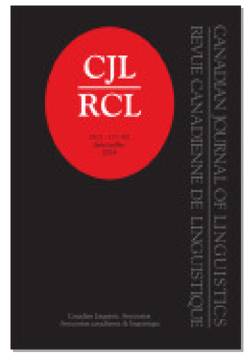
A Phonological Analysis of Schwa in German First Language Acquisition



Margaret Kehoe, Conxita Lleo

The Canadian Journal of Linguistics / La revue canadienne de linguistique, 48 (3/4), Sept.-Dec./sep.-déc. 2003, pp. 289-327 (Article)

Published by University of Toronto Press
DOI: 10.1353/cjl.2004.0030

Canadian Journal of Linguistics/Revue canadienne de linguistique 48(3/4): 289–327, 2003

A Phonological Analysis of Schwa in German First Language Acquisition

MARGARET KEHOE and CONXITA LLEÓ
University of Hamburg

1. INTRODUCTION

Schwa is one of the most frequently occurring vowels in West Germanic languages such as German, English, and Dutch (Delattre 1965). Phonological and phonetic investigations of its status have been a common theme in Germanic linguistics (Wiese 1988, 1996; Féry 1995; Becker 1998; Maas 1999, for German; Hammond 1997 for English; Kager and Zonneveld 1986; Kager 1989; van Oostendorp 1995, 1998, 2000 for Dutch). Phonological accounts differ, but they all share the view that schwa is unspecified, either segmentally or prosodically. Phonetic accounts refer to its non-peripheral vowel quality, low amplitude and short duration which make it distinctive from full vowels. Despite its high frequency and unique linguistic status, few studies have investigated children's early production of schwa (cf. Levelt 2000 in Dutch) nor have they examined how children learn the phonological characteristics that distinguish schwa from other vowels. As a means of addressing this gap in the phonological acquisition literature, this study examines the development of schwa in the acquisition data of young German children.

The aim of the study is two-fold. First, we document the stages of acquisition followed by a group of German-speaking children. We focus predominantly on schwa in word-final syllables (e.g., *Katze* [ˈkatsə] 'cat', *Apfel* [ˈʔapfl̩] 'apple') but include some discussion of schwa in compound nouns (e.g., *Badewanne* [ˈbaːdəˌvanə] 'bath(tub)', *Apfelsaft* [ˈʔapfl̩ˌzaft] 'apple juice').[1] Second, we offer a

The German children were originally tested as part of the project PAIDUS (Parameter Fixing in German and Spanish) supported by a grant of the Deutsche Forschungsgemeinschaft (DFG) to Conxita Lleó. The current study forms part of a larger study on the phonological and morphological development of bilingual (and monolingual) children. It was conducted at the Research Centre on Multilingualism, University of Hamburg, and was also supported by the DFG. We would like to thank Martin Rakow and Manuela Käselau for their dedicated work in the transcription and reliability aspects of the study.

[1] We will discuss the differences between syllables containing schwa and syllabic consonants later in the article.

phonological account of schwa acquisition, focussing particularly on the phonological properties that distinguish schwa from full vowels. Following recent analyses in the literature, we assume that schwa lacks specification at one or more levels. Schwa can be viewed as non-moraic (Kager 1989; Féry 1995) and, consequently, one developmental task faced by the child is learning that certain vowels are weightless. Just as acquiring a phonological vowel length contrast may take some time (monomoraic vs. bimoraic distinction), so may the acquisition of non-moraic vowels. Alternatively, schwa can be viewed as having a prosodic position but lacking articulatory features (van Oostendorp 1995, 1998, 2000). If we suppose that there is a constraint in the grammar that requires that segments be specified (i.e., possess articulatory features) in order to project to certain prosodic positions, the child will initially associate articulatorily specified segments to prosodic positions. In this sense, the developmental task for the child is overcoming the constraint that all prosodic positions must contain segmental features.

These two approaches to schwa representation — the first referred to as the No Mora account and the second, as the Projection account — are evaluated using the German child data. We analyse schwa and syllabic consonants separately. Our data reveal two stages in the development of schwa: one in which target schwa is prosodically (and segmentally) augmented to a long full vowel, and another in which target schwa is segmentally augmented to a short full vowel. The first stage was attested primarily in one child, whereas the second stage was attested in all four children. We interpret the first stage as consistent with the prosodic characteristics of the German language. According to certain authors (Féry 1995; Wiese 1996), all German syllables, except syllables containing schwa, are minimally bipositional or bimoraic. One German child is initially compelled by this constraint to produce all target schwa syllables as bimoraic. We interpret the second stage as consistent with a high ranking projection constraint requiring all syllables to be filled by articulatorily specified segments. This explains why all children substitute target schwa syllables by full vowels.

In the case of target syllabic consonants, different stages were attested. The children mainly produced target syllabic consonants as a full vowel plus coda consonant. They then went on to produce syllabic consonants before they produced schwa. The different timeline observed between schwa and syllabic consonants is one of the reasons why we ultimately reject an analysis of schwa as non-moraic. In the No Mora account, schwa and syllabic consonants are represented similarly (i.e., both as non-moraic), whereas in the Projection account, syllabic consonants differ from schwa in being specified for place. The earlier acquisition of syllabic consonants is consistent with an account in which syllabic consonants are represented differently from schwa.

The article is organised as follows. In the next section, we review the phonetic, phonological, and morphological characteristics of schwa in German, as well as the prosodic characteristics of German syllables. In section 3, we consider the literature available on the acquisition of schwa. Section 4 describes the database and methodology that we have employed. In section 5 we present the data which consist of a longitudinal analysis of schwa in word-final syllables and in compound nouns. We also present data on filler or epenthetic schwa from the same group of children. In section 6, we provide a formal account of the findings, and in the seventh and final section, we present the conclusions.

