered to be a low-mid vowel. The representation for low-mid vowels is acquired later than the representations for the high-mid vowels. According to Model III, then, the vowels /e/ and o/ will occur in the children's productions before the vowel /ɔ/.

/ε/ The vowel /ε/ is considered to be mid in Model I. According to this model /ε/ is therefore acquired in stage II, simultaneously with /e/, /o/ and /ɔ/. In Model II /ε/ is considered to be low and as such representable from the start, simultaneously with /ɑ/, /a/, /i/ and /u/. In Model III, finally, /ε/ is considered to be low-mid, and is predicted to be acquired in stage III, in a later stage than /e/ and /o/.

This is one aspect of the predictions that result from the Zipper model of the acquisition of vowel height in combination with the three different vowel categorizations. The other part concerns the height substitutions we expect to find in the child language data.

In order to formulate hypotheses in the height substitution area, additional assumptions need to be made as to what the most probable direction is for the substitutions to take in the initial stage: high or low. There are two aspects that can be of influence in this matter. One is the way height is phonologically represented: different categories of vowels could be grouped together on the basis of similarities in their respective representations. Up until now, the two ways to phonologically represent vowel height in a feature geometrical representations, either by [±high] [±low] or by a multi-tiered [±open] representation have not been discussed. In order not to get lost in too many variables while formulating the different predictions concerning the direction substitutions will take in the children's productions — three height categorizations, two representations and the Zipper model — as a working model, the 'high' 'mid' and 'low' characterizations as used in (8) will be taken as the actual representations of vowel height. For now, then, the different heights are represented as [high], [low] and [mid] for the three-height systems, and as [high], [low], [high, mid] and [low, mid] for the four-height system. In 6.5, when we are left with only one height categorization, we will turn to the representations for height as formulated in phonological theory.

In the three-height system, then, the representation does not give any direction as to what the substitutions for mid vowels in stage I will be: the available representations are [high] and [low], but these have nothing in common with the representation for mid vowels [mid]. In the four-height system a direction can be deduced from the representation in (8). The [high, mid] vowels have [high] in common with the [high] vowels, and in stage I we thus expect to find [high] substitutions for these [high, mid] vowel targets. In the child language data we should then find /i/'s for attempted /e/'s, and /u/'s for attempted /o/'s. The [low, mid] vowels have [low] in common with [low] vowels, and we expect to find /a/ and /ɑ/, and not /u/ and /i/, as substitutions for adult target /ɔ/ and /ɛ/. In the next stage, when, according to the Zipper model, [high, mid] vowels are acquired, /ɔ/ and /ɛ/ can be grouped with these vowels based on their common feature [mid]. In this stage we expect to find /e/ as a substitution for the target vowel /ɛ/ and /o/ for the target vowel /ɔ/, in addition to the substitutions /a/ and /ɑ/.

An additional aspect that will be assumed to influence the height direction of substitutions lies outside of the representation and is formulated as the 'retain color principle'. The lower a vowel is, the less pronounced its color, or, place of articulation characteristic. Vice versa, the higher a vowel is, the more pronounced its color. Assuming that in principle the place of articulation of a target vowel is retained in the substitute vowel, the adult model [mid] vowels of the three-height system will in the initial stage be substituted by [high] (colorful) vowels, rather than by [low] (colorless) vowels. In the four-height model, the adult model [low, mid] vowels /ɔ/ and /ɛ/ can be expected to become [low] in stage I because of the representation, or [high], because of the 'retain color' principle. In stage II, where [low, mid] vowels can either group with the [high, mid] vowels, or with the [low] vowels, the 'retain color' principle predicts that we are more likely to find [high, mid] vowel substitutions for attempted [low, mid] vowels. In principle, then, the three models raise the following expectations with respect to substitutions of attempted adult vowels:

(10) *Predicted substitutions*

target vowel	Model I	Model II	Model III (stage I)	Model III (stage II)
i	no sub	no sub	no sub	no sub
u	no sub	no sub	no sub	no sub
ɑ	no sub	no sub	no sub	no sub
a	no sub	no sub	no sub	no sub

target vowel	Model I	Model II	Model III (stage I)	Model III (stage II)
e	i ɩ	i	i	no sub
ɩ	no sub	i	i	no sub
ɛ	i ɩ	no sub	ɑ a / i	e ɩ
o	u	u	u	no sub
ɔ	u	u	ɑ a / u	o

Except for substitutions we can also expect avoidance of adult target words containing vowels that cannot be represented yet in the output representation of the child.

With these predictions in mind we will now turn to the child language data.

6.4 Data

6.4.1 Nature of the data

The data come from 7 children from the data corpus, 5 of whom were recorded from the beginning of meaningful speech. For the investigation of the development of vowel height the stressed vowel of every spontaneously produced word, that is, every spontaneous token, in the child's data was taken into consideration, from the initial recording up until the moment that the height system appeared to be mature and stable. In a study by Lieberman (1980) on the development of vowel productions in children acquiring English, it turns out that although the formant frequencies of vowels produced by children are quite different from those produced by adults, the spectral patterning of the vowels is correct. Also, formant frequencies of vowels like /ɩ/ and /æ/ are in proper relation to those of vowels like /i/ and /a/. This development of the approximation of the acoustic vowel space of, in this case, English, turns out to be already well on its way during the babbling stage. The transcriptions of vowels produced by the children in the present study that are used here can thus be regarded faithful reflections of their approximation of the classification of Dutch vowels.

In the introduction it was mentioned that the data were not easily interpretable, since on the whole substitutions of adult vowel targets always existed next to matches. Also, quite unexpected substitutions occurred, some of which could not be interpreted at all. However, there is also a series of characteristics in the development of vowel height that are stable across different children's data. A first indication of the characteristics that will be accounted for here is found in the tables below.

The predictions made in (9) concerning the order of acquisition of the different vowels are put to the test by the data in table I. In this table the ages of the five children that were recorded from the outset of meaningful speech at which an attempt — whether resulting in a match or a substitution — at the different Dutch vowels was recorded for the first time are listed.

Robin		Jarmo		Elke		Noortje		Tirza	
1;5.11	i a ɑ ɪ	1;4.18	i a ɑ ɪ	1;6.25	i u a ɑ	1;8.26	u ɑ	1,6.10	a ɑ ɪ
	e ɔ	1;5.2	u		ɪ ɔ	2;0.10	a	1,8.5	i u e o
1;5.22	o	1;6.13	e	1;7.8	e o	2,1.17	i ɪ e o	1,8.26	ɔ
1;6.23	u	1;6.27	o	1;8.13	ɛ	2;2,21	ɔ	1,9.11	ɛ
1;8.10	ɛ	1;7.15	ɔ			2;3.7	ɛ		
		1;8.12	ɛ						

Table I. Emergence of attempts to produce the different vowels

The interpretation of the table is that words from the language containing vowels that do not present problems to the output system of the child are more likely to be selected for use in production than words containing troublesome vowels. The contour of the Zipper model can be distinguished then: [high] and [low] vowels are (among the vowels) attempted first. For all the children the vowel /ɛ/ is avoided longest. This is contrary to the prediction of Model II, where /ɛ/, being a [low] vowel, is expected to occur simultaneously with /ɑ/ and /a/. The late appearance of target /ɛ/ confirms the predictions of Model III where /ɛ/, being a [low, mid] vowel, is expected to be acquired in stage III, later than /e/ and /o/, but simultaneously with /ɔ/. There is less evidence for this last prediction. Although in the data of three children /ɔ/ is indeed attempted later than /o/ and /e/, in the data of the two other children /ɔ/ is attempted before /o/, and simultaneously with or before /e/. The vowel /ɪ/ is in this table more like the [high] vowels (the classification of Model I) than like the [mid] vowels (the classification of Model II and Model III). On the basis of Table I, then, it can be concluded that Model II makes the wrong predictions with respect to /ɛ/. For Model I and Model III an equal amount of evidence is found: the vowel /ɛ/ behaves more like predicted in Model III, the vowel

/ɪ/ behaves more like predicted by Model I, and with respect to /ɔ/ the data of three children point to the classification in Model III, while the data of the two other children point to the classification in Model I (or Model II, for that matter).

Some actual examples of the initial attempts of Jarmo, Noortje and Tirza to produce the different vowels are in (11):

(11) *Sample of attempts to produce words containing the different vowels*

child	age	V	adult model	production
Jarmo	1;4.18	i	die 'that one' /'di/	['di]
	"	a	klaar 'ready' /'klaɹ/	['gɑ]
	"	ɑ	hap 'bite' /'hɑp/	['hɑp]
	"	ɪ	dit 'this' /'dɪt/	['tɪ]
	1;5.2	u	poes 'cat' /'pus/	['pu]
	1;6.13	e	deze 'this one' /'dezə/	['tɛiʃ]
	1;6.27	o	auto 'car' /'oto/	['oto:] ['ɑto:]
	1;7.15	ɔ	op 'all-gone' /'ɔp/	['ɔp]
	1;8.12	ɛ	Ernie (name) /'ɛɹni/	['nanɑ]
Noortje	1;8.26	ɑ	appel 'apple' /'ɑpəl/	['ɑp]
	"	u	koe 'cow' /'ku/	['ku]
	2;0.10	a	gemaakt 'made' /χə'makt/	['mɑ]
	2;1.17	ɪ	die 'that one' /'di/	['ti]
	"	ɪ	Willy (name) /'ʋɪli/	['ʋɪhi]
	"	e	twee 'two' /'tʋe/	['te:]
	"	o	boom 'tree' /'bom/	['pu]
	2;2.21	ɔ	pop 'doll' /'pɔp/	['pup]
	2;3.7	ɛ	bed 'bed' /'bɛt/	['pɛt]
Tirza	1;6.10	ɪ	Tirza (name) /'tɪɹt͡sa/	['tɪ,ʋa]
	"	ɑ	mamma 'mommy' /'mɑma/	['mɑmɑ]
	"	a	daar 'there' /'daɹ/	['ta]
	1;8.5	i	drie 'three' /'dʀi/	['dši]
	"	u	bloemen 'flowers' /'blumə/	['humə]
	"	e	beer 'bear' /'beɹ/	['bi:]
	"	o	boom 'tree' /'bom/	['moma]
	1;8.26	ɔ	op 'all-gone' /'ɔp/	['ɔpənə]
	1;9.11	ɛ	weg 'gone' /'ʋɛχ/	['dɪχ]

As a first step towards testing the predictions in (10), in table II the matching percentages, also given in raw numbers, of adult target vowels in the productions of the children are listed, measured over the entire period taken into consideration. It must be noted that the non-matches do not only include substitutions on the height axis but also those on the front-back axis. Since it is not clear yet to which height class every vowel belongs, every deviation from the adult target is counted as a non-match.

V	Robin	Tirza	Cato	Jarmo	Elke	Noortje	Eva
a	93.2 (222/208)	93.3 (126/135)	94.6 (106/112)	87.9 (203/231)	75 (84/112)	86 (80/93)	94.6 (122/129)
ɑ	86.8 (164/189)	83.2 (84/101)	90.7 (137/151)	82.3 (135/164)	85.9 (128/149)	75.2 (94/125)	95.5 (105/110)
u	85.9 (113/136)	97.4 (76/78)	92.7 (89/96)	91.4 (127/139)	90.5 (134/148)	92.4 (61/66)	98.1 (102/104)
i	83.1 (116/135)	96.2 (73/76)	100 (62/62)	97.8 (90/92)	89.5 (77/86)	94.2 (49/52)	100 (94/94)
ɩ	81.6 (155/190)	80.5 (66/82)	59.7 (40/67)	61 (99/162)	77.5 (100/129)	74.4 (58/78)	80.8 (59/73)
o	76.5 (244/319)	84.7 (83/98)	91.5 (129/141)	80.1 (145/181)	65.8 (96/146)	28.4 (33/116)	91.4 (138/151)
ɔ	64.2 (77/120)	92.7 (51/55)	81.5 (101/124)	82.6 (57/69)	73.7 (70/95)	91 (61/67)	92.5 (99/107)
e	51.2 (128/250)	79.2 (61/77)	58 (69/119)	79.5 (147/185)	71.2 (163/229)	35.8 (34/95)	87.8 (79/90)
ɛ	29.5 (23/78)	75 (30/40)	53 (27/51)	86.3 (44/51)	72.7 (48.66)	71.7 (38/53)	72.8 (59/81)

Table II. Mean matching percentages of attempts at adult model vowels

Three things are notable in this table. Firstly, on the whole the high vowels /i/ and /u/ and the low vowels /a/ and /ɑ/ have the highest matching rates in the data of the children. This is what we would expect on the basis of the Zipper model: [high] and [low] are available in the output representations from stage I on, and productions of [high] and [low] adult models need not be deviating. In this sense it is surprising that there are substitutions at all. It will be seen, below, that most of these substitutions are either on the front-back dimension not involving height, or they involve length (ɑ/a). Secondly, in the data of four of the seven children the adult model /ɛ/ has the highest error rate. This is, again, not in accord with the predictions in (10) of Model II, where /ɛ/ was expected not to be substituted at all. Finally, the target vowel /ɩ/ is for four children among the vowels with a relative low matching rate, and is grouped among the mid vowels rather than among the high and low vowels in the table. This presents a problem for Model I, where /ɩ/ is classified as [high], together with /i/ and /u/. In (10) it was predicted for Model I that /ɩ/ would not be substituted. In this case, the deviations are not mainly in the front-back dimension. The extremely low matching percentage for the targets /e/ and /o/ in Noortje's data are caused by the fact that she systematically diphthongizes these vowels to /ɛi/ and /ɑu/ respectively.

The target adult vowel /ɛ/ is marked in that it is attempted late by the children in the study and, when it *is* attempted, it is highly prone to errors in the production of the children. This is not an artefact of the status of /ɛ/ in adult Dutch, as can be seen in Table III, where percentages of the distribution of vowel sounds in Dutch conversational speech are presented, derived from data of Eggermont (1956) by Koopmans-van Beinum (1980).

ɑ	18.56
a	12.64
ɛ	11.54
ɩ	10.88
i	10.49
e	9.91
o	9.59
ɔ	8.62
u	3.55
ʉ	2.50
y	1.37
ø	0.35

Table III. Distribution of vowels in conversational speech

The vowel /ɛ/ occurs relatively frequently in Dutch conversational speech (11.54%). In comparison, in a recording of Robin at age 1;11.7, only 2 of the 104 stressed vowels were target /ɛ/, which amounts to 1.9 %. In a later recording, at age 2;0.18, still only 6 of the 177 stressed vowels are attempted /ɛ/'s, 3.4%. Similar low percentages are found for all the children. Incidentally, the opposite is found for target /u/. This vowel does not occur very frequently in adult Dutch conversational speech (3.55%). In the child language data, however, relatively high percentages of target adult /u/ are found. In the same recording of Robin at age 1;11.7, where 104 stressed vowels were counted, /u/ was attempted 15 times, a distributional percentage of 14.4%. In the recording at age 2;0.18, target /u/ still formed 10.2% of the attempted stressed vowels. Although on the whole target /i/ does not occur more frequently in the child language data than in the adult conversations that were investigated in table III, the comparatively high occurrence of /u/ in the child language data could very well be attributed to its [high] status. According to the Zipper model this should make /u/ an attractive target for the language acquiring child.[3]

Summarizing the facts so far, we have seen that (1) the high vowels /i/ and /u/ and the low vowels /ɑ/ and /a/ are in general attempted early and have a low error rate in the children's productions; (2) the vowel /ɛ/, on the contrary, is attempted late and has a high error rate in the productions of the children; (3) the vowel /ɪ/ is attempted as early as the high vowels /i/ and /u/, but is substituted relatively frequently in the children's productions; (4) the target mid vowels /e/ /o/ and /ɔ/ are, in general, attempted later than the high and low vowels, and have higher substitution rates than the high and low vowels in the production of the children.