2. PHONOLOGICAL BACKGROUND

2.1. Phonetic characteristics

Syllables containing schwa are phonetically distinct from syllables containing full vowels (Low, Grabe, and Nolan 2001). These phonetic qualities pertain to schwa in all languages and not only to schwa in German. Schwa vowels are characterized by lower amplitude and shorter duration than full vowels (Lindblom 1963). The shortness of schwa, although evident in non-word-final position, is not necessarily evident in word-final position, where schwa may sometimes be as long as a non-final stressed vowel, due to final lengthening (Fischer-Jørgensen 1969). The central defining feature of schwa pertains to its quality. Schwa represents a deviation in the vowel space from a peripheral to mid-central position, often referred to as neutral (Koopmans-van Beinum 1994). Several authors have noted that the quality of schwa may be affected by the acoustic and articulatory properties of neighbouring consonants (Browman and Goldstein 1992; Koopmans-van Beinum 1994). Van Oostendorp (2000) interprets the latter characteristic as evidence for the placelessness of schwa.

2.2. Phonological characteristics

2.2.1. Terminology

Throughout the article, uppercase schwa (i.e., SCHWA) will be used as a cover term to refer to any syllable containing a schwa or syllabic consonant. Following van Oostendorp (1995, 1998, 2000), we distinguish between two types of SCHWA in German: underlying SCHWA and reduction schwa as given in the examples in (1) and (2), respectively. The examples of reduction schwa are adapted from Vennemann (1991:212).

(1) Underlying SCHWA:

a.	Robbe	Robb[ə]	'seal'
	genug	g[ə]nug	'enough'
b.	Vogel	Vog[l̩]	'bird'
	Garten	Gart[n̩]	'garden'

(2) Reduction schwa;

El/e/fant	→	El[e]fant, El[ɛ]fant, El[ə]fant	'elephant'
Käng/u/ruh	→	Käng[u]ruh, Käng[ʊ]ruh, Käng[ə]ruh	'kangaroo'
Asp/i/rin	→	Asp[i]rin, Asp[ɪ]rin, Asp[ə]rin	'aspirin'

This classification should not be awarded any theoretical status but allows us to make a practical distinction between the different roles that SCHWA may play in a language (van Oostendorp 1995 1998, 2000). Underlying SCHWA refers to those forms which are present in the underlying representation as SCHWA and which surface as SCHWA (occasionally, as zero); reduction schwa refers to those forms which are present in the underlying representation as full vowels and which optionally surface as schwa depending upon factors such as speech style, speech rate, and underlying vowel quality. In the case of underlying SCHWA, we make a further distinction beween syllables containing schwa (1a) and syllables containing syllabic consonants (1b).

Note that the classification of underlying schwa (1a) is a point of contention in the literature on German: Some phonologists ascribe an underlying /e/ or /ɛ/ vowel to this form of schwa (Wurzel 1970; Kloeke 1982; Becker 1998). Possible arguments in favour of an underlying full vowel are alternations such as *léb* + [ə]*nd* 'living' → *leb* + [ˈɛ]*nd* + *ig* 'alive', in which the alternating vowel is typically /e/ or /ɛ/, and cases of exceptional emphasis in which schwa, for reasons of contrast, surfaces as /e/ (*b*[ə] + *laden*/*b*[ˈe] + *laden und entladen* 'load/load and unload'). Wiese (1996) notes that there appears to be a special relationship between schwa and /e/ but argues that this does not constitute proof of deriving the former from the latter. Under distinctive feature theory, the change from schwa to [ɛ] or [e] is minimal and this may explain the close connection between these vowels.

In the current study, we focus only on underlying SCHWA (words from (1a) and (1b)), that is, forms that will always be heard by the child as SCHWA. (See Kehoe 2002 for an analysis of reduction schwa in young German children's productions.)

2.2.2. *Representation of schwa*

In this section, we discuss two approaches to schwa representation which form the basis of our later analyses. In the first approach, schwa is mora-less or weightless (Kager 1989; Féry 1995). It projects a syllable but not a mora. The main advantage of this approach is that it explains the non-stressability (but metrifiability) of schwa. Schwa can never receive stress because in the underlying representation, it is non-moraic. According to Féry (2000), other phonotactic restrictions associated with schwa such as the fact that it disallows [h] and [ʔ] as onsets fall out from its non-moraic status. In German, moraic syllables require onsets whereas non-moraic syllables can be realized without onsets. Compare *Uhu* [ˈʔuːhu] 'owl' and *Ehe* [ˈʔeː.ə] 'marriage' in which the laryngeal onset /h/ must be realized before the full vowel [u] but not before schwa.

There are two main "No Mora" theories: Kager's (1989), which is couched within Lexical Phonology and Féry's (1995), within Optimality Theory (OT). In Kager's theory, schwa is weightless in the underlying representation but is assigned a mora at a later stage in the derivation; in Féry's theory, schwa remains non-moraic at the surface. Note that proponents of both theories have focussed on the prosodic emptiness of schwa and have provided little details on the segmental specification of schwa. Because the segment, schwa, is shown to be attached to an empty prosodic position,[2] we assume that schwa is intended to be segmentally specified as indicated by the phonetic symbol [ə] in (3).[3]

(3) Representation of schwa: No Mora account

σ
| no mora
[ə] segmental specification (i.e., [+place])

In the second approach to schwa representation, schwa is prosodically specified but only minimally segmentally specified. The most recent advocate of this approach is van Oostendorp (2000), who has developed an elaborate phonological account of schwa within the framework of Projection Theory. Schwa is represented as a bare root node specified for [−cons] only, as shown in (4).

(4) Representation of schwa: Projection account

σ
|
μ mora
|
[−cons] minimal segmental specification

For the purposes of contrasting the two approaches (No Mora vs. Projection), schwa is shown here as moraic. In actual fact, the representation in (4) is an adaptation of van Oostendorp's (1995, 1998, 2000) approach because he does not work within the framework of moraic theory, but rather in X-bar syllable theory. We believe, however, that this representation does not contradict his claims concerning the specification of schwa, as will be discussed below.

In Projection Theory, the behaviour of schwa can be understood in terms of the relationship between segmental material and prosodic structure.[4] If a segment contains certain features, it should project to a certain prosodic position (e.g., the head of a syllable or foot, or mora in our approach) and conversely, if a segment appears in a certain prosodic position (i.e., the head of a syllable or foot, or mora in our approach), it should contain certain (vocalic) features. This relationship is formalized by means of the following general constraints, where F = (vocalic) Feature, and P = Prosodic position:

---

[2]The authors do not make clear to what extent schwa is segmentally specified. Given current views of schwa representation, it may be assumed that schwa is also segmentally underspecified to some degree.

[3]Here and throughout the article, representation of SCHWA will include syllabic, moraic, and segmental tiers. The segmental tier is an abbreviation for the featural specifications of the target segment. In particular, as we focus on place specification, [+place] is indicated.

[4]For similar views, see Rose's (2000) theory of headedness and prosodic licensing applied to phonological acquisition.

(5) PROJECT(P, F): If a vowel appears in position P, it should be [+F].

(6) PROJECT(F, P): If a vowel is [+F], it should appear in position P.

One very positive aspect of Projection Theory is that it provides a cohesive account of the different roles of schwa. Reduction schwa is due to the constraint PROJECT(V, Foot) (V refers to the set of vocalic features), which requires that vowels with vocalic features appear in the heads of feet. In other words, a vowel with vocalic features appearing in the non-head position of a foot would violate this constraint. This accounts for the process of vowel reduction because it is preferable for an unstressed syllable to contain a vowel without vocalic features (i.e., schwa) than to contain one with vocalic features (i.e., a full vowel). Underlying schwa is accounted for by the constraint PROJECT([$-$cons], σ), which forces an underlying [$-$cons] root to occur in the head of a syllable. A constraint such as PROJECT(σ, V), which requires that syllable heads contain vocalic features, will block underlying schwa from surfacing. Such a constraint may be active at the early stages of acquisition. Finally, epenthetic schwa, another type of schwa to be discussed later, is accounted for by the constraint PROJECT(σ, [$-$cons]), which requires that syllables, which initially contain no vowel, have at least a [$-$cons] root. Insertion of schwa is the most economical way of complying with this constraint because schwa contains exactly a [$-$cons] root.

We will contrast these two approaches to schwa, the No Mora account (Kager 1989; Féry 1995) and the Projection account (van Oostendorp 1995, 1998, 2000) in our analyses of the child data. One criticism that has been raised against the non-moraic approach is that it is stipulative (van Oostendorp 2000:215). Schwa is claimed to bear no mora but no elaborate theory has been developed which relates segmental content to number of moras. As we will observe later, aspects of the child data also pose a problem for the No Mora account.

2.2.3. Representation of syllabic consonants

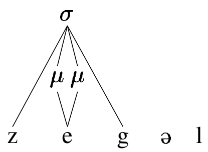
Following on from the preceding discussion, some attention should be given to the special case of syllabic consonants. Most authors consider a schwa plus sonorant coda or syllabic consonant to be a phonetic variant of the same underlying form (Hall 1992; Féry 1995; Wiese 1996). Opinions differ, however, on whether the schwa plus sonorant coda or syllabic consonant is the default phonetic form. Following Féry (1995), we assume that syllabic sonorants are the default form and, thus, the adult output forms will be transcribed to reflect this throughout this article.

Turning to the phonological representation, in the No Mora approach, schwa and syllabic consonants are treated similarly.[5] In Kager's (1989) account, both

[5]Prior to the development of non-linear phonology, the standard account of syllabic consonants in German was that the consonant which becomes syllabic is not preceded by a schwa in underlying representation. Schwa is derived via epenthesis in consonant sequences

schwa and the sonorant coda are non-moraic (and unsyllabified) throughout the early stages of syllable formation as shown in (7).[6]

(7)



Segel 'sail'

At a later stage in the derivation, schwa is assigned a mora but the final sonorant remains non-moraic. In Féry's (1995) account, the final sonorant is directly syllabified as the head of the unstressed syllable. Like schwa, it is non-moraic but is segmentally specified as shown in (8). We employ Féry's account to illustrate the non-moraic analysis.[7]

(8) Representation of syllabic consonants: No Mora account

σ
| no mora
[n] segmental specification (i.e., [+place])

In the Projection account (Van Oostendorp 1995, 1998, 2000), schwa and syllabic consonants are treated differently. Whereas schwa is minimally specified as [−cons], syllabic sonorants are fully specified. They form the head of an unstressed syllable in the lexical representation, as in Féry's (1995) approach. In Dutch, a constraint (PROJECT(σ, [−cons])) is active at the post-lexical level, requiring syllables to contain vocalic heads. As a result, schwa is epenthesized. In German, such a constraint does not apply (or applies optionally) and, thus, the sonorant remains the head of the syllable in the surface form as shown in (9).[8]

---

that are otherwise unsyllabifiable (Wiese 1996). For example, the monomorphemic form *Atem* 'breath' would be underlyingly representated as /aːtm/. Because of the rising sonority of the final cluster, the only way for this string of segments to be syllabified would be through insertion of schwa before the final sonorant consonant. A later weakening rule in the postlexical phonology would allow the nucleus to be filled by a non-obstruent consonant, thereby deriving the syllabic consonant.

[6]In Kager's (1989) approach, pre-schwa consonants are incorporated into the previous syllable during the derivation, creating a superheavy syllable that will then automatically be assigned stress. This explains the strong tendency for syllables preceding schwa to bear stress.

[7]It has frequently been argued that coronal consonants, such as /n/ and /l/, are underspecified for place (see, e.g., Paradis and Prunet 1991). Even given this claim, we assume that coronal syllabic consonants are still characterized by a consonantal place node, as indicated in (8).

[8]Van Oostendorp's theory is based on Dutch data. There are differences between Dutch and German with respect to schwa epenthesis in forms with syllabic sonorants. Schwa

(9) Representation of syllabic consonants: Projection account

σ
|
μ mora
|
[n] segmental specification (i.e., [+place])

Given the different treatments of schwa and syllabic consonants in the two accounts, we will examine whether there are differences between the acquisition patterns of schwa and syllabic sonorants in the child data which may provide insight into the benefits of one approach over the other. In the literature, several criticisms have already been directed at the No Mora approach with respect to its treatment of syllabic consonants. Van Oostendorp (2000:214) points out that, under a moraic view of syllable structure, sonorants are the consonants typically viewed as moraic. Yet, in the No Mora account, it is exactly these consonants which are non-moraic.