The conclusions that can be drawn from these facts are: (a) The Zipper model is a good premise for investigating the acquisition of vowel height (from points 1 and 4 above); (b) The position of the vowel /ɪ/ is still unclear: the children's early attempts to produce the vowel point to a categorization with the [high] vowels, while the comparatively frequent substitutions for /ɪ/ in the data point to a classification with [mid] or [high, mid] vowels; (c) The classification of vowels in Model II makes the wrong predictions with respect to /ɛ/. In this model /ɛ/ is categorized as a low vowel and, on the basis of the Zipper model, is thus predicted to be like the other low vowels /a/ and /ɑ/ to the language acquiring child. Instead of being one of the most easily acquired vowels, /ɛ/ appears to be the most problematic target vowel. Model II clearly loses out to the Models I and III on this point, and will therefore be left aside in the further consideration of the acquisition of vowel height.

Now we have seen the error rates of the different vowels, we will turn to the nature of these errors. Investigating how the adult model vowels are actually managed in the production of the child, especially the target mid vowels and the still ambiguous vowel /ɪ/, gives us more information about the initial state and the subsequent development of the output system with respect to the representation of height. Asymmetries in the directions taken

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[3] The findings here concerning /ɛ/ and /u/, namely that frequency of occurrence in the adult language does not affect the children's productions, indicate again that phonological acquisition is more than a matter of copying the adult language.

by the substitutions, will furthermore help to force a choice between the remaining two height classifications, Model I and Model III.

6.4.2 Substitution patterns

6.4.2.1 Finding the systematic substitutions

Above it was mentioned that in the development of a representation for height 'all or none' patterns are hardly found. This was unlike the development along the place of articulation dimension, where very systematic patterns in what did and what did not occur could be found. Concerning height, the predictions refer to tendencies in the data: *if* a substitution occurs in the data it is likely to go in such and such direction. In this respect, tracing the different vowels in the data over a longer stretch of time also brings to light an interesting pattern in the data of some of the children. For some children, especially with respect to the mid vowels, three stages can be discerned: an initial stage where the target adult vowel is matched in the productions of the child, followed by a period where a whole array of substitutes is produced, often next to a matching vowel, followed by a period where the child settles on one or two substitutes next to the matching vowel. In the second stage often quite random substitutions occur in the data, random in the sense that they involve vowel productions that are unpredictably raised or lowered compared to the adult target. The 'Free variation model' of Blache, mentioned in the introduction, appears to refer to this stage. However, the free variation does not involve the Place of Articulation features.

In the data of Elke at age 1;9.24 we find the following productions for target /e/: [e], [i], [ɩ], [ɑ], [ɛ] and [ɛi]. From age 2;3.27 on she settles on [e], [i] and [ɩ] for target /e/. Noortje starts out producing [o] and [ɑu] for target /o/. Subsequently, in a recording at age 2;7.2, she produces [o], [ɔ], [u], [ɑu] and [a] for this target, and then settles again on [ɑu] and [o]. Robin initially matches target /o/'s in his productions, then, from age 1;7.13 until 1;9.10 produces either [o], [ɔ], [ɑu], [ɑ], [a] and [u] for this target. He finally sticks to [o] and [u]. This is illustrated in (12)

(12) *Examples of 'random' substitutions*

child	age	attempted V	adult model	production
Elke	1;9.24	/e/	eend 'duck' /'ent/	['ɑtʃ]
			heet 'hot' /'het/	['ets] ['ɛts]
			meer 'more' /'meɹ/	['mɪɔ̃χ] ['mɪ] ['me]
			thee 'tea' /'te/	['teĭ] ['tɪə] ['tɛɪ]
Noortje	2;7.2	/o/	oog 'eye' /'oχ/	['ɔχ]
			ook 'also' /'ok/	['ɑuk]
			dood 'dead' /'dot/	['toːŭt]
			poten 'paws' /'potə/	['paːtɑ]
			rode 'red one' /'rodə/	['huwĭja]
Robin	1;7.13	/o/	boom 'tree' /'bom/	['bɔm] ['bum]
			auto 'car' /'oto/	['ɑuta]
			mooi 'beautiful' /'moɪ/	['buɪ] ['boɪ] ['bɔɪ]
	1;8.24		brood 'bread' /'bʀot/	['baĭt]
			boot 'boat' /'bot/	['buːt]
			auto 'car' /'oto/	['oːtə]

It appears that, at least for a number of children, the height dimension slowly becomes systematized, i.e. phonologized, while it starts out as a predominantly phonetically driven subpart of the Place structure of vowels. That is, while the place of articulation of attempted vowels is in general matched, the height appears to be guessed rather than systematically assigned. As soon as the child recognizes that, for example, the phonological representation of /e/ has more in common with the representation of /i/ than with the representation of /a/, the child will group /e/ with /i/ in its output representations, which results in systematic /i/ substitutions. Because the phonological development of the height dimension is being investigated here, the intention is to look for substitutions that result from the developing phonological system of the child. These are thought to be the substitutions that appear systematically in the data of the children. The global idea is that systematic substitutions are the ones that occur regularly and for a longer period of time in the productions of the child. This is given a numerical basis by only taking into account the substitutions (and matches) that occur in more than 5% of the productions of the different target vowels.

In table IV substitutions for target vowels are listed that are present in the data over 10% of the time.[4]

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[4] Because the proportion of substitutions of adult model vowel attempts is measured with respect to all the attempts over the whole period taken into consideration, the 10% limit is not as low as it seems. In individual recordings up to 100% of the attempts to produce an adult model vowel result in a non-matching vowel production

V	Robin	Jarmo	Tirza	Elke	Noortje	Catootje	Eva
a		ɑ (10.4) (24/230)		ɑ (15.2) (17/112)	ɑ (12.9) (12/93)		
ɑ	a (10.1) (19/189)	a (12.2) (20/164)	a (11.9) (12/101)		a (22.4) (28/125)		
i	ɪ (14.7) (20/136)						
e	i (18.8) (47/250) ɪ (24.8) (62/250)	i (11.3) (21/186)		ɪ (11.4) (26/229)	i (11.6) (11/95) ɛi (30.5) (29/95)	i (23.8) (40/168) ɪ (12.5) (21/168)	
ɪ	i (13.7) (26/190)	i (34) (55/162)	i (13.4) (11/82)	i (20.2) (26/129)	i (15.4) (12/78)	i (36.8) (42/114)	i (13.7) (10/73)
o			ɑu (11.2) (11/98)	ɑu (13.7) (20/146) ɔ (12.3) (18/146)	ɑu (62.1) (72/116)		
ɔ	u (30.8) (37/120)	o (11.6) (8/69)		u (15.8) (15/95)		o (10.5) (14/124)	
ɛ	ɪ (44.9) (35/78) ɑ/a (12.8) (10/78)	ɑ/a (13.7) (7/51)	ɪ (15) (6/40) ɑ/a (10) (4/40)	ɑ (16.7) (11/66)	ɑ/a (24.5) (13/53)	ɪ (16.1) (14/87)	ɪ (18.5) (15/81)

Table IV. Substitutions occurring over 10% of the time

A summary of these relatively often occurring substitutions is given in (13):

(13) *Relatively systematically occurring substitutions (10% scale)*

a → ɑ	(3 children)	o → ɑu	(3 children)
ɑ → a	(4 children)	o → ɔ	(1 child)
i → ɪ	(1 child)	ɔ → o	(2 children)
ɪ → i	(7 children)	ɔ → u	(2 children)
e → i	(4 children)	ɛ → ɪ	(4 children)
e → ɪ	(3 children)	ɛ → ɑ/a	(5 children)
e → ɛi	(1 child)		

The data in (14) illustrate these substitutions:

(14) *Examples of the relatively systematically occurring substitutions in (13)*

a → ɑ	klaar 'ready' /'klaɹ/	['kɑ]	Jarmo	1;6.13
ɑ → a	brand 'fire' /'bʀɑnt/	['bant]	Robin	1;9.10
i → ɪ	die niet 'that one not' /'di 'nit/	['dɪnt]	Robin	1;6.23

ι → i	zitten 'sit' /'zιtə/	['tsitə]	Tirza	1;8.5
e → i	zebra 'zebra' /'zebʀa/	['hipa]	Catootje	1;11.9
e → ι	beer 'bear' /'beɹ/	['pι]	Elke	1;9.10
e → εi	tekenen 'draw' /'tekənə/	['tεikə]	Noortje	2;6.5
o → ɑu	koken 'cook' /'kokə/	['kɑukə]	Noortje	2;6.19
o → ɔ	boot 'boat' /'bot/	['bɔ]	Elke	1;8.31
ɔ → o	monkey 'monkey' /'mɔŋki/	['kogi]	Jarmo	2;0.28
ɔ → u	botsing 'crash' /'bɔtsιŋ/	['pusin]	Robin	2;0.18
ε → ι	weg 'gone' /'ʋεχ/	['dιχ]	Eva	1;6.1
ε → ɑ/a	helpen 'help' /'hεlpə/	['hɑupə]	Catootje	1;11.22

In Table V substitutions are listed that occurred in 5% – 10% of the time:

V	Robin	Jarmo	Tirza	Elke	Noortje	Catootje	Eva
a				ε (7.1) (8/112)			
ɑ				a (7.4) (11/149)			
i				ι (9.3) (8/86)			
u	y (8.9) (12/136)	y (5) (7/140)					
e		ι (5.4) (10/186)	ι (9.1) (7/77) i (9.1)	i (5) (9/180)			
o	u (6) (19/319) ɔ (9.1) (29/319) ɑu (6) (19/319)	ɔ (9.4) (17/181)		u (6.2) (9/146) ɑ (6.2) (9/146)			ɔ (6) (9/151)
ɔ	o (5) (6/120)			o (9.5 (9/95)	u (6) (4/67)	u (6.4) (11/172)	
ε	i (9) (7/78)			ι (7.6) (5/66)		ɑ (8) (7/87) e (5.7) (5/87)	ɑ (7.4) (6/81)

Table V. Substitutions occurring 5% — 10% of the time

Summarizing this table, in the 5%–10% scale the following substitutions occur (again):

(15) *Relatively systematically occurring substitutions (5%-10% scale)*

a → ɛ	(1 child)	i → ɪ	(1 child)
ɑ → a	(1 child)	e → ɪ	(2 children)
u → y	(2 children)	e → i	(2 children)
o → ɔ	(3 children)	ɛ → i	(1 child)
ɔ → u	(2 children)	ɛ → ɪ	(1 child)
ɔ → o	(2 children)	ɛ → e	(1 child)
o → u	(2 children)	ɛ → ɑ	(2 children)
o → ɑ	(1 child)		
o → ɑu	(1 child)		

Examples of the substitutions that did not appear in (14) already are in (16):

(16) *Examples of the relatively systematically occurring substitutions in (15)*

a → ɛ	kaars 'candle' /'kaɹs/	['tɛʃ]	Elke	1;8.29
u → y	stoel 'chair' /'stul/	['dys]	Robin	1;6.23
o → u	brood 'bread' /'bʀot/	['put]	Elke	1;10.7
o → ɑ	auto 'car' /'oto/	['ɑto]	Elke	1;8.29
ɛ → i	Bert (name) /'bɛɹt/	['pit]	Robin	1;11.21
ɛ → e	centjes 'cents' /'sɛntjəs/	['tenə]	Catootje	1;10.11

Finally, the information from (13) and (15) is combined in (17):

(17) *Systematic substitutions in the data*

N child	substitution	N 10%	N 5%		N child	substitution	N 10%	N 5%
7	ɪ → i	7			3	a → ɑ	3	
7	ɛ → ɑ/a	5	2		2	i → ɪ	1	1
6	e → i	4	2		2	u → y		2
5	ɑ → a	4	1		2	o → u		2
5	ɛ → ɪ	4	1		1	e → ɛɪ	1	
5	e → ɪ	4	2		1	a → ɛ		1
4	o → ɑu	3	1		1	o → ɑ		1
4	o → ɔ	1	3		1	ɛ → ɪ		1
4	ɔ → o	2	2		1	ɛ → e		1
4	ɔ → u	2	2					

These are the data that will be accounted for in the remainder of this chapter.

6.4.2.2 Symmetries and asymmetries in the substitutions

For ease of exposition, the predictions formulated in (10) are repeated here in (18) for the Models I and III:

(18) *Predicted substitutions*

target vowel	Model I	Model III (stage I)	Model III (stage II)
i	no sub	no sub	no sub
u	no sub	no sub	no sub
ɑ	no sub	no sub	no sub
a	no sub	no sub	no sub
e	i ɩ	i	no sub
ɩ	no sub	i	no sub
ɛ	i ɩ	ɑ a / i	e ɩ
o	u	u	no sub
ɔ	u	ɑ a / u	o

Considering the substitutions in (17) above, a number of monodirectional substitutions is present in the data, listed in (19).

(19) *Monodirectional substitutions*

a.	o → u	g.	ɛ → e
b.	ɔ → u	h.	u → y
c.	e → i	i.	e → ɛi
d.	ɛ → i	j.	o → ɑu
e.	ɛ → ɩ	k.	o → ɑ
f.	e → ɩ		

The substitutions in (19a–e), o → u, ɔ → u, e →i, ɛ →i, are all instances of raising non-low adult model vowels, and they all support the Zipper model of the development of height and also both the height classifications of Model I and Model III. The substitution in (19f), e → ɩ, is an instance of raising a target mid vowel in Model I, but an instance of plain shortening in Model III. The opposite applies to (19g), ɛ → e: in Model III ɛ → e is regarded as an instance of raising, while in Model I it is considered an instance of lengthening.[5] The substitution in (19h), u → y, takes place in the front-back dimension and always occurs in Coronal environments. As such it is of no concern to the acquisition of height. The mono-directionality of the substitutions in (19i, j), e → εi and o → ɑu, is of course an artefact of the fact that diphthongs are not taken into consideration. Diphthongizing of the long mid target vowels is a production strategy that loosely fits the Zipper model, in that instead of raising or lowering a mid vowel, the whole range from low to high is employed. Another diphthong that is regularly found in the data for an adult target /e/ is [ɑi], where the low-high range is used to the fullest extent. Finally, in (19k), o → ɑ, there is a substitution that goes against the predictions in (18) of both height models: a (high) mid vowel is lowered to /ɑ/, while only raisings are expected in the case of (high) mid vowels. However, this lowering is only apparent, as will become clear below.

There is also a number of bidirectional substitutions in (17). These are listed in (20).

(20) *Bidirectional substitutions*

a. ɩ ↔ i
b. o ↔ ɔ
c. a ↔ ɑ
d. ε ↔ ɑ/a

The bidirectional substitution in (20a), ɩ ↔ i, is problematic for Model III, since it involves a lowering of a high target /i/ to a mid vowel /ɩ/. To Model I, however, it would be a substitution of two high vowels. The same applies to (20b), o ↔ ɔ: in Model III the lowering of /o/ to /ɔ/ is not predicted to occur, but in Model I this substitution involves only length. The changes of /a/ to /ɑ/ and of /ɑ/ to /a/, (20c), provide no problems, since in both models these occur within the class of low vowels. Neither of the models, finally, accounts for the bidirectional substitution in (20d), ε ↔ ɑ/a, although to Model III only one direction, ɑ/a → ε, is problematic.

Model I thus appears to make the best predictions concerning the substitutions that are expected to occur in the children's production data. The height classification of Model III, however, fares better in accounting for the late appearance in the children's productions of target words containing /ε/, and the relatively high error rates of both target /ε/ and /ɩ/ in the data. What has not yet been considered is the influence of adjacent segments on the children's productions of adult model vowels. It

[5] The reader is reminded of the long and short series of vowels in Dutch, presented in (3).

turns out that several obscuring external circumstances can be found that affect the children's productions. These contexts are discussed next. It will be seen that after filtering out the substitutions affected by context, the scales are tipped more towards Model III. First the substitutions are tackled that are problematic to both or either of the height classifications, then, for completeness, the substitutions that appear to confirm the predictions in (18) applying to both models are investigated.