2.3. Morphological characteristics

Having discussed the phonetic and phonological characteristics of SCHWA, some attention should be given to its morphological distribution. We focus on two main types of schwa that appear in early child speech: SCHWA in word-final syllables and SCHWA in compound nouns. The former may appear in uninflected and inflected nouns (*Schnecke* [ˈʃnɛkə] 'snail'; *Hunde* [ˈhʊndə] 'dog-PL'), inflected adjectives (*kleine* [ˈklaɪnə] 'small'), and uninflected and inflected verbs (*duschen* [ˈduːʃn̩] 'to shower'; *dusche* [ˈduːʃə] 'shower 1SG'). All of these morphological environments were attested in our data; however, the majority of items consisted of uninflected nouns and verbs. Within the framework of prosodic morphology, the plural in German can be expressed as a bisyllabic trochee, in which the second syllable is occupied by SCHWA (Wiese 1996). The same applies to the infinitive form of the verb, as well as to inflected adjectives and verbs. The latter may also give rise to more complex prosodic forms, which are not considered here given that they did not appear frequently in the database.

Examples of compound SCHWA are given in (10). As with word-final SCHWA, they consist of schwa (10a) or syllabic consonants (10b).

(10) Examples of compound nouns containing SCHWA:

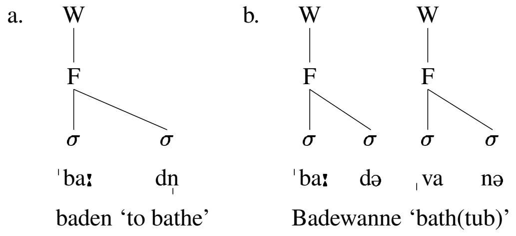
a. Bad[ə]wanne 'bath(tub)'
b. Apf[l̩]saft 'apple juice'

The prosodic structure of SCHWA in both sets of words (i.e., word-final and compound SCHWA) is similar: SCHWA forms the second syllable of a trochaic foot and is situated in Prosodic-Word-final position, as shown in (11). We, nevertheless,

epenthesis appears to be obligatory in Dutch (see the discussion of epenthetic u-schwa by van Oostendorp 2000:186) and optional in German.

maintain a distinction between the two forms of SCHWA in our analyses, because this distinction may prove to be relevant in acquisition.

(11) Prosodic structure of word-final and compound SCHWA:



2.4. Prosodic characteristics of German syllables

In the final part of this section, we review the prosodic characteristics of German stressed and unstressed syllables. Some background information on German syllables is necessary, because, as will be seen later, the acquisition patterns of the children (in particular, Bernd) reflect these prosodic characteristics.

The rhyme of the syllable in German is minimally bimoraic and maximally trimoraic (Féry 1995). One of the fundamental phonotactic regularities of Modern Standard German is that a short vowel can always be followed by one more consonant than a long vowel or diphthong (Moulton 1956; Wiese 1988, 1996; Hall 1992). This pattern is consistent with the presence of a phonological vowel length distinction in German: tense vowels and diphthongs are bimoraic; lax vowels are monomoraic. Examples of bimoraic and trimoraic syllables are given in (12a) and (12b).

(12) a. Bimoraic syllables:

VV			V_iV_j			VC		
Kuh	[kuː]	‘cow’	Ei	[ʔaɪ]	‘egg’	Bett	[bɛt]	‘bed’
Zoo	[tsoː]	‘zoo’	Frau	[fʀaʊ]	‘woman/wife’	Mann	[man]	‘man’

b. Trimoraic syllables:

VVC			VV_iV_j			VCC		
viel	[fiːl]	‘a lot (of)’	faul	[faʊl]	‘bad/lazy’	Film	[fɪlm]	‘film’
Bahn	[baːn]	‘train’	Bein	[baɪn]	‘leg’	Bank	[baŋk]	‘bank’

Within the framework of OT, Féry (1995) summarizes these patterns in terms of two syllable size constraints for German:

(13) BIMOR (Bimoraic syllables):
Syllables are minimally bimoraic.

(14) TRIMAX (Trimoraic maximum):
Syllables are maximally trimoraic.

The first constraint is consistent with several phonotactic facts of German. In word-final or in hiatus position, open syllables with lax vowels do not occur; in word-internal position, syllables with lax vowels are closed by ambisyllabic consonants, thus allowing the bimoraic constraint to be fulfilled.[9] The second constraint, TRIMAX, is somewhat controversial because it is frequently claimed that syllables are universally maximally bimoraic. Féry (1995) argues that the phonological details of German strongly favour the presence of trimoraic syllables (see also Hall 2002a, 2002b). That is, there is phonotactic equivalence between lax vowels followed by two consonants and tense vowels and diphthongs followed by one consonant. Furthermore, trimoraic syllables frequently attract stress in German, suggesting that a weight difference between trimoraic and bimoraic syllables is necessary. Trimoraic syllables are frequent in word-final position; bimoraic syllables are preferred in word-internal position.[10]

The discussion up until now has focussed on stressed syllables. The moraic status of unstressed syllables is less clear. At this point, we exclude discussion of schwa syllables. Several authors propose that all syllables in German, regardless of whether they are stressed or unstressed, minimally consist of two elements in the rhyme (Wiese 1988, 1996; Féry 1995). This would imply that a phonological vowel length distinction exists both in stressed and unstressed syllables and that a single consonant following an unstressed lax vowel would always be ambisyllabic. Wiese (1996:46) presents the examples in (15) as support for a minimal rhyme condition in German, whereby the unstressed open syllables consist of either a long vowel or a short vowel followed by an ambisyllabic consonant. The circle above a segment indicates ambisyllabicity.

(15)	Metall	[meːˈtal]	∼	[mɛˈt̊al]	'metal'
	Philosophie	[fiːloːzoːˈfiː]	∼	[fil̊ɔz̊ɔˈf̊ɪː]	'philosophy'
	Kalender	[kaːˈlɛndɐ]	∼	[kaˈl̊ɛndɐ]	'calendar'

Other authors argue that the minimal rhyme condition does not apply to unstressed syllables, claiming that the vowel length opposition is neutralised in this position (Becker 1998) and that ambisyllabicity only applies after stressed syllables (Ramers 1992). Note that, as is the case with stressed syllables, an unstressed syllable in word-final position cannot consist of a lax vowel (see the

[9]Most German phonologists assume that an intervocalic consonant following a short vowel is ambisyllabic (Ramers 1992; Féry 1995; Wiese 1996). However, Jensen (2000) has recently questioned ambisyllabicity for German, and Hall (1992) points out that the usual argument for ambisyllabicity is circular. Therefore, there remains some question about whether German syllables are minimally bimoraic.

[10]We do not take into consideration an alternative theoretical position, namely that the German syllable is maximally bimoraic. Trimoraic rhymes, which occur predominantly in word-final position, could be analysed as bimoraic rhymes plus a final consonant, the latter forming the onset of an empty-headed syllable. See recent work by Piggott (1999), Féry (2002), and Goad (2002) for further elaboration.

examples in (16)) suggesting that, at least, word-final unstressed syllables (with the exception of schwa syllables) must be viewed as minimally bimoraic. This phonological constraint appears to play a role in the acquisition patterns of Bernd, to be discussed later.

(16)	Kaffee	[ˈkafe]	*[ˈkafɛ]	'coffee'
	Auto	[ˈʔaʊto]	*[ˈʔaʊtɔ]	'car'

3. ACQUISITION OF SCHWA

We turn now to review the findings on the acquisition of SCHWA. Two main strategies have been described in the literature: 1. Syllable or vowel deletion, and 2. Production of a full vowel (Stoel-Gammon and Herrington 1990). Syllable deletion occurs most often in word-initial or word-medial position, but at the earliest stages of phonological development, it occasionally occurs in word-final position as well. Lohuis-Weber and Zonneveld (1996) and Taelman and Gillis (2001) provide data on two Dutch children, Joost and Maarten, respectively, who frequently deleted SCHWA in word-final position. Examples are given in (17).[11]

(17) Deletion of word-final SCHWA by Dutch children:

	Orthography	Underlying form	Child output	Gloss	Child and age
a.	knopje	/ˈknɔpjə/	[kɔp]	'button'	Joost 2;1
	tafel	/ˈtɑfəl/	[taf]	'table'	Joost 2;1
b.	sleutel	/ˈsløtəl/	[søt]	'key'	Maarten 1;9,21
	toren	/ˈtorə/	[to]	'tower'	Maarten 1;11,8

The second strategy is to substitute SCHWA with a full vowel (or full vowel plus consonant) such that this vowel is often perceived as containing secondary stress, as in the examples from Stoel-Gammon and Herrington's (1990) study of phonologically disordered English-speaking children.

(18) Full vowel substitutions of target SCHWA:

	Orthography	Target form	Child output	Child and age
a.	chicken	[ˈtʃɪkn̩]	[ˈdɪˌʔɑn]	G1 3;8
b.	Christmas	[ˈkrɪstməs]	[ˈwɪsˌmɑs]	G1 3;8

When are children first able to accurately produce SCHWA syllables? Stoel-Gammon and Herrington (1990), after reviewing the vowel literature on normally developing English-speaking children, suggest an early age range for the acquisition of schwa. It was listed as a vowel of "intermediate difficulty", being typically

[11]For the child Dutch data, we depart from the convention adopted elsewhere in this article by showing the underlying forms given by the authors cited rather than the adult output forms.

mastered around the age of 2;0 years. In contrast, Allen and Hawkins' (1978) investigation of syllable reduction by six children, aged 2;2–3;9, indicates a later age of acquisition. They found that this group of children reduced target schwa syllables 50% of the time in multisyllabic words, where their definition of reduction included production of a central vowel (schwa or central full vowel) and vowel deletion. Thus, there appears to be no consensus on when children are able to accurately produce schwa; some studies report that children produce schwa as early as age 2;0; others, as late as 3;9 years.

One possibility that must be addressed is that the purported difficulty children experience in the production of SCHWA may reflect articulatory difficulty. This is contradicted by Davis and MacNeilage's (1990) observation that schwa is frequent in babbling and is a frequent vowel substitute for virtually all other vowels. It is also contradicted by the occurrence of "filler syllables" in early child speech, which are often phonetically realized as a central vowel, schwa, or syllabic consonant (Peters and Menn 1993; Veneziano and Sinclair 2000; Lleó 2001a, 2001b; Peters 2001). These findings thus seem to suggest that an "ease of articulation" argument cannot fully explain the late realization of SCHWA (Fikkert 1994:180).[12]

From a phonological standpoint, children acquiring languages with SCHWA must either acquire a distinction between moraic and non-moraic vowels, or learn to associate a prosodic position with a featurally defective segment. Which option is chosen will depend on the theoretical perspective adopted for target SCHWA, the first corresponding to the No Mora account (Kager 1989; Féry 1995) and the second to the Projection account (van Oostendorp 1995, 1998, 2000). Evaluation of the former approach is rendered difficult because little is known about the moraic development of unstressed syllables. Studies on the moraic development of stressed syllables indicate that vowels are initially represented as monomoraic and that the distinction between monomoraic and bimoraic vowels is acquired later (Fikkert 1994; Demuth 1996), although the exact developmental timeline may vary from language to language (Kehoe and Stoel-Gammon 2001; Kehoe and Lleó 2003). By analogy, we might assume that vowels in unstressed syllables are initially represented as monomoraic and that the distinction between moraic vowels and non-moraic schwa is also acquired later. Alternatively, under the Projection account, where schwa is represented in the adult grammar as monomoraic, the task for the child is not one of acquiring an additional moraic distinction but one of learning to associate a prosodic position with a defective segment (i.e., segmentally unspecified or minimally specified). Children may initially substitute the defective segment with a fully specified one.

We now turn to the methodology and data.

[12]Nevertheless, as with many aspects of speech production in children, the fine-grained phonetic characteristics of schwa (duration and spectral qualities) may not be adult-like until late in acquisition (Nittrouer 1993).

4. METHODOLOGY

The data consist of the spontaneous word productions from four monolingual German-speaking children (Bernd, Marion, Thomas, and Britta) who were audio-recorded fortnightly (monthly after 2;0) from the onset of their first word productions (1;0 to 1;3) through to approximately 3;3 years. They were recorded in their homes in unstructured play situations, while interacting with their mothers and one investigator. Following testing, all sessions were glossed and phonetically transcribed and all productions were entered into the Macintosh database 4th Dimension. Four time points were identified as analysis periods. They represented the following age intervals:

1. onset of word production to 1;7;
2. age 1;10–2;0;
3. age 2;3–2;6;
4. age 2;9–3;1.