6.4.3 External circumstances affecting vowel height: the problem cases

6.4.3.1 Raising of low vowels

The substitution [ɛ] for /a/ occurred in 6% of the data of one child, Elke. In fact, raised productions of target low vowels occur in the data of almost all the children. These productions all turn out to be instances of assimilations to adjacent Coronal or Labial segments. The raising involved is a corollary of the Coronal or Labial color that these originally low vowels acquire. Examples of these assimilations are given in (21):

(21) *Raisings that are actually POA feature assimilations*

kaas 'cheese' /'kas/	['kɛʃ]	1;8.13	Elke
kaars 'candle' /'kaɹs/	['kɛʃ] ['tɛʃ]	1;8.31	Elke
banaan 'banana' /bɑ'nan/	['nɛn]	1;10.7	Elke
dansen 'dance' /'dɑnsə/	['tɛsɑ]	1;10.7	Elke
bal 'ball' /'bɑl/	['pɔŭw]	1;18.13	Elke
tandpasta 'toothpaste' /'tɑmpɑsˌta/	['tɛmpɑpa]	2;0.18	Tirza
draaimolen 'merry-go-round' /'draiˌmolə/	['dɛiˌmolə]	2;1.2	Tirza
aap 'monkey' /'ap/	['ɔp]	1;6.10	Robin
slapen 'sleep' /'slapə/	['bɔpɨ]	1;8.24	Robin

The raised target low vowels in the productions of the children, then, occur in recoverable circumstances and have no consequences for the model of acquisition of height, nor do they require yet another classification of vowels.

6.4.3.2 Lowering of target mid vowels

The other substitution that went against the predictions of both models in (18) was o → ɑ. This production [ɑ] occurred in 6.2% of the total number of attempts to produce /o/ in the data of Elke, and instances of this same substitution also occur in the data of other children. However, it is only produced in very specific circumstances, namely only in productions of the adult model *auto* 'car' /'oto/. An alternative pronunciation for *auto*, often heard in Dutch, is /'ɑuto/, with the diphthong /ɑu/ instead of /o/ as the stressed vowel. Five of the children that regularly produce /ɑu/ for /o/ do this only when they produce *auto*, and it is in the data of these children that /ɑ/ is found. This /ɑ/, then, may well be a shortened diphthong /ɑu/, and not a lowering of an adult target /o/.

The other instance of lowering is ɛ → ɑ/a, and occurs relatively frequently in the data of all the children. There are two clear environments in which target /ɛ/ is produced [ɑ] or [a], namely before dark /l/ (ɫ) and before Dorsal consonants. Examples of apparent lowerings before dark /l/ are in (22):

(22) *Apparent lowerings before dark /l/*

helpen 'to help' /'hɛɫpə/	['hɑupə]	1;4.26	Eva
		1;11.22	Cato
wel 'it <u>is</u>' /'ʋɛɫ/	['ʋɑu]	1;9.8	Eva
		2;2.29	Cato
		2;2.27	Robin
		2;9.12	Noortje
zelfde 'same' /'zɛɫfdə/	['zɑuftə]	2;4.23	Cato
		2;2.27	Robin
		2;6.5	Noortje
melk 'milk' /'mɛɫk/	['mɑuk]	1;11.9	Cato
		2;2.27	Robin
		2;2.27	Jarmo
speldje 'hairpin' /'spɛɫtjə/	['pɑutjə]	2;2.29	Cato
welke 'which one' /'ʋɛɫkə/	['ʋɑukə]	2;2.27	Robin
schelp 'shell' /'sχɛɫp/	['hɑup]	2;5.23	Noortje
Elke (name) /'ɛɫkə/	['ɑɫkə]	2;2.6	Elke

As can be seen, in most cases dark /l/ itself does not appear in the child's production, but instead an /u/ is produced. These data are actually similar to Old English Breaking (OEB). Here front vowels became centring diphthongs, as in (23) (examples taken from Gussenhoven & van de Weijer 1990):

(23) *Old English Breaking*

ceald	'cold'	(Gothic: kalds)
healdan	'hold'	(Gothic: haldan)
healf	'half'	

The analysis presented in Gussenhoven & van de Weijer (1990) for OEB reflects the general view held in the philology literature (Dresher 1978, Sievers 1928). They argue that the dark allophone of the phoneme /l/ has secondary velarization, i.e. it has a Dorsal node. This node is supposed to spread to the preceding vowel, making it — partially — back. The [ɑ] productions of the children, which occur in the same environment, are thus rather viewed as substitutions in the front-back dimension than as lowerings. The fact that in most of the productions of the children an [u] is produced instead of the target dark /l/ strengthens this analysis.

Another context for OEB is a following /x/ — transcribed in our data as /χ/. Interestingly, a following /χ/ /k/ or /ŋ/ brings about an [ɑ] or [a] in the children's production too, as can be seen in (24):

(24) *Apparent lowering in the context of /χ/ /k/ or /ŋ/*

gek 'silly' /ˈχɛk/	[ˈhɑχə]	2;3.28	Cato
	[ˈhɑk]	2;0.18	Tirza
	[ˈsak]	2;1.26	Robin
lekker 'good' /ˈlɛkəɹ/	[ˈlɑkə]	2;4.9	Cato
	[ˈlɑkɪ]	1;10.22	Tirza
	[ˈtaka]	1;11.7	Robin
weg 'gone' /ˈʋɛχ/	[ˈʋɑχ]	2;0.18	Robin
	[ˈhaχ]	2;7.2	Noortje
eng 'creepy' /ˈɛŋ/	[ˈɑŋ]	2;4.8	Robin

Again, the analysis of Gussenhoven & van de Weijer is that the Dorsal node of /x/ spreads to the preceding vowel: a backing process, not a lowering process. This is probably also the reason why we find so few cases where a back vowel becomes /ɑ/ or /a/ in these environments. A noticeable fact is that it is especially /ɛ/ that is sensitive to dark /l/ and Dorsal consonants. Other front vowels are hardly ever affected by these contexts. An additional noticeable fact is that the backing of /ɛ/ results in /ɑ/ and not in /ɔ/, which would be expected especially in Model I. In Model III the possibility of a low substitute is present, although in the case of 'all other things being equal' /ɔ/ would be expected too. In this case, then, it appears that Model II, abandoned in 6.4.1, where both /ɛ/ and /ɑ/ are considered to be low, holds some truth after all. We will come back to this below.

6.4.3.3 Lowering of the high vowel /i/

In (17) there are two children who produce [ɩ] for the target vowel /i/. This is a problem case for Model III, where /ɩ/ is considered to be a [high, mid] vowel. For one child, Robin, the production [ɩ] is clearly related to context. In 11 of the 19 cases where [ɩ] is produced instead of /i/ the target utterance is *die niet* 'that one not' /ˈdi ˈnit/, which is in Robin's productions from age 1;6.10 until age 1;8.10 merged to [ˈdɩnt], [ˈdɩ̃nt], [ˈdɩŋnt] or even [ˈdnt] without any vowel at all.

In Beddor, Krakow & Goldstein (1983) the effects of nasalization on vowel height are analyzed. It turns out that nasalization centralizes vowel height: it lowers high vowels, while it raises low vowels. Contextually nasalized mid vowels are raised. Furthermore, a front-back asymmetry exists in that front vowels are more likely to be lowered than back vowels (Beddor et al. 1983:199). This centralization of vowel height is caused by the interaction of the nasal formant (FN) and the first formant (F1) of the non-nasal vowel, the frequency of which is shifted upward in the nasal version because of the nasal coupling. A higher F1 leads to a lower perceived vowel. In high vowels, F1 is the first peak in the nasal vowel spectrum, and the vowel is accordingly perceived as lower. In low vowels, however, a low-frequency FN is the first peak in the nasal vowel spectrum instead of the increased-frequency F1, and this results in a higher perceived vowel. In Beddor et al. (1983) it is subsequently investigated how the acoustic factors could lead to sound change. Interestingly, the conclusion of their calculations is that lack of knowledge of the effects of nasalization results in high vowels being reproduced as lower (oral) vowels. They conclude the section with the relativization: "Of course, it is unlikely that any potential imitator has *no* knowledge of nasalisation — the model simply shows the degree of lowering that would be expected in the most extreme case." (p.103). The first language acquiring children investigated here, however, can probably be regarded as 'imitators' with relatively *little* knowledge of the effect of nasalization, and this would then account for the [ɩ] productions for target /i/'s in nasal environments.

Other productions of Robin where target /i/ has become /ɩ/ in nasal environments are:

(25) *Robin's* i → ɩ *substitutions in nasal environments*

a.	weet ɪk niet 'I don't know' /ˈʋetɪk ˈnit/	[ˈfɩnɩnɩˈnɩt]	1;11.7
b.	Milo (name) /ˈmilo/	[ˈmɩlə]	1;11.7
c.	vier konijntjes 'four rabbits' /ˈviɹ koˈnɛintjəs/	[ˈfɩˌnɔ̃ˈnæintjəs]	2;1.26
	vier boten 'four boats' /ˈviɹ ˈbotə/	[ˈfiə ˈbotə]	2;1.26

The two utterances in (25c) are especially significant: before the nasal string [nɔ̃] in [nɔ̃'næintjəs] target /i/ of *vier* is produced [ɩ], while before the oral string ['botə] it is produced [i].

With regard to back vowels a few cases suggestive of a contextual influence of nasals are found in the data of Eva, Elke, Cato and Robin:

(26) *Influence of nasals on vowel height in the data of other children*

schoenen 'shoes' /'sχunə/	['om]	1;10.11	Cato
	['sɔnə]	1;10.7	Robin
	['hɔŋə]	1;4.26	Eva
bloem 'flower' /'blum/	['pɔŋ]	1;11.28	Elke
	['bomɩ]	1;10.11	Cato

While for Robin the nasal context is probably responsible for the shift from /i/ to /ɩ/, for the other child in (17), Elke, no such context is present. Four of the eight productions where target /i/ becomes [ɩ] concern the word *fiets* 'bicycle' /'fits/, and this target is responsible for most of the [ɩ] productions in the data of other children too. There seems to be no specific reason for lowering or shortening in this case. In spite of this, the postulation of a nasal context for the /i/ to [ɩ] shifts in Robin's data and the few /u/ to [ɔ, o] shifts that there are appears quite attractive. These /i/ to [ɩ] shifts, together with the assumption that a nasal context has a lowering effect on high vowels would then support Model III instead of causing a problem for it. Were /i/ and /ɩ/ of the same height, and given that length is initially quite random in the children's productions (Fikkert 1994), more context-free shifts from /i/ to /ɩ/ would probably be expected in the data (but below we will see other asymmetries in this regard in the front vowel class). However, the direction of change in the children's productions is predominantly from /ɩ/ to [i], namely in more than 10% of the data of all seven children.

Summarizing the facts so far, the substitutes that were not predicted to surface in (18) but are nonetheless present in the child language data can be traced back to contextual influences. The influence of adjacent Coronal and Labial consonants features caused the apparent raisings of low vowels, and adjacent Dorsal segments resulted in the apparent lowering of /ɛ/. The apparent lowering of /o/ to [ɑ] turned out to be a shortening of /ɑu/ to [ɑ]. Finally, the apparent lowering of /i/ to [ɩ] is regarded as an actual lowering, caused by a nasal context. Up until now, the four-height classification of vowels, Model III, is most consistent with these facts. Consideration of the way children further handle the target mid vowels /o/, /ɔ/, /e/ and /ɛ/, finally, leads to the ultimate classification of Dutch vowels.

6.4.4 The mid vowels /o/, /ɔ/, /e/, and /ɛ/

6.4.4.1 /o/ and /ɔ/

In Model III the production [ɔ] for an adult target /o/ would involve lowering, namely of a high-mid vowel to a low-mid vowel. However, in this case no condition for lowering can be found in the data. One example of the randomness of this apparent lowering of /o/ to [ɔ] is in (27):

(27) *Apparent randomness in the production of /o/*

a.	boom 'tree' /'bom/	['bom]	1;10.21	Elke
b.		['bɔm]		
c.		['bum]		

Next to the matching production in (27a), target /o/ is in the child's production 'lowered' to [ɔ] (27b), but in the same session and in the same target word it is also raised to [u] (27c). In the introduction to this chapter the findings of Fikkert (1994) with respect to the acquisition of vowel length were summarized: vowel length is initially completely random in the data, with slightly more lengthened short target vowels than shortened long target vowels. With respect to /o/ and /ɔ/ the data investigated here clearly show this randomness: 4 children reached the 5%-10% or 10% limit for o → ɔ, and 4 children, 3 of which are overlapping, reached this limit for o → ɔ. Measured over the 6 different children, 73 out of 797 target /o/'s were produced [ɔ], i.e. 9.2%, while 37 out of 408 target /ɔ/'s were produced [o], i.e. 9.1%. In a later stage, a context for lengthening/shortening is found in target words of the type $CV(V)C_{son}$. Short vowels are lengthened when this final sonorant is not produced, and long vowels are shortened when this final sonorant does become produced in the production of the child. In this stage, then, /o/ is shortened, and not lowered, to /ɔ/ before a produced sonorant in the same way as /a/ is shortened to /ɑ/ and /e/ is shortened to, for example /ɪ/.

Additional evidence against Model III with respect to the postulated height difference between /ɔ/ and /o/ is found when the predicted stages concerning substitutions are considered. In Model III it was hypothesized that in Stage I both /o/ and /ɔ/ would have the substitute [u], while /ɔ/ would also have the low vowels as potential substitutes. In Stage II /o/ would, in the ideal case, no longer be substituted, while /ɔ/ would be substituted for [o]. In the data of Elke, Noortje and Jarmo, however, target /o/ is produced as [ɔ] from the start, /ɔ/ is hardly ever produced as [ɑ] or [a], and the regularly employed substitute [u], produced for target /ɔ/, is never replaced by [o]. On the basis of these facts it is concluded that the contrast of /o/ and /ɔ/ is only in terms of length and not in terms of height.

For the back mid vowels, then, Model I makes the right predictions: target /o/ and /ɔ/ can, in terms of height, be used interchangeably in the children's productions, and they are both substituted for the high vowel /u/. The interesting thing is that this does not apply to what would be the mirror image relation in Model I between the front vowels /e/ and /ɛ/.

6.4.4.2 /ɛ/ and /e/ versus /e/ and /ɪ/

Of the 454 /ɛ/ attempts in the data of the seven children only 7 are produced as [e], which amounts to 1.5%, and of 1056 /e/ targets, 20 are produced as [ɛ], which amounts to 1.9%. However, considering the alternative classification, where /e/ and /ɪ/ are considered to be of the same height, no free variation in length is found in this relation either. While a large number of e → ɪ shifts is found in the child language data, hardly any ɪ → e shifts occur: only 13 out of 831 attempts, i.e. 1.6%.