In the case of two children (Marion and Thomas), an additional time period (age 1;8–1;9), referred to as Interim (INT), was also examined for word-final SCHWA.

Target words with SCHWA were selected from the data sessions included within these time points. They included bisyllabic words with word-final SCHWA and compound nouns containing SCHWA. In the first set of words, we distinguished between syllables containing (i) schwa and (ii) syllabic consonants. Examples of representative target words are given in (19).

(19) Examples of target words:
a. Word-final SCHWA: i. Robbe 'seal', Ente 'duck', Katze 'cat'
ii. Vogel 'bird', Löffel 'spoon', Garten 'garden'
b. Compound SCHWA: Badewanne 'bathtub', Apfelsaft 'apple juice'

Words were selected for inclusion if they were produced with no noise overlay, with reasonable vocal intensity, and if they occurred in phrase-final position (word-final SCHWA only). Because words containing word-final SCHWA were plentiful in the database, a maximum of 20–30 words per category (schwa vs. syllabic consonant) and per time period (1–4) were randomly selected for each child. Target words containing compound SCHWA were less frequent in the database. All such words produced during the designated time periods were included in the analysis. The final database consisted of 743 words with word-final SCHWA and 140 words with compound SCHWA.

4.1. Phonetic transcription, coding, and reliability

To determine schwa accuracy, we employ a narrow phonetic transcription which we assume reflects vowel quality (or spectral) differences. All target words were transcribed by a native speaker, who was told to pay particular attention to the vowel quality, length, and stress of the target unstressed syllable.

Since the transcription of SCHWA may pose difficulties, some discussion here is warranted. An exploratory transcription session with two native speakers of German indicated that children's production patterns for target schwa fell into five main categories: 1. reduplicated or deleted vowel; 2. full vowel (phonetically long); 3. full vowel (phonetically short); 4. centralized vowel; and 5. schwa, as illustrated by the example *Sonne* [ˈzɔnə] 'sun': 1. [ˈnɔnɔ] or [nɔn]; 2. [ˈzɔnɛː]; 3. [ˈzɔnɛ]; 4. [ˈzɔnɛ̈]; and 5. [ˈzɔnə]. Production patterns for target syllabic consonants included the following categories:[13] 1. reduplicated or deleted vowel; 2. full vowel + consonant; 3. full vowel (short); 4. centralized vowel + consonant; 5. schwa + consonant or syllabic consonant, as illustrated by the example *Apfel* [ˈʔapfl̩] 'apple': 1. [ˈʔaba] or [ʔap]; 2. [ˈʔapfɛːl] or [ˈʔapfɛl]; 3. [ˈʔapɛ]; 4. [ˈʔapfɛ̈l]; 5. [ˈʔapfəl] or [ˈʔapfl̩].[14] The most controversial category is that of 4, whereby both transcribers maintained that they frequently perceived a centralized vowel which could not yet be transcribed as a "true schwa". The diacritic associated with the vowel [ɛ], namely [ɛ̈], indicates a centralized full vowel which is heard as distinct from [ə]. We will discuss the importance of this production pattern later in the article. Note finally that, occasionally, children produced schwa for a target syllable containing a syllabic consonant, or they produced a syllabic sonorant for a target syllable containing schwa. These responses were classified as correct.

A subset of the data was retranscribed by a second native speaker. Percent agreement according to four categories (that is, excluding category 1: reduplicated or deleted vowels) was 70% (56/80); percent agreement according to the distinction "full vowel" versus "SCHWA" (categories 2–4 vs. 5) was 86% (69/80), and percent agreement according to the phonetic length of the unstressed vowel (category 2 vs. 3–5) was 93% (74/80). Although the reliability results for the four vowel categories are on the low side, it must be noted that transcription of vowel quality in unstressed syllables is notoriously difficult. Furthermore, the main emphasis of this study rests on the category "full vowel" versus "SCHWA", in which a reliability rate of greater than 80% was reached, and this is generally considered acceptable.

[13] We did not include syllabic /ʀ/ in our analyses because in many regions of Germany, it is vocalized as a central vowel (e.g., *Kater* [ˈkɑːtɐ] 'tom cat'). Our data indicate that vocalized /ʀ/ proceeded through different stages of acquisition from other target syllabic consonants: it was initially produced as the full vowel [a], and then later as [ɐ]. See Neef and Neugebauer (2002) for further justification of the different treatment of syllabic consonants /n, l/ versus vocalized /ʀ/.

[14] As will be seen later in discussion of the data, categories 3 and 4 were less frequently attested for target syllabic consonants. They are listed here to maintain consistency with the error patterns given for target schwa. Note as well that two types of error patterns are listed in category 2: a long vowel plus consonant and a short vowel plus consonant (e.g., [ˈʔapfɛːl] or [ˈʔapfɛl]). These patterns are grouped together because they were not systematic enough to divide into two distinct patterns. At this point in time, we leave the question open whether target syllabic consonants may be characterised by an additional stage in which the final syllable is produced as "super-heavy".

5. DATA

In this section, we present the main findings for word-final and compound SCHWA.

5.1. Longitudinal analysis of word-final SCHWA: All children

Analysis of the transcription findings revealed three main phases of SCHWA acquisition: 1. an early phase characterized by vowel reduplication or deletion; 2. a middle phase characterized by production of a full vowel (and coda consonant); and 3. a final phase characterized by production of a central vowel, schwa, or syllabic consonant. Note that these phases represent an approximation of the data; there was overlap between production patterns and forms characteristic of earlier and later phases co-occurred at any given time. We discuss phases of acquisition first for all children by referring to the five production categories outlined above, and then provide additional discussion of Bernd's patterns in section 5.2.