Some examples of these infrequent substitutions are given in (28):

(28) *Examples of infrequently occurring substitutions*

ɛ → e	1.5% (7/454)	Ernie (name) /'ɛɹni/	['ɛnə]	Robin	1.11.7
e → ɛ	1.9% (20/1056)	beer 'bear' /'beɹ/	['bɛə]	Jarmo	2,3.9
ɪ → e	1.6% (13/831)	is dat 'is that' /'ɪs,dɑt/	['e,tɑt]	Jarmo	2;4.1

The substitutions that occur systematically (reaching the 10% limit) within the class of front vowels are mono-directional, ɛ → ɪ, e → ɪ, ɪ → i and e → i. Considering the free variation in length then, it has to be concluded that /ɪ/ lengthens to /i/, and /e/ shortens to /ɪ/, while /ɛ/ does not lengthen. This is compatible with findings of Koopmans-van Beinum (1980), who investigated perceptual errors of vowels. The vowels were presented to subjects in three conditions: isolated, in isolated words and in free conversation. The confusions of vowels we find in the child language data are most similar to the perceptual confusions of adults in the first two conditions. It turned out that vowels produced in isolation are hardly ever confused with other vowels. One perceptual error that does occur, however, is a short vowel being perceived as a long vowel. A produced short vowel /ɪ/ is in 5.6% of the cases perceived as /i/, and, notably, in 8.2% of the cases as /e/. The short vowel /ɛ/, however, is hardly ever confused with a long vowel in these circumstances. The explanation in Koopmans-van Beinum is that short vowels are mainly confused with those long vowels that are nearest in the F1 — F2 plane, and that no such long vowel is present in the neighbourhood of /ɛ/. In isolated words, long vowels have a shorter duration and are confused more with short vowels. In this case /e/ is perceived as /ɪ/ in 15.4% of the cases, while it perceived as /ɛ/ in only 2.8% of the cases. In free conversation /e/ is still in 27.2% of the cases confused with /ɪ/, but more confusions with /ɛ/ arise in this condition (10.5%). The vowel /i/ is in this condition often confused with /ɪ/ (30.9%). Both /ɪ/ and /ɛ/ are now perceptually confused with /ʉ/, 28.7% and 45.6% respectively. These numbers are summarized in the table below.

vowel context	perceptual confusion	percentage
isolated vowel	ɪ → i ɪ → e	5.6% 8.2%
isolated words	e → ɪ e → ɛ	15.4% 2.8%
free conversation	e → ɪ e → ɛ i → ɪ ɪ → ʉ ɛ → ʉ	27.2% 10.5% 30.9% 28.7% 45.6%

Table VI. Perceptual confusions of vowels (as measured by Koopmans-van Beinum 1980)

The nature of the adjacent consonants is, unfortunately, not taken into consideration in these measurements. It would, for example, be nice to know if the /i/ to /ɪ/ changes occurred predominantly in nasal contexts.

A classification of the front vowels based on confusions of long and short vowels both in perception and in the child language data does not lead to a completely satisfactory result. However, a class containing /e/ and /ɪ/, as in Model III, appears to be more strongly motivated than a class grouping /e/ and /ɛ/, as in Model I.

Combining the conclusions for /o/ and /ɔ/ and for /e/ and /ɛ/ results in a merge of Model I and Model III: the resulting classification is like Model I for the back vowels, but like Model III for the front vowels. The classification is, of course, also like Model II where an extra height level is introduced for /ɛ/. The isolated position of /ɛ/ in such a classification accounts for the facts concerning this vowel in the data of the children: /ɛ/ is attempted late, it is prone to errors, it does not become lengthened in the children's productions, and it is produced /ɑ/ in Dorsal contexts.

The merged model is like in (29):

(29) *Height classification: present proposal*

	Front	Central	Back
high	i y		u
high mid	e ø ɩ ʉ		o ɔ
low mid	ɛ		
low		a	ɑ

Finally, let us check the predictions that apply to the front vowels in this model, concerning the matches and substitutions that are expected to occur in child language. Above, the predictions concerning the back vowels as they were classified in Model I, and as they are classified now in (29), already turned out to fare better than the predictions made by the four-height Model III.

In the initial stage, where only [high] and [low] are available, it was predicted that target /e, ɩ, ɛ/ would all result in [i] productions by the child. This prediction was based on the Zipper model and on the principle of color preservation. Based on its representation, which included [low], the target /ɛ/ could also surface as one of the [low] vowels in the child's production. We do indeed find [i] as an important substitute for /e/ and /ɩ/ in the data of the children. In the data of Jarmo and Robin [i] is the only or at least the most often surfacing vowel when attempts to produce adult target words containing /e/ or /ɩ/ are made. The target /ɛ/ is simply not attempted at all in the initial stage. In the second stage it was predicted that target /e/ and /ɩ/ would no longer need to be substituted in the child's production. Target /ɛ/ would now surface as one of the [high, mid] vowels /ɩ/ or /e/ rather than /i/. A [low] substitute could still surface too. Indeed, [ɩ] frequently surfaces in the data when words containing /ɛ/ are attempted. In the data of Catootje, attempted /ɛ/ results in the higher vowels [ɩ] or [e], and [ɑ] in context. In the data of Elke an adult model /ɛ/ surfaces as [ɛ] next to [ɩ], [e] and context-free [ɑ]. Also in the data of Robin attempted /ɛ/ initially surfaces almost exclusively as [ɩ]. It is not the case that at this point [i] has completely disappeared as a substitute for target /e/ and /ɩ/, but in general, sharp transitions from one stage to the other are hardly ever found in child language.

On the whole, then, the predictions concerning substitutions in the language acquisition period of the presently proposed height classification agree with the substitutions found in the child language data.

In the next section two contexts for substitutions that are not problematic at all to the Zipper model are addressed.

6.4.5 External circumstances: the non-problem cases

6.4.5.1 Raising of /e/

A large number of the target /e/'s that become [i] in the children's productions are in the target word followed by a word-final /r/. This segment has been transcribed as /ɹ/ in the data and is a very sonorant, almost vocalized allophone of /r/, only occurring in word-final positions. The most dramatic numbers of e → i changes in this environment are in the data of Elke (13/17), Jarmo (18/21) and Noortje (10/11). In Catootje's data the proportion is 23/40, and in Robin's data it is 13/47. Examples of these forms are in (30):

(30) *e → i substitutions in context*

beer 'bear' /ˈbeɹ/	[ˈpi]	1;7.13	Robin
	[ˈpiə]	2;1.17	Noortje
	[ˈpiː]	1;8.13	Elke
	[ˈpiə]	1;8.12	Jarmo
	[ˈpiː]	1;8.5	Tirza
meer 'more' /ˈmeɹ/	[ˈmi]	1;6.10	Robin
	[ˈmiɑ̈]	2;4.4	Noortje
	[ˈmiɔ̆χ]	1;9.24	Elke
	[ˈmi]	2;0.28	Jarmo
	[ˈmiː]	1;10.22	Tirza
weer 'again' /ˈʋeɹ/	[ˈʋi]	2;1.26	Robin
	[ˈʋi]	2;4.29	Elke
peer 'pear' /ˈpeɹ/	[ˈpi]	2;2.15	Catootje
	[ˈpiəʀχ̆]	2;8.2	Tirza
	[ˈpiu]	2;3.7	Noortje

Although most of the e → i changes appear to be due to this /ɹ/ context, it can be argued that it does not detract from the merits of the hypothesis that initially children will group mid vowels with high vowels in their production. It is known that in adult Dutch a following /ɹ/ has an effect on the preceding vowel, that has been described as 'monotonizing' (van

Bakel 1976); in this environment vowels become less tense. In general, in Dutch a sequence /eɹ/ sounds more like /ɪɹ/, /ɪ/ being the lax counterpart of /e/. The cases like in (30) that were described as e → i cases are, then, actually ɪ → i changes. In sum, the change from /e/ to /ɪ/ is due to the /ɹ/ context but the shift from /ɪ/ to /i/ is due to the developing system of the child. Indeed, of the e → ɪ shifts, at least 50% occur in target words where /e/ is followed by /ɹ/.

6.4.5.2 Raising of /ɛ/

A familiar context is present for a large proportion of the ɛ → ɪ shifts in the data of Robin, namely the nasal context. In the study of Beddor et al. (1983) it was mentioned that nasalization had a centralizing effect on vowels. Oral high vowels become lowered nasal vowels, but low oral vowels become raised nasal vowels. From age 1;10.21 on, 14 of the 19 /ɛ/ to /ɪ/ shifts occur in a target word where /ɛ/ is adjacent to a nasal consonant. Examples are given in (31):

(31)	ɛ → ɪ *substitutions in context*			
	zwemmen 'swim' /ˈzʋɛmə/	[ˈfɪmə]	1;10.21	Robin
	denk het niet 'don't think so' /ˈdɛŋkət ˈnit/	[ˈtɪkə ˈnɪt]	1;11.21	
	ben je nou 'are you now' /ˈbɛnjə ˈnɑu/	[ˈbĩː ˌnɑ̃u]	2;0.18	
	tram niet eng 'tram not scary' /ˈtrɛm ˌnit ˈɛŋ/	[ˈpɪm ˈnɪt ˈɪŋ]	2;1.7	
	denk het wel 'think so' /ˈdɛŋkət ˈʋɛl/	[ˈdɪntjəˈʋoː]	2;1.26	

In the data of other children, /ɛ/ to [ɪ] shifts are not so predominantly bound to a nasal context.

Up to now, no other contextual influences that account for large proportions of shifts in vowel height have been detected in the data. A context that might have been expected to have some influence, given the presence of Vowel Harmony in languages of the world, is other vowels in the target word. No indication of such an effect is found in the data, however. In a small number of cases the child simply uses one type of vowel persistently throughout the whole utterance, like in (32):

(32) *Vowel perseverations*

mond hap 'mouth bite' /'mɔnt 'hɑp/	['mɑnt 'hɑp]	2;0.20	Cato
ik heb 'I have' /'ɪk 'hɛp/	['ɪˌkɪp]	1;10.8	Eva
pappa komt morgen thuis 'daddy comes home tomorrow' /'pɑpa 'kɔmt 'mɔɪχə 'tœys/	['pɑpə 'tɑm͜'mɑχə'tɑus]	2;1.26	Robin
mamma bed 'mommy bed' /'mɑma 'bɛt/	['mɑmɑ 'pɑtj͜]	2;8.1	Noortje
moet sokken 'need socks' /'mut 'sɔkə/	['mut 'sukə]	2;8.29	
Bert schrikt 'Bert starts' /'bɛɹt 'sʀɪkt/	['bɛˀ'tlɛkf]	2;2.25	Tirza
	['bɪt hɪn 'sɪkt]	2;2.25	
baby 'baby' /'bebɪ/	['bibi]		all
aardbeien 'strawberries' /'aɹˌbɛiə/	['a'bɑijə]	2;2.27	Jarmo

A summary of the contexts for changes in vowel features discussed above, finally, is in (33):

(33) *Summary of contexts for vowel substitutions*

Change:	Influenced by:
– target low vowels raise	– Place of Articulation features of adjacent consonants
– target high vowels lower	– Adjacent nasal consonants in adult model word
– target /ɛ/ becomes /ɑ/ /a/	– Dorsal component of dark /l/ or adjacent Dorsal consonants
– target /ɛ/ becomes /ɪ/ (Robin)	– Adjacent nasal consonants in adult model word
– target /o/ becomes /ɑ/ Actually: target /ɑu/ becomes /ɑ/	
– target /e/ becomes /ɪ/ Actually: /e/ becomes /ɪ/	– syllable-final /ɹ/.

6.4.6 Substitutions resulting from a developing system

The substitutions that occur in the child language data that are likely to result from a height representation which is not fully developed and/or stabilized yet are listed in (34):

(34) *Substitutions resulting from a developing system*

e → i

ɪ → i

o/ɔ → u

ɛ → ɪ

A sample from the child language data that illustrate these shifts is in (35) for front vowels, and in (36) for back vowels:

(35) *Height substitutions in front vowels due to the underdeveloped phonological system*

zebra 'zebra' /'zebʀa/	['ʋɪpa]	1;10.25	Catootje
kikker 'frog' /'kɪkəɹ/	['kikɑ]	1;10.25	
bellen 'call' /'bɛlə/	['bɪlə]	1;11.22	
ik 'I' /'ɪk/	['itə]	1;7.22	Eva
heks 'witch' /'hɛks/	['hɪts]	1;6.1	
sesamstraat 'Sesame street' /'sesɑmˌstrat/	['sisa]	1;6.10	Robin
spelen 'play' /'spelə/	['piə]	1;10.7	
zes 'six' /'zɛs/	['zɪs]	1;6.10	
"	['sajə]	1;10.7	
wipwap 'see-saw /'ʋɪpˌʋɑp/	['fipˌʋɑp]	1;10.21	
Vera 'Vera' /'vera/	['fija]	2;11.0	Noortje
kip 'chicken' /'kɪp/	['pɪk]	2;3.21	
spetter 'splash' /'spɛtəɹ/	['pɑtɑ]	2;7.2	
sesamstraat 'Sesame street' /'sesɑmˌstrat/	['sisa]	1;10.8	Tirza
zitten 'sit' /'zɪtə/	['tsitə]	1;8.5	
kleppers 'clogs' /'klɛpəɹs/	['klɪpəs]	2;3.12	
wc 'wc' /ˌʋe'se/	['sɪs]	1;8.30	Elke
vis 'fish' /'vɪs/	['hiʃ]	1;10.21	
bed 'bed' /'bɛt/	['pɪt]	1;8.30	
fles 'bottle' /'flɛs/	['pɑtʃ]	1;8.30	
eekhoorn 'squirrel' /'ekˌhoɹn/	['hɪˌnɑun]	2;4.1	Jarmo
bellen 'call' /'bɛlə/	['bɑʋə]	2;2.6	
vis 'fish' /'vɪs/	['sɪʃ]	1;6.13	

(36) *Height substitutions in back vowels due to the underdeveloped phonological system*

foto 'picture' /'foto/	['huto]	2;4.9	Catootje
kapot 'broken' /ˌkɑ'pɔt/	['put]	1;11.9	
poppetje 'little figure' /'pɔpətjə/	['pupjə]	2;3.28	
opeten 'eat' /'ɔpetə/	['upetə]	2;6.6	
boot 'boat' /'bot/	['but]	1;8.22	Eva
kapot 'broken' /ˌkɑ'pɔt/	[ˌta'put]	1;10.8	
op 'on' /'ɔp/	['uf]	1;10.8	
boven 'upstairs' /'bovə/	['bufɛ]	1;7.27	Robin
olifant 'elephant' /'oliˌfɑnt/	['hupɪˌfɑnt]	1;11.7	
pop 'doll' /'pɔp/	['pup]	1;8.24	
botsing 'crash' /'bɔtsɪŋ/	['pusɪn]	2;0.18	
pop 'doll' /'pɔp/	['pup]	2;2.21	Noortje
klok 'clock' /'klɔk/	['kuk]	2;5.23	
pop 'doll' /'pɔp/	['pup]	1;11.8	Tirza

boterham 'slice of bread' /'botəˌram/	['putəˌram]	2;2.25	
brood 'bread' /'brot/	['put]	1;8.30	Elke
boot 'boat' /'bot/	['put]	1;11.7	
pop 'doll' /'pɔp/	['pup]	1;8.30	
kapot 'broken' /ˌka'pɔt/	['put]	1;9.10	

In the data of two children, Robin and Catootje, clear stages in the phonological development of height can be discerned, in the sense that the proportion match/substitution dramatically changes at a certain point in time. Before this point a high proportion of substitutions occur, while after this point this proportion has diminished significantly. In the data of the other children the proportions of raised vowels decrease in less obvious steps. For Robin two of these breaking points occur. One is around age 1;9.10, and is only significant for front vowels, the other is about three months later, around age 2;0.18. The different proportions of matches and systematic substitutions before and after these points are in table VII:

	1;5.11–1;8.24/1;9.10	1;9.10–2;0.18	2;0.18–2;1.26
ɩ	ɩ **55.9%** (19/34) i **44.1%** (15/34)	ɩ **86.1%** (62/72) i **13.9%** (10/72)	ɩ **98.7%** (74/75) i **1.3%** (1/75)
e	e **23.1%** (15/65) i **47.7%** (31/65) ɩ **29.2%** (19/65)	e **50%** (38/76) i **17.1%** (13/76) ɩ **30.2%** (23/76)	e **75.6%** (65/86) i **1.2%** (1/86) ɩ **23.3%** (20/86)
ɛ	ɛ **9.1%** (1/11) ɩ **81.8%** (9/11) i **9.1%** (1/11)	ɛ **23.1** (6/26) ɩ **61.5%** (16/26) i **15.4%** (4/26)	ɛ **50%** (16/32) ɩ **46.9%** (15/32) i **3.1%** (1/32)
o/ɔ	o/ɔ **76.1%** (70/92) u **15.2%** (14/92) au **8.7%** (8/92)	o/ɔ **78.6%** (142/182) u **16.5%** (30/182) au **5.5%** (10/182)	o/ɔ **91.7%** (144/157) u **8.3%** (12/144) au **0.69%** (1/144)

Table VII. Breaking points in Robin's development of vowel height

The high vowel substitute [i] is produced for the target mid vowels /e/ and /ɩ/ in about 50% of the time in the first three months of recording. In the next three months the proportion of high vowel substitutes decreases to about 15%, and after that decreases further to only 1.2%. At this point, then, the representation for (front) high-mid vowels is stabilized in Robin's output representation. The proportion of high vowel substitutes for the target mid back vowels is much lower in the first three months, 15%, and decreases only in the last three months. No explanation for this asymmetry in height development between front and back vowels, which is a general characteristic of the data, is available at the moment. Target /ɛ/, finally, is not attempted much in the first three months, and is only matched once. In the next three month, 61% of the low-mid target /ɛ/'s still result in high-mid [ɩ]'s. In the last three months the production [ɩ] still appears to form a large proportion of the attempted /ɛ/ targets. However, virtually all instances of this [ɩ] occur in nasal environments. The nature of the subsitute [ɩ] has changed from context-free to context-sensitive, and this entails that the representation for /ɛ/ is becoming more permanently available in Robin's output representations.

For Catootje a breaking point is found in the period around age 2;0.20-2;1.4. The proportion of raised productions of target mid, and especially front mid, vowels decreases after this period and, again, this is assumed to result from the stabilization of output representation for high-mid and low-mid vowels in the child's system. This is illustrated in table VIII.

	1;10.11–2;0.20/2;1.4	2;0.20/2;1.4–2;2.29
ɩ	ɩ **47.5%** (19/40) i **52.5%** (21/40)	ɩ **70.8%** (51/72) i **29.2%** (21/72)
e	e **51.3%** (39/76) i **34.2%** (26/76) ɩ **14.5%** (11/76)	e **72.3%** (68/94) i **17.0%** (16/94) ɩ **10.6%** (10/96)
ɛ	ɛ **39.3%** (11/28) ɩ/e **60.7%** (17/28)	ɛ **97.9** (46/47) ɩ **2.1%** (1/47)
o/ɔ	o/ɔ **95.3%** (223/234) u **4.7%** (11/234)	o/ɔ **98.6%** (146/148) u **1.4%** (2/148)

Table VIII. Breaking point in Catootje's development of vowel height

Table VII and VIII also illustrate that the development of vowel height representations does not (or hardly) comprise all-or-nothing stages: substitutions of target mid vowels occur next to matches in the production of the children, and the proportion of matches gradually increases over time. Nevertheless, in the next section the developments are regarded as absolute, in order to show how the systematic substitutions can be regarded as resulting from a developing phonological representation of vowel height.

6.5 The acquisition of a vowel height representation

6.5.1 The representation of vowel height

The feature geometrical representation for Place features that was adopted in the previous chapters contained separate nodes for place of articulation features and height features. Formerly, height and place of articulation features were grouped under a single Place node. The height features [±high] and [±low] had been accommodated under the Dorsal node, together with the feature [±back] (cf. Sagey 1986). Apart from the fact that the grouping of these features did not corresponding to any natural class of segments in the world's languages, it also became clear that it should be possible to refer to height features independently of place of articulation features. An example illustrating this came from Brazilian Portuguese, and was presented in the introduction to this chapter. In the currently available feature geometrical representations that have incorporated this insight, two types of independently operating height nodes are found: (a) the Tongue Position node (Lahiri & Evers 1991) which contains the traditional features [±high] and [±low];[6] (b) the Aperture node (Clements 1989, 1991) which contains the feature [±open] in a multi-tiered representation. These two models of vowel height representation are briefly introduced below. In 6.5.2 the question is addressed whether the Zipper model can be aligned with a phonological representation of height, given the classification of Dutch vowels that was settled on. In other words, is it possible to capture the developmental stages in the acquisition of height in terms of the systematic construction of a phonological representation.

6.5.1.1 [±high] and [±low]

In SPE [±high] and [±low] are defined in terms of displacements from the neutral position of the tongue, which is supposed to be raised and fronted, "[...] approximating the configuration found in the vowel [e] in English *bed*" (Chomsky & Halle 1968:304). The feature [+high] involves raising of the tongue body above the neutral position, while [+low] involves lowering of the tongue body below the neutral position. A specification [–high] indicates that no raising of the tongue body above the neutral position is

[6] In Lahiri & Evers (1991), however, the main point is that height features should be separated from place of articulation features, by means of grouping them under a separate Tongue Position node. They are not specifically concerned with the ultimate organization of this node.

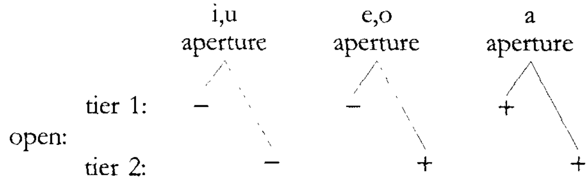
involved in the sound and, similarly, the specification [–low] indicates that the sound involves no lowering of the tongue body below the neutral position. Because of the fact that [±high] and [±low] are defined relative to this neutral position, only three heights can be represented: [+high, –low], for high vowels, [–high, +low], for low vowels, and [–high, –low] for mid vowels. The fourth logically possible combination, [+high, +low] is, however, a physically impossible combination of features, since it is not possible to simultaneously raise the tongue body above the neutral position and lower it below this same neutral position. This combination is therefore not employed in the representation of height. With [±high] and [±low], then, no height distinction between high-mid vowels and low-mid vowels can be made. This is problematic for the representation of the vowel /ɛ/ as it has been classified above. In SPE the feature [±tense] is used to distinguish between the different vowels within the three representable height classes. This does not solve the problem for /ɛ/, however. The [–high, –low] set of front vowels would contain /e/, /ɪ/ and /ɛ/, and since both /ɛ/ and /ɪ/ form the [–tense] counterpart of [+tense] /e/ in this class it is impossible to distinguish /ɪ/ from /ɛ/.

6.5.1.2 [±open]

In Clements (1989a, 1991) an alternative system is proposed that is able to capture four (and more) vowel heights. In this model, where vowel height is characterized along a 'uniform phonetic and phonological dimension' (Clements 1991:70), [±high] and [±low] are replaced by the binary feature [±open], whereby [–open] means 'relatively high' and [+open] means 'relatively low'. In the feature geometry this feature is organized under the Aperture node, and is independent of the Place of Articulation features. Various degrees of vowel height are expressed by arraying this feature on rank-ordered tiers. On the highest ranked tier the basic disposition of vowels is expressed, either [+open] or [–open]. This captures the same distinction as [±low] in the [±high] [±low] system, i.e. low versus non-low vowels. On the next lower tier finer distinctions are made by assigning another instance of [open]. A third 'layer' of [open] would refine the distinctions in vowel height even further. According to Clements, this representation is not only able to represent vowel systems with four heights or more, but is also able to capture various synchronic phonological processes that treat height as a scalar phenomenon, like the height assimilations in the Bantu languages Nzebi, Esimbi and Kinande (Clements 1991, Hyman 1988). This type of process cannot be easily captured with the binary features [±high] [±low]. In Clements' model assimilatory raising is regarded a spreading of [–open] to [+open] on a designated tier.

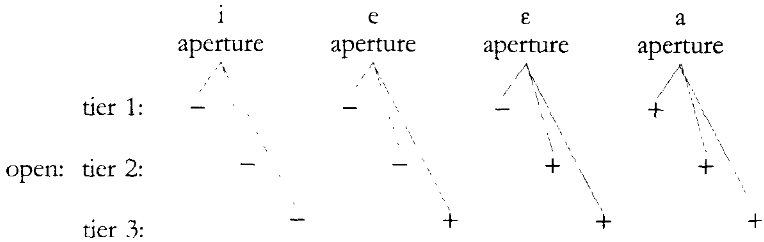
The familiar three height vowel system in Clements' model looks like (37):

(37) *Three vowel height system (from Clements & Hume 1993)*



In the three vowel height system, then, /i/ and /u/ are relatively high on both tier 1 and tier 2; /e/ and /o/ are relatively high on tier 1, but relatively low on tier 2; /a/ is relatively low on both tier 1 and tier 2. A height difference between /e/ and /ɛ/ involves an [open] specification on a third tier, like in (38):

(38) *Four vowel height*

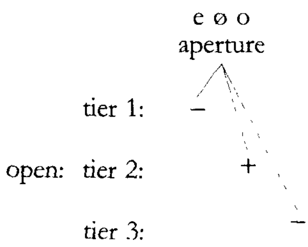


In this model it is possible to refer to /ɛ/ and /a/ uniquely, as '[+open] on tier 2'.

It is assumed that in the unmarked case [+open] on tier n implies [+open] on tier n+1. This immediately forces Clements to assume that a language like French has a marked [±open] classification, since the high-mid and low-mid vowels are apparently more closely related to each other than either of these classes is to the high or low vowels.[7] The high-mid vowels in French, then, have the representation in (39), whereby the [open] specifications on tier 2 and tier 3 are reversed:

7 Sluyters (1992:135) remarks that the same probably applies to Italian and Brazilian Portuguese.

(39) *High-mid vowels in French*



Even though this is taken to be the marked option, the possibility that is created to reverse [open] specifications on tiers allows the system to predict many different height classifications, especially given the in principle unlimited amount of tiers where [±open] specifications can be accommodated.

Although neither of the two systems appears to be ideal, then, in the next section an attempt will be made to reconcile the findings with regard to the development of height with either of these phonological representations.

6.5.2 The representations and the Dutch acquisition data

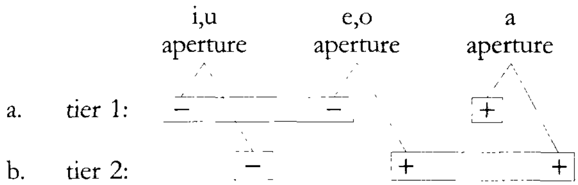
6.5.2.1 [±high] and [±low]

The fact that four vowel heights cannot be represented poses a problem for this model in capturing the way Dutch front vowels should be classified. Furthermore, in 6.3 it was mentioned that the representation of height by the two binary features [±high] and [±low] does not give a clue as to how target mid vowels will initially be represented in the child's phonological output system. It can be assumed that in the initial stage the two extremes on the height dimension, [+high] and [+low], are the phonologically active features in the output representation of the child. From the representation of target mid vowels, [–high, -low], however, it is not obvious whether these vowels will initially be grouped with the [+high] or with the [+low] representation. The color preservation principle was invoked to bring relief in this case: the coronality of target /e/, /ɪ/ and /ɛ/, and the dorsality of target /o/ and /ɔ/ are retained when they are grouped with the high vowels /i/ and /u/ respectively. This accounts for the raising of /e/ and /ɪ/ to /i/ and of /o/ and /ɔ/ to /u/. It does not, however, capture the fact that target /ɛ/ is produced as /ɪ/ rather than /i/ by the children. The special relation between /ɛ/ and the low vowels in contextually triggered substitutions also does not follow from the SPE-type representation of vowel height.

6.5.2.2 [±open]

In this model, the acquisition of a vowel height representation involves both a feature and tiers. A vowel system with only two heights (like the child's system in the initial stage) only needs the feature [±open] on a single tier to represent this. Knowing that the target mid vowels /e/, /o/ and /ɔ/ can initially receive an output representation that is the same as the output representation for high vowels, it can be deduced that it is actually tier 1 which is active in the initial stage, and not, for example, tier 2 in a three-height system. Were tier 2 active first, the representation would give rise to the expectation that the target mid vowels are substituted by the low vowels. This is illustrated in (40):

(40) *Stage 1: tier 1 versus tier 2*



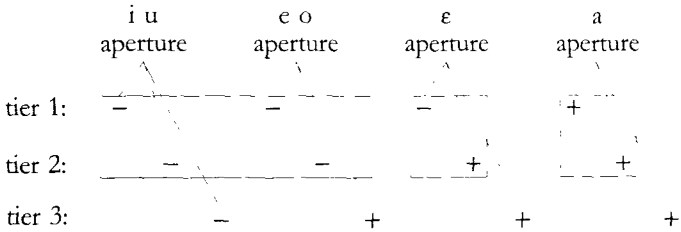
In (40a), the grouping of vowels is shown according to the feature [±open] on tier 1, while in (40b) the grouping that results from a feature [±open] on tier 2 is indicated. If it is assumed that in the unmarked case [–open] on tier 1 implies [–open] on all other tiers — and [+open] on tier 1 implies [+open] on all other tiers[8] — then a [–open] output representation in the initial stage results in [i] and [u] productions. In (40a) the target mid vowels are represented as [–open] on tier 1, like the high vowels. Since nothing else is specified this results in the production [i] or [u]. This is what is found in the child language data.

Now let us turn to the partly four-height system of Dutch, where [±open] is active on three tiers. In stage I, where only tier 1 is available in the output representation of the child, it is again predicted that the target mid vowels, including /ɛ/, receive an output representation in the child's phonological system that results in the production of a high vowel. It will be assumed that the fact that a production [i] for target /ɛ/ is in general not found in the data is due to the initial avoidance of target words containing /ɛ/ by the children. A logical next step in the acquisition of the height representation would be that tier 2 becomes available in the output

[8] See Sluyters (1992:149) for a proposal to this effect.

representation of the child. This, however, leads to a problem. In (41) it can be seen that at this stage /e/, /ɪ/, o/ and /ɔ/ still have the same representation as the high vowels. The vowel /ɛ/, however, now has a distinctive representation, and is no longer expected to be substituted. This is quite contrary to our findings, and the opposite of the development of height as stated in the Zipper model.

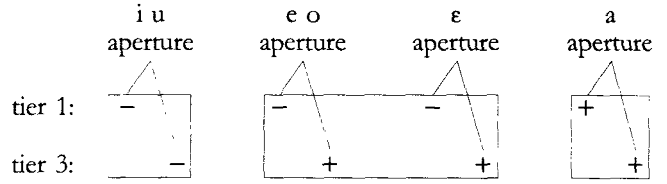
(41) *False predictions of Clements' model*



The right predictions are made if it is assumed that tier 3 rather than tier 2 becomes active next in the output system of the child. Instead of developing according to a numerical logic, the height representation thus appears to develop according to the Jakobsonian principle of maximal contrast: the first tier is acquired first, followed by the last tier. The prediction is that this applies to height systems with any number of tiers: if a language required five vowel height tiers, the first tier would become active first, followed by the fifth tier (the last one). Pictured this way, the gradual availability of a height representation for vowels is another instance of a Zipper model: the two extremes, tier 1 and $\text{tier}_{\text{final}}$ — the length of the 'zipper' — are available first. The subsequent opening up of the system is then expected to proceed from the higher tiers to the lower tiers. For Dutch this hypothesis cannot be tested since there are only three tiers. In a five vowel-height system, however, the development is hypothesized to proceed from tier 1 (stage I), to tier 4 (stage II), and subsequently, from top to bottom, to tier 2 (stage III) and tier 3 (stage IV). This remains to be empirically tested.

In the second stage of the development of a height system with three tiers, then, the available height representations are as in (42):

(42) *Second stage in the development of a three-tiered height system*



Target /ε/ in this stage has an output representation identical to the one for the high-mid vowels /e/ and /ι/. The [±open] specifications of tier 2 are at this point filled in 'by default', the default situation still being that [α open] on tier 1 implies [α open] on all other tiers unless otherwise specified. This representation for mid and low-mid front vowels leads to [e] or [ι] productions.

Finally, the marked position of /ε/ also finds an explanation in the [±open] representation: the default situation where [α open] on tier 1 implies [α open] on all other tiers is contradicted once in the representations for (high)-mid vowels, but twice in the representation of /ε/.