5.1.1. Early phase

The children displayed two main patterns in their earliest productions of target syllables containing SCHWA, namely, reduplication of the stressed vowel resulting in a bisyllabic production, and deletion of the target schwa syllable resulting in a monosyllabic production. Of these two patterns, the first was most frequent. Only one of the children (Marion) deleted the SCHWA syllable, whereas three of the children (Thomas, Bernd, and sometimes Marion) frequently reduplicated the stressed vowel at the earliest stages of word production (Thomas and Bernd at time point 1; Marion at time point 1 and INT). Britta was extremely precocious in her phonological development and never exhibited this early phase of SCHWA production. The percent production of category 1 patterns across the four age levels (as well as INT) is given in Figure 1 for target schwa and syllabic consonants.

Examples of schwa deletion and vowel reduplication are presented in (20a) and (20b), respectively.

(20) Early phase of SCHWA acquisition: Category 1

	Orthography	Target form	Child output	Gloss	Child and age
a.	Deletion of SCHWA:				
	Sonne	[ˈzɔnə]	[nanː]	‘sun’	Marion 1;5,3
	malen	[ˈmaːln̩]	[maɪ]	‘to paint’	Marion 1;5,3
	Apfel	[ˈʔapfl̩]	[ʔaːp]	‘apple’	Marion 1;5,24
b.	Reduplication of stressed vowel:				
	Jacke	[ˈjakə]	[ˈjaja]	‘jacket’	Marion 1;6,7
	Hose	[ˈhoːzə]	[ˈʔojo]	‘pants’	Marion 1;6,20
	Onkel	[ˈʔɔŋkl̩]	[ˈʔɔko]	‘uncle’	Thomas 1;6,16
	Apfel	[ˈʔapfl̩]	[ˈʔafa]	‘apple’	Thomas 1;7,1

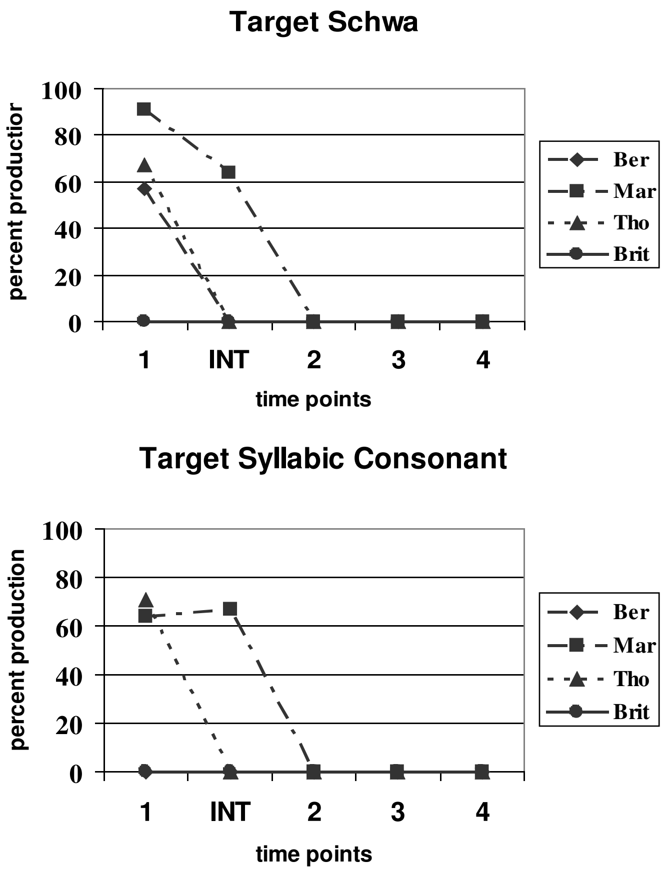


Figure 1: The percent production of category 1 patterns (reduplicated vowel and SCHWA deletion) across the four age levels (+ INT) for target schwa and syllabic consonants

5.1.2. Middle phase

The next phase in schwa development was substitution of the target schwa syllable by a phonetically long or short full vowel, or in the case of target syllabic sonorants, by a full vowel, or full vowel plus sonorant coda. The full vowel was different from the preceding stressed vowel and was almost always [ɛ]: 88% (126/144) of full vowel substitutions involved [ɛ]; the next most frequent full vowel substitution was [a] at 8% (11/144).[15] The percent production of categories 2 and 3 across the four age levels (as well as INT) is given in Figures 2 and 3 respectively for target schwa and syllabic consonants.

[15]These values are based on full vowel substitutions (categories 2–3) during the time points 2–4.

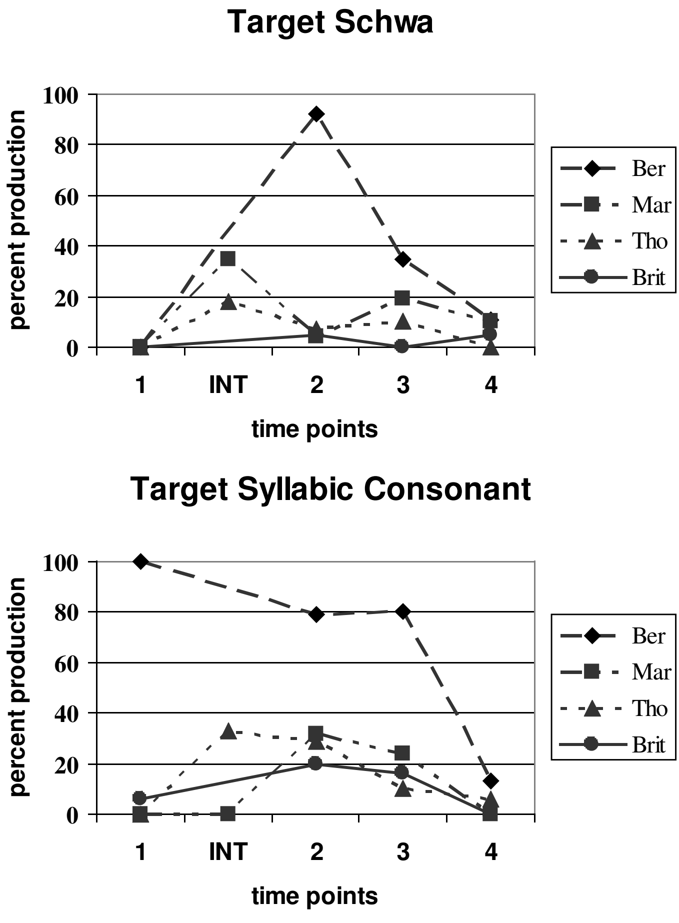


Figure 2: The percent production of category 2 patterns (long vowel or vowel + consonant) across the four age levels (+ INT) for target schwa and syllabic consonants

As can be observed from Figure 2, Bernd passed through a stage (time point 2 for target schwa; time points 1–3 for target syllabic sonorants) during which the majority of SCHWA syllables were produced as category 2 (i.e., production of long full vowel or vowel + consonant) (see section 5.2). In contrast, Britta displayed little tendency to produce target SCHWA as heavy. The other two children, Marion and Thomas, displayed behaviour that fell in between these two extremes. They showed a mild tendency to produce target schwa syllables as phonetically long at the Interim time point and to produce target syllabic consonants as full vowel plus consonant across several time points (INT, time points 2–3).