6.5.3 The development of vowel height in an I A U model: a sketch

A feature model that has not been considered in detail in this thesis — because with respect to Place of Articulation it did not identify the categories of consonants and vowels that we found to play an important role in child language and in the languages of the world — is the I A U model of Place as it can be found in, among other theories, Dependency Phonology. The components |i| |a| and |u| incorporate both place of articulation and height information: the component |i| refers to a high front vowel, the component |u| refers to a high back vowel and the component |a| refers to a low vowel. Mid vowels are captured by adding instances of |a| to either |i| or |u|. This makes the model less apt to account for processes that specifically refer to [+high] or [–low] vowels, independent of place of articulation information; in an I A U model these vowels can only be captured by referring to segments that lack an instance of |a| in some way or another. However, considering the development of vowel height in child language independently of these issues, a sketch of how this works in an I A U model is the following.

It was seen in the developmental data that while the place of articulation information of attempted vowels was in general matched, problems occurred with height. The components |i| (front) and |u| (round and, if not in combination with |i|, back) of attempted vowels are thus present in the children's output representations. Bare |i| and |u|, furthermore, represent the high front and high back vowels /i/ and /u/, the two vowels that presented hardly any problems to acquisition. The other non-problematic vowel /a/, is represented by bare |a| (low). The components |i| |a| and |u|, then, do not form a problem as long as they are represented as single components. However, in order to represent mid vowels, either of the type |i| or of the type |u|, the components |i| or |u| need to be combined in one way or another with |a|. According to this model, then, the problems for acquisition lie in the different dependency relations that need to be established between either |i| or |u| and |a|. The model is also able to capture the fact that mid vowels are raised at first: given the fact that place of articulation is matched, in the initial stage all the front vowels are represented with the single component |i|, resulting in /i/ productions, while all the back vowels are represented with the single component |u|, resulting in /u/ productions.

The explanation for the special status of /ɛ/, furthermore, could be along the following lines: the representation for /ɛ/ is {a;i}(in Dependency Phonology), so A-headed instead of I-headed like the other mid vowels. Initially, /ɛ/, being a front vowel and place of articulation being matched, is represented as |i|. In the next stage, it would have to be assumed, it has become possible in the developing system to construct a complex representation whereby |a| is in dependent position, {i;a} or {u;a}. This is the representation for the (high) mid vowels /e/ /ɪ/ /o/ and /ɔ/. The vowel /ɛ/ is, again because of its frontness, at this stage represented as {i;a}, and thus becomes [ɪ]. The marked characteristic of /ɛ/ that the child needs to acquire — the presumed cause of the specific problems with this vowel in the acquisition period — is that |a| instead of |i| is the head of the complex representation. In this way, the I A U model provides an account for the acquisition of vowel height. In order for this type of model to account for the whole system of the acquisition of Place, including the vowel-consonant interactions, some revisions with regard to the components that refer to place of articulation of consonants and vowels need to be considered.

6.6 Conclusions

In this chapter the challenge was to throw some light on the phonological developments regarding vowel height. It appears that no systematic work on this topic has been done earlier. Several unstable factors interfered with this task. Firstly, at least three different height classifications of Dutch vowels have been proposed in the literature, with either three or four vowel heights, and with different distributions of the vowels over these height classes. No known synchronic phonological evidence is available in adult Dutch to settle the case. The study reported in this chapter, then, comprises an investigation of the classification of Dutch vowel height. Secondly, the development of the height dimension, unlike the Place of Articulation dimension, does not proceed in relatively well-observable stages, but is more probabilistic in nature. Substitutes for target adult vowels exist next to matches in the child language data, and often it appears that the height aspect of the produced vowels has come about in a random way. In addition, vowel height is sensitive to acoustic and other assimilatory influences from context. Nevertheless, it has been possible to get some insight in the data. The conclusions that were reached are summarized below.

The height classification of Dutch vowels

Several findings in the developmental data pointed to the classification of Dutch vowels as illustrated below. Compared to the other mid vowels, the vowel /ɛ/ was attempted late by the children in this study and was subsequently especially error-prone in the children's productions. Based on these idiosyncratic characteristics of /ɛ/ it was concluded that Dutch has a three-height vowel system for back vowels but a four-height system for front vowels. Furthermore, it was found that /ɪ/ is a mid vowel rather than a high vowel. The resulting model is also acoustically motivated.

(43) *Height classification for Dutch vowels*

	Front	Central	Back
high	i y		u
high mid	e ø ɪ ʉ		o ɔ
low mid	ɛ		
low		a	ɑ

The developing system

The contours of Jakobson's model of the acquisition of vowel height, reconstructed in this chapter as the Zipper model of the acquisition of vowel height, are clearly recognizable in the child language data. The model simply entails that high and low vowels are acquired first, while the remaining vowels become available gradually, proceeding from the higher to the lower vowels. It was found that high and low target vowels are indeed attempted first by the language acquiring children, while the low-mid vowel /ɛ/ was attempted last. Also, both the high and low target vowels are among the attempted vowels with the highest percentage of matches in the children's productions. Again, /ɛ/ belongs to the vowels with the lowest matching percentage.

Focusing on the systematically and relatively frequently occurring matches and substitutes for target adult vowels in the children's productions, the general developmental pattern is that children tend to raise target mid vowels. Context-free target /e/ and /ɪ/ are produced as [i], target /o/ and /ɔ/ become [u]. The vowel /ɛ/ is attempted somewhat later, at the time that the representation for high-mid vowels has become available, and is then produced as [ɪ]. Several contexts were found that affected the height of the adult model vowels in the children's productions. This made it clear once again that segments should never be studied out of context. Apart from the fact that interesting interactions among adjacent elements are missed this way, it would have been impossible to account for the data if only lists of matches and substitutions of adult model vowels had been taken into consideration.

The phonological representation of vowel height

In feature geometrical representations that have incorporated the insight that height features can operate independently of place of articulation features, two types of height nodes were found: one, the Tongue Position node (Lahiri & Evers 1991) contained the traditional features [±high] and [±low], the other, the Aperture node (Clements 1989, 1991) contained the feature [±open] in a multi-tiered representation. Both representations have their drawbacks. The [±high] [±low] features are unable to represent four-height vowel systems without the help of other features such as [±tense]. Furthermore, so-called scalar height assimilations are not easily accounted for in this system. In contrast, Clements' [±open] feature in a multi-tiered representation, designed especially for coping with the problems of the [±high] [±low] system, seems to be rather unrestricted in the height classifications it allows, and is therefore at risk of being redundant.

Assuming that the matches of both high and low vowels and the context-free raisings of mid vowels in child language are due to a developing output representation of height, the two ways to phonologically represent vowel height were — despite their imperfections — compared with regard to their ability to capture the developmental facts. It turned out that the systematic substitutions found could be regarded as following from Clements' [±open] representation, whereby the tiers gradually become available. The underdeveloped representations predicted the grouping of mid vowels with high vowels, and of low-mid vowels with high-mid vowels, in the productions of the children. Furthermore, the late appearance of low-mid /ɛ/ found an explanation in the fact that the representation for this vowel deviated on two tiers from the representation that was assumed to be unmarked.

Finally, a sketch was presented of a developing output representation in terms of an I A U model. Here, the problem for acquisition lies in establishing the appropriate dependency relations between the elements |i| or |u| and |a|.

In order to proceed with an analysis of developing height representations data from other languages need to be considered. Acquisition data from languages that employ four vowel heights for both front and back vowels, which has been claimed for Bantu languages and Romance languages like Italian and French, and from languages that employ five vowel heights, which has been claimed for Scottish, would be valuable for testing the predictions. A further refinement of the insight in the developing height system would benefit from acquisition data from languages that refer to vowel height in phonological processes; the more pronounced role of height in such phonological systems probably results in more obvious patterns in the acquisition data than we were able to find in the Dutch data.

7 Summary and conclusions

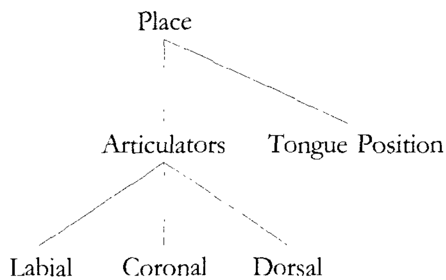
"Pooh," he said, "where did you find that pole?" Pooh looked at the pole in his hands. "I just found it," he said. "I thought it ought to be useful. I just picked it up." "Pooh," said Christopher Robin solemnly, "the Expedition is over. You have found the North Pole!" "Oh!" said Pooh.

——— A. A. Milne, *Winnie-the-Pooh*

This thesis has dealt with aspects of acquisition relevant to the phonological representation of place features. Current phonological analyses have given us a better understanding of phonological systems in general and have provided tools that allow us to gain both deeper and new insights in the developing phonological system. The analyses of child language data presented here have profited from these developments in phonological theory.

A leading idea of current phonological theory that has played an important role in the present study is that consonants and vowels share the same set of place of articulation features. This hypothesis is not entirely new: the history shows alternating periods of segregation and unification of place features of consonants and vowels. The contemporary view of the organization of the place of articulation features, as opposed to the height features, is brought into perspective in chapter 3, where the history of place of articulation features, from Jakobson (1938) to Clements & Hume (1993), is reviewed. The focus of this study is on the various reasons for grouping or separating consonants and vowels that have been put forward in the course of time. It can be seen that more and more demands have been put on what a place configuration should and should not be able to represent. A mere listing of the relevant phonological elements of segments is not enough: they need to be grouped and ranked so as to reveal natural classes, (group) behaviour in phonological processes, relative markedness in inventories, etc. It is, then, no simple matter to come up with a place configuration that meets all these demands. Improving the feature organization so as to better reflect the build-up of the languages' segment inventories often leads to a less well-motivated representation of 'group behaviour in phonological processes' and vice versa. Attaching special importance to arguments concerning assimilations between consonants and vowels it is concluded in this work that the organization of place of articulation (POA) features as proposed in Lahiri & Evers (1991) is most adequate. In this feature geometry, place of articulation features are monovalent, and refer to both consonants and vowels. A simplified illustration of this organization is given in (1):

(1) *Place feature organization adopted in this thesis*



As can be seen, the height features are organized under a separate node. This is to express the fact that height features can operate independently of POA features in phonological processes in the world's languages. In the feature geometrical representation of Lahiri & Evers the traditional features [±high] and [±low] are grouped under this separate node. In Clements' proposal (1989, 1991) the separate node is called the Aperture node, and contains the feature [±open] in a multi-tiered representation. Developmental aspects of both place of articulation and tongue height features are investigated in this thesis.

The acquisition data that provided the factual basis of the findings in the present work come from twelve children acquiring Dutch as their first language. The ages of the children varied between 1;0 and 1;11 years at the start of the data-collecting period. At two-weekly intervals recordings of their speech were made, for a period of about a year. These recordings were transcribed and stored in a computerized database. In chapter 2 a detailed description is presented of the way in which the data were collected and the subsequent organization of these data in the database.

The field of child phonology is explored in chapter 4 by scrutinizing a well-known child language phenomenon, Consonant Harmony, and reanalyzing it in terms of Vowel Consonant Harmony. An example of such a form is the production ['puf] for *poes* 'cat' /'pus/. The few non-linear accounts of child language concentrate mainly on this phenomenon. The analysis that has been put forward in the literature, addressed in section 4.1, is, roughly, that the coronal segment /s/ of the adult target *poes* is unspecified for Place in the child's phonological system. Subsequently, the feature Labial from the other consonant, /p/, automatically spreads to this unspecified position. As such, Consonant Harmony involves spreading between two non-adjacent segments. An important principle of phonology is that phonological processes can only involve elements that are adjacent at some level of analysis. A constraint that controls this requirement is the Line Crossing Prohibition: association lines of features or nodes in a non-linear representation may not cross association lines of similar features or nodes in spreading processes. The two consonants involved in Consonant Harmony can be analyzed as being adjacent in different ways. One way is to assume that consonants and vowels share different sets of place features; in this way the place features of consonants will not 'see' the place features of the intervening vowel. However, if it is assumed that consonants and vowels share the same set of place features, it has to be assumed that consonants and vowels are on separate planes. Planar segregation of consonants and vowels can be invoked when the linear order of consonants and vowels is predictable in a language. This does not apply to adult English or Dutch, but in McDonough & Myers (1991) it is assumed that this is the case in child language. In the child's phonological system consonants and vowels thus reside on different planes and, accordingly, association lines of the intervening vowels will not be crossed in the spreading process. In section 4.2 the problems with this account are outlined. The hypothesis that the sequence of consonants and vowels is predictable in child language is not confirmed by the data, which actually makes the spreading process between the two non-adjacent consonants impossible. A new perspective on Consonant Harmony, which circumvents the whole problem of non-adjacency, is presented in section 4.3. Here, the phenomenon is approached from the perspective of the vowel intervening between the two consonants that were thought to be involved in the assimilation process. This reveals that it is the POA feature of the adjacent vowel that affects the consonant, and not the POA feature of the non-adjacent consonant. In the case of ['puf], then, Labial spreads from the /u/ rather than from the /p/. Clear evidence for this position comes from productions like ['pum], ['pun] or ['sum] for target *schoen* 'shoe' /'sχun/. The target word does not contain any labial consonant, and the labial consonants in the children's productions can only result from the labiality of the vowel /u/. Consonant Harmony is thus reanalyzed as Vowel-Consonant Harmony.

Contrary to Consonant Harmony and the acquisition of consonants in general, which has received abundant attention in the literature, the acquisition of vowels, more specifically, the acquisition of a height representation, has been a neglected topic in the field of child phonology. As mentioned above, in theories that assume feature geometrical representations it is currently assumed that height features are grouped under a separate node from the POA features: the Tongue Position node in Lahiri & Evers (1991), or the Aperture node in Clements (1989, 1991). In chapter 6, the attention is shifted to this branch of the Place node, and the development of a height representation for vowels is explored.

Both an opaque set of data and a variety of proposals concerning the height classification for the Dutch vowels interfered with this task. Some insight is provided by the model of the acquisition of height proposed by Jakobson (1941/1968). Jakobson proposes that children first acquire the two extreme points on the height axis, namely [+high] and [+low]. Subsequently, high-mid vowels are acquired, followed by low-mid vowels. This model of vowel height development is slightly adapted (section 6.1) in order to make it possible to predict what kind of vowels, with regard to height, the children will produce in the initial and intermediate stages of development, and what kind of height representations children will assign to target adult vowels that require a height representation not acquired yet. This model is termed the 'Zipper model' of vowel height acquisition.

Several different height classifications have been proposed for Dutch, either with three or with four heights, and with different distributions of the vowels over these height classes (section 6.2). There is no known synchronic phonological evidence to decide on any of the proposals, and the chapter thus comprises an investigation into the height classification of Dutch. Assuming that the systematic height substitutions found in child language data would shed some synchronic phonological light on the matter, the different height classifications were tested for their performance with respect to the predictions of the Zipper model. The set of attested systematic substitutions, however, included substitutions that went against the predictions of the Zipper model. In section 6.4.3 these substitutions are investigated. It turns out that several consonantal contexts have an effect on the vowel produced by the children. Apparent lowerings of /ɛ/ to /ɑ/ occur in the environment of dark /l/ and dorsal consonants, and are actually instances of backing. Apparent raisings of low vowels are actually assimilations to the Place of Articulation feature of an adjacent consonant. Adjacent nasal consonants can lead to both raising of low vowels and lowering of high vowels, due to an acoustic effect.

Focusing on the context-free matches and substitutions in the data, then, the following conclusions are reached concerning the developing system and the height classification of Dutch vowels. The front round vowels and diphthongs have been left out of consideration in this chapter.

Concerning the developing system, the contours of Jakobson's model of the acquisition of vowel height are clearly recognizable in the child language data. It is found that high and low target vowels are attempted first by the language acquiring children, while the low-mid vowel /ɛ/ was attempted last. Also, both the high and low target vowels are among the attempted vowels with the highest percentage of matches in the children's productions. Again, /ɛ/ belongs to the vowels with the lowest matching percentage.

The general developmental pattern is that children tend to raise target mid vowels. Context-free, target /e/ and /ɩ/ are produced as [i], target /o/ and /ɔ/ become [u]. The vowel /ɛ/ is attempted somewhat later, at the time that the representation for high-mid vowels has become available, and is then produced as [ɩ].

Concerning the height classification of Dutch vowels, the findings in the developmental data point to the classification of Dutch vowels illustrated below in (2). Compared to the other mid vowels, the vowel /ɛ/ is attempted late by the children in this study and is subsequently especially error-prone in the children's productions. Based on these idiosyncratic characteristics of /ɛ/ it is concluded that Dutch has a three-height vowel system for back vowels but a four-height system for front vowels. Furthermore, it is found that /ɩ/ is a mid vowel rather than a high vowel. The resulting model is also acoustically motivated.

(2) *Height classification for Dutch vowels*

high	i		u
high mid	e ɩ		o ɔ
low mid	ɛ		
low		a	ɑ

Assuming that the matches of both high and low vowels and the context-free raisings of mid vowels in child language are due to a developing output representation of height, in section 6.5 three ways of phonologically representing vowel height are compared with regard to their ability to capture the developmental facts: the traditional set [±high] [±low] (now under a separate Tongue Position node), Clements' feature [±open] in a multi-tiered representation (under a separate Aperture node) and the I A U model as employed in for instance Dependency Phonology.

Apart from the fact that it is impossible to represent four vowel heights with the features [±high] and [±low] alone, the representation in itself does not provide an insightful account of the developmental findings. From the representation for mid vowels for example, [–high, -low], it cannot be predicted how adult model mid vowels will be represented in the initial stage, when only [+high] and [+low] are available representations.

The [±open] representation of height also has its drawbacks, but it turns out that both the order of development and the systematic substitutions that were found can be regarded to follow from the gradual availability of such a representation. It would have to be assumed that in the unmarked case, a [–open] specification on tier 1 entails a [–open] specification on all tiers, which is the representation for high vowels, while a [+open] specification on tier 1 entails a [+open] specification on all tiers, i.e. the representation for low vowels. At first, then, only tier 1 is active in the phonological system. High and mid vowels are [–open] on tier 1, while low vowels are [+open] on tier 1. This underdeveloped representation thus correctly predicts the grouping of mid vowels with high vowels in the productions of the children. The problematic status of /ε/ finds an explanation in the fact that the representation for this vowel deviates from the unmarked state on two tiers. The representation contains a specification [–open] on tier 1, which in the unmarked case entails [–open] specifications on all tiers. The full representation of /ε/, however, contains [+open] on tier 2 and 3. This, then, is one model of the acquisition of a height representation that deserves further attention.

Finally, the I A U model also provides an account of the developmental facts concerning vowel height. In this model, the acquisition of a vowel height representation involves the acquisition of the dependency relations between |i| or |u| and |a|. In the initial stage it is assumed that only the bare elements |i|, |u| and |a| are available. These elements represent the high vowels /i/ and /u/, and the low vowel /a/ respectively. This model too, correctly predicts that in the initial stage front mid vowels, which all contain |i|, are grouped with the high front vowel, while mid back vowels, which all contain |u|, are grouped with the high back vowel. As yet the model does not, however, refer to the natural classes of consonants and vowels that were found to play an important role in assimilation processes in the world's languages and the developing phonological system, namely coronal consonants and front vowels, and dorsal consonants and back vowels. Also, as illustrated in chapter 3, it is as yet not clear how in Dependency Phonology phonological processes, like assimilation, are handled in detail. Development of the model in both these directions would render it competitive with the feature geometrical representation with respect to the representation of Place.

The ultimate goal of research on the acquisition of phonology is to come up with a developmental model of an output system that is able to account for all the productions that can be found. In chapter 5 a first proposal in this direction is formulated, confining itself to an account of the Place of Articulation structure of lexical outputs. For this study the combinations of place of articulation features of the vowels and consonants in every single word the child produced were investigated. The following observations were made:

I. At first no combinations of different POA features are found in words produced by the children. In this stage we do not find productions like ['pi] or ['pat], but we do find productions like ['tɪs] or ['pɔp].

II. No combinations of either a coronal consonant and a labial vowel in CV sequences or a coronal vowel and a labial consonant in VC-sequences are found in the data for some time. In this stage we do not find productions like ['so] or ['ɛmə], but we do find productions like ['mi] or ['otə].

III. C_1VC_2 sequences, where C_2 is a labial consonant while C_1 is a non-labial consonant do not occur in the data for a long time. In this stage we do not find productions like ['sup] or ['kɪp], but we do find productions like ['pus] or ['pɑk].

IV. $C_1V(C_2)$ sequences, where C_1 is a dorsal consonant, do not occur in the data for a long time. During this time we do not find productions like ['kɑt], but we do find productions like ['tɑk].

In order to account for these observations, a comprehensive developmental model of a phonological output system that generates lexical output representations for Place of Articulation features is proposed. This output system generates every form the child produces, whether it matches the attempted adult model or not — including instances of Vowel-Consonant harmony, of which a procedural analysis was presented in chapter 4, and other child language phenomena — while it does not generate forms the child does not produce.

The phonological output system consists of three components: (1) a component F containing the phonological features that need to get associated to some higher organizing unit in the output representation. In this chapter these are limited to the Place of Articulation features Labial and Dorsal while Coronal was assumed to be the default value; (2) a component U containing the phonological units to specify (or: higher organizing units). It is argued that, initially, POA features link to a unit much larger than the segment, termed WORD. This unit has the size of a minimal Prosodic Word; (3) a component C, containing constraints. In the chapter the discussion is limited to constraints on the association of POA features.

Output representations generated by this system are fully dependent on the contents of the components U, F and C, and developments in these components concomitantly lead to developments in the output representations. Two main sources of development are posited: (a) developments in the phonological units available for specification in the component U of the output system; (b) developments in the importance of constraints on output representations.

Initially the WORD is the only available unit for specification. Consequently, productions of the children contain consonants and vowels that share the same POA feature (this accounts for observation I above). It was found that some children specifically select words from the adult language that can be faithfully represented with this limited system. Other children do not perform any selection on the words they attempt to produce, which leads to productions that deviate from the adult model. A word like *stoel* /ˈstul/ 'chair', which contains a combination of coronal consonants and a labial vowel, is in this stage produced as [ˈdys]. The representation assigned to the word 'stoel' is {WORD}. The unit WORD is unspecified in this representation, which results in both coronal consonants and vowels in the production.

The subsequent segmentalization of WORD proceeds step by step; the left edge is the first unit within the unit WORD that can be singled out for specification. It is important to note that the term 'edge' is used to abstract away from 'consonant' or 'vowel' (this accounts for observation II). In this stage a possible representation is {[WORD, Labial}. In this representation the left edge is specified for Labial, while the rest of the word remains unspecified. This results in productions where a labial segment precedes coronal segments, like [ˈpit] and [ˈotə].

Later, the sonority peak of WORD and the right edge of WORD become available for specification as well. However, at this point not all the representations that could in principle be generated with the units in U and the POA features in F are attested in the data. This is the result of constraints on representations. For some children an absolute ban on Dorsal segments is observed in the initial stages. This is captured by the constraint '*Dorsal', which simply states that an output representation cannot contain a Dorsal specification. As soon as the WORD edges become available as units for specification the constraint on Dorsal specifications becomes more specific; Dorsal specifications are from now on banned from the left edge of WORD only: '*Dorsal → [WORD' (observation IV). This constraint is active in the output systems of all but two of the children, and even in their system it appears to be active at some level. Furthermore, a special relation is observed between the left edge of the WORD and the feature Labial (observation III). This bond between Labial and the left edge is captured by a constraint that specifically directs Labial specifications to this edge: 'Labial → [WORD'.

These constraints are active in the output system of the children for quite some time. Adult model words requiring output representations that violate either of these constraints are assigned alternative output representations that satisfy the constraints in the phonological output system of the children. This, again, leads to productions that deviate from the adult model. In this stage we find, for example, ['patə] for *slapen* /'slapə/ 'sleep'. Here, the left edge, rather than the right edge, is specified Labial, in order to satisfy the edge constraint on Labial specifications. Other examples are ['fep] for *zeep* /'zep/ 'soap' and ['pun] for *schoen* /'sχun/ 'shoe'. In these cases a left edge with a Labial specification is included in the representation in order to satisfy the edge constraint on Labial specifications. A final example is ['tɑkə] for *katten* /'kɑtə/ 'cats'. Here the right edge, instead of the left edge, is specified for Dorsal, in order to satisfy the edge constraint on Dorsal specifications. These deviating productions, then, include forms that have been analyzed as instances of fronting, Consonant Harmony, Vowel-Consonant Harmony and metathesis.

The edge constraints gradually become less effective and the WORD-based units become, in a way that remains to be investigated, equated with independent, segment-sized units. It then becomes possible for children to specify segments in any position for any POA feature.

This system, then, and the specific developments that are proposed to take place, accounts for the Place of Articulation feature structure of all words produced by the children in the course of their acquisition of the language.

There are several lines along which this research can be elaborated. For one thing, the model should in the ideal case be able to account for the entire feature structure of lexical outputs. The acquisition data should thus be scanned for patterns in other feature areas than place of articulation. With respect to manner features, for example, it has been observed in the acquisition data that, just like the place of articulation features, certain features are linked to specific edges (cf. Fikkert, in preparation).

The validity of the model as it stands as a universal model is another issue that needs to be addressed. This means that it should be tested against acquisition data from languages other than Dutch.

Another move that could be fruitful is to investigate the relationship between the model proposed here and that of Optimality Theory (Prince & Smolensky 1993, McCarthy & Prince 1993). In this theory too, output representations result from the interaction of phonological structures that can in principle be generated by one part of the phonological system and a system of hierarchically ordered constraints that form the other part of the phonological system. The idea is that the set of constraints is universal, but that the hierarchical order of these constraints is language-specific. The child thus needs to determine the constraint hierarchy of his native language. It can be assumed that at the outset of acquisition, the set of universal constraints is in a default ordering. The hypothesis is then that the patterns that can be observed in acquisition data reflect this default ordering. Also, acquisition data could detect universal constraints that are not clearly observable in the adult language. The constraint on Dorsal specification of the left WORD edge, posited in chapter 5, could be an example of this. This constraint was thought to affect the output representations of the children in such a way that initial dorsal consonants did not occur in their productions for some time. While in adult Dutch initial /k/ and /χ/ do occur, /ŋ/ never occurs in this position. At some level, then, this constraint still affects output representation in adult Dutch (and other languages). It needs to be investigated whether the other constraint, directing Labial specifications to the left edge, is reflected in any way in the languages of the world.

The interplay of current phonological thinking and child language data as it has been employed in this thesis has only alluded to the many interesting possibilities there are of gaining insight into on the one hand the acquisition of phonological systems and on the other hand their structure. The challenge is to keep up the time-consuming, but fruitful, practice of investigating detailed longitudinal developmental data from the perspective of linguistic theory, in order to unravel the construction of a phonological system.

Appendix The International Phonetic Alphabet

revised to 1989

Consonants

	bilabial	labiodental	dental	alveolar	postalveolar	retroflex	palatal	velar	uvular	glottal
plosive	p b			t d		ʈ ɖ	c	k g	q ɢ	ʔ
nasal	m	ɱ		n		ɳ	ɲ	ŋ		
trill	ʙ			r					ʀ	
tap or flap				ɾ						
fricative	ɸ β	f v	θ ð	s z	ʃ ʒ		ç	x ɣ	χ ʁ	h ɦ
lateral fricative				ɬ ɮ						
approximant	w	ʋ		ɹ			j			
lateral approximant				l		ɭ	ʎ			

Where symbols appear in pairs, the one to the right represents a voiced consonant.

Vowels

	Unrounded			Rounded		
	Front	*Central*	*Back*	*Front*	*Central*	*Back*
Close	i	ɨ	ɯ	y	ʉ	u
	ɪ			ʏ	ʊ	
Close-mid	e		ɤ	ø		o
		ə			ɵ	
Open-mid	ɛ		ʌ	œ		ɔ
	æ	ɐ				
Open	a		ɑ	ɶ		ɒ

Diacritics

ʰ	pʰ	aspirated
̤	b̤	breathy voice
̪	t̪	dental
̥	d̥	voiceless
̜	ɔ̜	less rounded
̹	ɔ̹	more rounded
̟	u̟	advanced
̠	i̠	retracted
̈	ë	centralised
̫	t̫	labialised
j̮	tj̮	palatalized by diminutive suffix
	t͜s	or affricates and double articulations
ʲ	tʲ	palatalized
̃	ẽ	nasalised
̚	t̚	no audible release
̞	e̞	lowered
̝	e̝	raised

Suprasegmentals

ˈ	primary stress
ˌ	secondary stress
ˑ	half-long
˘	extra short
.	syllable break
⁀	linking (absence of a break)
/	reiterated articulation or pause
ː	long

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Samenvatting

Over de verwerving van plaats

De fonologische theorie heeft de afgelopen jaren een groot aantal ontwikkelingen doorgemaakt. Met name het niet-lineaire perspectief op de structuur van segmenten heeft het inzicht in fonologische systemen aanzienlijk verdiept. Hoewel het onderzoek naar de fonologie van de eerste taalverwerving grote baat heeft bij de recente ontwikkelingen in de fonologie, is er tot nu toe nog op verbazingwekkend kleine schaal van geprofiteerd. Met het onderzoek waar dit proefschrift verslag van doet is gepoogd dit hiaat enigszins op te vullen. Vanuit het perspectief van de niet-lineaire fonologie is aan de hand van kindertaaldata de ontwikkeling van een Plaatskenmerkrepresentatie geanalyseerd, toegespitst op de heranalyse van een verschijnsel dat bekend staat als Consonant Harmonie, de ontwikkeling van een lexicaal outputsysteem en de ontwikkeling van vocaalhoogte.

Om systematische analyses van kindertaaldata te kunnen maken die zowel gedetailleerd zijn als ook algemeen geldend, is een uitgebreid gegevensbestand onontbeerlijk. Voor dit onderzoek is een gegevensbestand van ruim 20.000 taaluitingen aangelegd van 12 Nederlandstalige kinderen die tussen de 1;0 (één jaar) en 1;11 (één jaar en elf maanden) oud waren bij het begin van het onderzoek. Van deze kinderen zijn gedurende een periode van gemiddeld een jaar om de week bandopnames gemaakt. De taaluitingen van de kinderen zijn fonetisch getranscribeerd en in een geautomatiseerd gegevensbestand ondergebracht. In hoofdstuk 2 wordt een uitgebreide beschrijving gegeven van deze dataverzameling.

Een belangrijke aanname in dit proefschrift is dat consonanten en vocalen dezelfde verzameling plaatskenmerken, Labiaal, Coronaal en Dorsaal, delen. In de geschiedenis van de plaatskenmerken, die in hoofdstuk 3 doorlopen wordt, zien we dat er afwisselend perioden zijn waarin vocalen en consonanten gescheiden verzamelingen van plaatskenmerken hebben, en waarin ze overlappende verzamelingen van plaatskenmerken hebben. In dit hoofdstuk worden de gronden waarop gescheiden of (gedeeltelijk) overlappende verzamelingen plaatskenmerken voor consonanten en vocalen aangenomen zijn besproken. Met name uit assimilatieprocessen die in de talen van de wereld voorkomen blijkt dat voorvocalen samen met coronale consonanten, ronde vocalen samen met labiale consonanten, en achtervocalen samen met dorsale consonanten, natuurlijke klassen vormen.

In de kenmerkrepresentatie die in dit proefschrift aangenomen wordt (Lahiri & Evers 1991) wordt naar deze natuurlijke klasse verwezen: Labiaal verwijst naar zowel ronde vocalen als labiale consonanten, Coronaal naar voorklinkers en coronale consonanten, en Dorsaal naar achterklinkers en dorsale consonanten. De kenmerken Labiaal, Coronaal en Dorsaal vormen één deel van de plaatskenmerken, namelijk de 'plaats van articulatie' kenmerken (POA kenmerken). Het andere deel wordt gevormd door de kenmerken die naar de positie van de tong verwijzen (TP kenmerken), zoals [±hoog] [±laag] of [±open]. De POA en TP kenmerken kunnen onafhankelijk van elkaar functioneren in fonologische processen.

In hoofdstuk 4 wordt het onderzoeksveld van de kindertaalfonologie betreden. De aandacht wordt hier gericht op een proces dat in de literatuur bekend staat als een kindertaalfenomeen bij uitstek: Consonant Harmonie. Consonant Harmonie is één van de weinige verschijnselen uit de kindertaal die reeds met behulp van de niet-lineaire fonologie geanalyseerd zijn. In dit hoofdstuk wordt echter een nieuw perspectief op de kindertaalgegevens geboden. Consonant Harmonie wordt in de literatuur beschreven als een assimilatieproces tussen twee niet adjacente (naast elkaar staande) consonanten in een woord. Een voorbeeld van Consonant Harmonie is de kinderuiting [puf] voor het woord 'poes': de labialiteit van de /p/ spreidt naar (wordt overgedragen op) de /s/. In de fonologische theorie kan een proces als spreiding van kenmerken echter niet zonder meer plaatsvinden. Een belangrijk principe stelt dat een fonologisch proces alleen betrekking kan hebben op segmenten die op een bepaald moment in de fonologische derivatie adjacent zijn. Om de twee niet-adjacente consonanten op een bepaald moment in de derivatie adjacent te laten zijn, moeten binnen de voorgestelde analyses van Consonant Harmonie veronderstellingen gedaan worden die bij nader onderzoek van kindertaalgegevens niet waargemaakt kunnen worden. Theoretisch is plaats-assimilatie tussen twee niet-adjacente consonanten dan onmogelijk. De POA kenmerkorganisatie die in dit proefschrift als uitgangspunt is genomen, waarbij Labiaal, Coronaal en Dorsaal zowel naar consonanten als vocalen verwijzen, biedt echter een nieuw perspectief op Consonant Harmonie dat tevens het adjacentieprobleem omzeilt. Wanneer we in de zogenaamde gevallen van Consonant Harmonie de aandacht op de vocaal richten, dan vinden we dat het POA kenmerk van deze vocaal vrijwel altijd het kenmerk is dat de geassimileerde consonant aangenomen heeft. De produktie [puf] is dus niet ontstaan door spreiding van het kenmerk Labiaal van de /p/ naar de /s/, maar door spreiding van het kenmerk Labiaal van de /u/ naar de /s/.

Extra evidentie voor het standpunt dat assimilatie uitgaat van de vocaal en niet van de consonant wordt gevonden in een groot aantal gevallen van assimilatie in de kindertaaldata waarbij geen ander segment dan de vocaal een plaatskenmerk zou kunnen overdragen. Een voorbeeld hiervan is de produktie [pun] voor 'schoen': de coronale consonant /n/ kan geen labialiteit overdragen op de initiële consonant maar de labiale /u/ kan dat wel.

Niet alleen het kenmerk Labiaal kan worden overgedragen, ook de kenmerken Coronaal en Dorsaal kunnen van een vocaal naar een adjacente consonant spreiden. Voorbeelden hiervan zijn de kinderuitingen [tɛi] voor 'bij' en [uŋə] voor 'schoenen': een Coronale vocaal zorgt ervoor dat de consonant Coronaal wordt, een Dorsale vocaal zorgt voor een Dorsale consonant. De conclusie is dat Consonant Harmonie in feite Vocaal-Consonant Harmonie is: een assimilatieproces tussen een adjacente consonant en vocaal.

De vraag die vervolgens in hoofdstuk 5 gesteld wordt is of bovengenoemde gevallen van Vocaal-Consonant Harmonie voorbeelden zijn van een op zichzelf staand fonologisch proces, of dat ze samen met alle andere kindertaaluitingen volgen uit de structuur van het fonologisch systeem in ontwikkeling. Om een antwoord op deze vraag te geven is van zes kinderen de POA kenmerk structuur van iedere taaluiting geanalyseerd. Dit resulteerde in een aantal verrassende observaties. Wanneer de eerste geproduceerde woordenschat van kinderen beschouwd wordt, en vervolgens de wijze waarop die woordenschat zich uitbreidt, dan blijken we met een opvallend strikt georganiseerde ontwikkeling van de POA kenmerken van doen te hebben. In dit hoofdstuk wordt een ontwikkelingsmodel van het lexicaal outputsysteem voorgesteld dat de patronen in de kindertaaldata kan verklaren. Een belangrijke bevinding is dat kinderen in eerste instantie geen woorden produceren waarin consonanten en vocalen met verschillende POA kenmerken worden gecombineerd. Ze produceren alleen woorden die ofwel helemaal Coronaal zijn, met coronale consonanten en voorvocalen (woorden als 'die', 'zes', 'thuis'), ofwel helemaal Labiaal, met labiale consonanten en ronde vocalen (woorden als 'pop' 'boom' 'mooi'). Een derde mogelijkheid is dat een coronale of labiale consonant gecombineerd wordt met een lage vocaal (woorden zoals 'mama', 'dat'). We nemen in dit geval aan dat de lage vocalen ongespecificeerd zijn voor POA kenmerken en dat de woorden waarbij de vocaal /a/ of /ɑ/ is ook onder de noemer 'helemaal Labiaal' of 'helemaal Coronaal' vallen. Een aantal kinderen blijkt zich bovendien niet alleen in hun eigen produktie tot deze combinaties te beperken, maar ook specifiek woorden met deze combinaties uit hun moedertaal te selecteren voor produktie. Anderen selecteren woorden uit het Nederlands die wel een combinatie van verschillende POA kenmerken bevatten, maar produceren deze woorden niet als zodanig. Een woord dat niet geheel uit Labiale segmenten bestaat, zoals het bekende woord 'poes' dat een coronale /s/ bevat, wordt in dit stadium geproduceerd als [puf]. Deze uiting bestaat geheel uit labiale segmenten: de coronale /s/ heeft plaatsgemaakt voor een labiale /f/. Een ander voorbeeld is het woord 'stoel' dat coronale consonanten heeft maar geen coronale vocaal; dit woord wordt geproduceerd als [dys], met zowel coronale consonanten als een coronale vocaal. In deze eerste stadia lijkt de POA kenmerkrepresentatie die in het outputsysteem van kinderen voor woorden gegenereerd wordt dus niet segmentspecifiek te zijn, maar woordspecifiek. Om dit te verklaren wordt voorgesteld dat het outputsysteem in het begin nog geen segmentele eenheden als 'C' en 'V' bevat, doch slechts de grove eenheid WOORD. Deze eenheid kan gespecificeerd worden voor het kenmerk Labiaal, {WOORD, Labiaal}, wat resulteert in labiale consonanten en vocalen in de produktie, of de eenheid blijft ongespecificeerd, {WOORD}, wat resulteert in coronale consonanten en vocalen in de produktie. Eenheden die kleiner zijn dan WOORD, maar die wel WOORD-afhankelijk zijn, komen vervolgens één voor één beschikbaar. Als eerste wordt het mogelijk om de linker woordgrens onafhankelijk van de rest van WOORD te specificeren voor een POA kenmerk. De rest van het woord blijft ongespecificeerd en deze representatie, {[WOORD, Labiaal}, resulteert in woordprodukties waarbij een labiaal segment, consonant of vocaal, vooraf gaat aan coronale segmenten. De eenheid 'woordgrens' verwijst in dit stadium dus ofwel naar een consonant ofwel naar een vocaal in de geproduceerde taaluiting; we vinden wèl produkties van het type [pɛt] voor 'pet' en [otə] voor 'auto', maar geen produkties van het type [dos] voor 'doos' of [ɛmə] voor 'emmer'. Vervolgens kan ook naar de rechter woordgrens en naar de sonoriteitspiek van WOORD verwezen worden. Tegelijkertijd komen twee woordgrenscondities op de outputrepresentatie aan het licht. De ene conditie verbiedt dat de linker woordgrens gespecificeerd wordt voor Dorsaal, de andere conditie vereist dat een specificatie Labiaal in ieder geval met de linker woordgrens geassocieerd wordt. Deze condities hebben een tijdlang het effect dat POA kenmerken naar specifieke woordgrenzen gedirigeerd worden. De interactie van de specifieke eenheden die beschikbaar zijn voor kenmerkspecificatie en de condities op specificatie van deze eenheden leidt ertoe dat het outputsysteem telkens slechts een beperkt assortiment aan outputrepresentaties kan genereren. Met deze beperkte verzameling representaties kunnen echter alle taaluitingen van de bestudeerde kinderen verklaard worden. Specifieke verschijnselen, zoals Vocaal-Consonant Harmonie ([pun] voor 'schoen') of metathesis ([tɑkə] voor 'katten'), maar ook de produkties die overeenkomen met de uitspraak van volwassenen ([pɛt] voor 'pet' en [tɑk] voor 'tak') volgen allemaal uit de gepostuleerde structuur van het outputsysteem. De woordgrenscondities verliezen geleidelijk aan hun grip op de representaties en tenslotte is het mogelijk om segmenten, onafhankelijk van hun positie in het woord, voor ieder POA kenmerk te specificeren.

De ontwikkeling van de TP kenmerken, de andere tak van de Plaatsknoop in de kenmerkrepresentatie, komt aan de orde in hoofdstuk 6. Hiertoe zijn de vocalen, met uitzondering van de ronde voorklinkers en diftongen, in de kindertaaldata uitgebreid onderzocht. Een groot deel van het hoofdstuk is gewijd aan het bespreken van twee factoren die het zicht op de ontwikkeling van vocaalhoogte bemoeilijken, namelijk (a) de hoogte-categorisatie van het Nederlands en (b) het ontbreken van duidelijke patronen in de data. Allereerst komt uit de literatuur geen eenduidig beeld naar voren van de hoogte-categorisatie van de Nederlandse klinkers (in volwassenentaal): er worden ofwel drie ofwel vier klinkerhoogtes onderscheiden, en de klinkers worden door de één anders over de verschillende categorieën verdeeld dan door de ander. Synchrone evidentie voor een bepaalde categorisatie lijkt in het Nederlands niet voorhanden. De data zelf vormen de tweede onstabiele factor. De ontwikkeling van de TP kenmerken vertoont op het eerste gezicht geen duidelijk patroon. Het patroon blijkt echter gedeeltelijk verstoord te worden door 'invloeden van buitenaf'. Adjacente nasale consonanten hebben bijvoorbeeld tegelijkertijd een verhogende werking op relatief lage vocalen (/ɛ/ wordt [ɪ]) en een verlagende werking op hoge vocalen (/i/ wordt [ɪ]) in kindertaal. Wanneer dergelijke gegevens buiten beschouwing gelaten worden, blijft er uiteindelijk een systematische verzameling gegevens over.

Aan de hand van deze kindertaaldata, en met name op basis van de uitzonderlijke positie die hierin door de vocaal /ɛ/ wordt ingenomen — de /ɛ/ wordt het laatst geprobeerd en leidt tot de meeste fouten — wordt in het hoofdstuk beredeneerd dat voor het Nederlands een asymmetrische categorisatie voor vocaalhoogte aangenomen moet worden, met drie hoogtes voor de achtervocalen, en vier hoogtes voor de voorvocalen. In dit model zijn /i u/ hoog, /e ɪ o ɔ/ midden, /ɛ/ laag-midden en /ɑ a/ laag. Het ontwikkelingspatroon dat uit de kindertaalgegevens tevoorschijn komt vertoont grote gelijkenis met het ontwikkelingsmodel zoals dat door Jakobson (1941/1968) is voorgesteld. In dit model wordt aangenomen dat eerst [+hoog], /i/ of /u/, en [+laag], /a/, verworven worden en vervolgens van hoog naar laag de hoge middenklinkers (/e/ /ɪ/ /ɔ/ en /o/ in het Nederlands) en tenslotte de lage middenklinkers (/ɛ/ in het Nederlands). Daar deze beschrijving aan het openen van een rits doet denken, is het in dit hoofdstuk het 'ritsmodel' genoemd. De substituut-vocalen in de kindertaaldata die niet door context veroorzaakt zijn, zijn zonder uitzondering hoger dan de vocaal uit het doelwoord: /e/ en /ɪ/ worden vervangen door /i/, /ɔ/ en /o/ worden /u/ en later, wanneer woorden met een /ɛ/ geproduceerd gaan worden, wordt /ɛ/ vervangen door /ɪ/. Middenvocalen worden in eerste instantie dus met de hoge vocalen gegroepeerd. Tenslotte wordt in dit hoofdstuk bekeken hoe de feiten met betrekking tot de ontwikkeling van vocaalhoogte verklaard kunnen worden in termen van een fonologische representatie die in concrete stadia beschikbaar komt. De bekende [±laag] [±hoog] representatie, die eigenlijk al niet in staat is om vier vocaalhoogten te representeren, blijkt in dit opzicht niet inzichtelijk te zijn. In het begin zijn de kenmerken [+hoog] en [+laag] beschikbaar, maar deze representatie doet verder geen voorspellingen over hoe in dit stadium de middenvocalen, [−hoog, -laag], in het fonologisch systeem van kind gerepresenteerd worden. De recentelijk voorgestelde representatie van Clements (1989, 1991) biedt in dit opzicht mogelijkheden. De structuur voor vocaalhoogte die door Clements wordt voorgesteld bestaat uit één kenmerk, [±open] dat op meerdere, hiërarchisch geordende niveaus voorkomt. Het ritsmodel van Jakobson en de systematische substitutiepatronen vinden in dit model een fonologisch-theoretische verklaring wanneer aangenomen wordt dat de verschillende niveaus in de TP representatie één voor één ter beschikking komen. Verder moet aangenomen worden dat in het ongemarkeerde geval [+open] op niveau 1 inhoudt dat alle niveaus als [+open] gespecificeerd zijn, terwijl [−open] op niveau 1 inhoudt dat alle niveaus als [−open] gespecificeerd zijn. Op het moment dat alleen niveau 1 beschikbaar is kunnen alleen de representaties [+open] op niveau 1 en verder en [−open] op niveau 1 en verder gegenereerd worden. Dit zijn de representaties voor de hoge en de lage vocalen. De hoge middenvocalen hebben in Clements' model ook de specificatie [−open] op niveau 1 en 2, maar een specificatie [+open] op niveau 3, de lage middenvocalen hebben een specificatie [−open] op niveau 1, maar [+open] op niveau 2 en 3. Eén van de voorspellingen van dit model is dat deze vocalen in het begin dezelfde representatie krijgen als de hoge, en niet als de lage, vocalen, en dus als hoge vocalen, /i/ of /u/, geproduceerd zullen worden. Dit komt overeen met de bevindingen in de data.

Curriculum Vitae

Claartje Levelt werd op 30 maart 1965 te Woudenberg geboren. Na het behalen van het diploma gymnasium α aan de Nijmeegse Scholengemeenschap te Nijmegen in 1983, begon zij aan de studie Italiaanse taal- en letterkunde aan de Rijksuniversiteit Leiden, alwaar zij op 2 juli 1984 het propaedeutisch examen behaalde. Daarna doorliep zij het doctoraalprogramma van de studie Algemene Taalwetenschap, eveneens aan de Rijksuniversiteit Leiden. Op 22 februari 1989 studeerde zij af op een doctoraalscriptie over de verwerving van fonologie. Vanaf 1 april 1989 was zij als Onderzoeker in Opleiding verbonden aan de Nederlandse Organisatie voor Wetenschappelijk Onderzoek, met als standplaats de Vakgroep Algemene Taalwetenschap te Leiden. Het onderzoek dat in dit kader werd verricht naar de verwerving van fonologie is uitgemond in het proefschrift dat thans voor u ligt. Vanaf 1 februari 1994 is zij als Docent en Onderzoeker verbonden aan het Holland Institute of Generative Linguistics (Rijksuniversiteit Leiden).