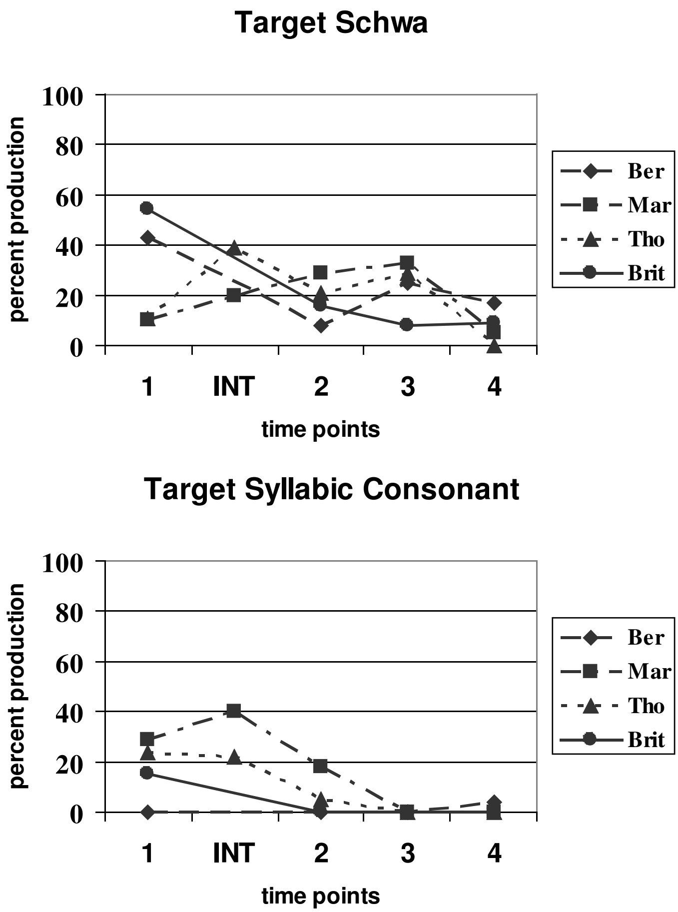


Figure 3: The percent production of category 3 patterns (short vowel) across the four age levels (+ INT) for target schwa and syllabic consonants

Turning to category 3 (production of short full vowel), Figure 3 shows that all children substituted target schwa syllables with a short full vowel. This was Britta's main production pattern. At time point 1, she produced 54% of target schwa syllables as short full vowels. Bernd also produced a high percentage of target schwa syllables as short at time point 1. However, this pattern could be interpreted as a variant of his reduplicated vowel pattern and should thus be seen as distinct from the short vowel substitutions present at time point 3. The difference between the vowel substitutions during these two phases was that the substituted vowels were variable in vowel quality at the earlier time point (e.g., [ɛ, æ, a]) whereas they were predominantly [ɛ] at the later time point.

Figure 3 also shows that target syllabic consonants were rarely produced as a short full vowel, except by Marion and Thomas at the earliest time points (time point 1 and INT). Again, this pattern could be interpreted as a variant of the reduplicated vowel pattern (category 1) rather than being akin to the short vowel substitutions observed for target schwa syllables at later time points: the substituted vowels were variable in quality ([a, e, o]) rather than being predominantly [ɛ]. Nevertheless, we present this production pattern for target syllabic consonants, so as to display the same sets of patterns for both types of SCHWA syllables.

Examples of category 2 and 3 error patterns are given in (21a) and (21b), respectively.

(21) Middle phase of SCHWA acquisition:

	Orthography	Target form	Child output	Gloss	Child and age
a.	Category 2: Substitution of full vowel (long) or full vowel plus consonant				
	(Erd)beere	[ˈbeːʀə]	[ˈbɛdæː]	‘(straw)berry’	Marion 1;9,1
	Tasche	[ˈtaʃə]	[ˈtasæː]	‘bag’	Thomas 1;9,0
	Kabel	[ˈkaːbl̩]	[ˈkaːpɛl]	‘cable’	Marion 1;10,19
	Trommel	[ˈtʀɔml̩]	[ˈtχɔmɛl]	‘drum’	Thomas 1;11,2
b.	Category 3: Substitution of full vowel (phonetically short)				
	Decke	[ˈdɛkə]	[ˈdætʰɛ]	‘blanket’	Marion 1;10,5
	Leute	[ˈlɔɪtə]	[ˈloɪtɛ]	‘people’	Thomas 1;11,2

5.1.3. *Final phase*

The final phase of SCHWA development was characterized by the production of a centralized vowel (+ consonant) (category 4) or by the production of schwa or syllabic consonant (category 5). The centralized vowel was most often transcribed as [ɛ̈], but occasionally, other vowels (e.g., œ̈, ʌ) were found. The percent production of categories 4 and 5 across the four age levels (as well as INT) is given in Figures 4 and 5 respectively for target schwa and syllabic consonants.

Again, we can observe some differences in the way schwa and syllabic consonants were realized. Figure 4 reveals that target schwa syllables were frequently produced as a centralized vowel at time points 2–4, whereas target syllabic consonants were less often realized in this way. Instead, as Figure 5 illustrates, target syllabic consonants were produced accurately by Marion and Thomas at the later time points and by Britta already at the earliest time point. By age 3;0, all children realized syllabic consonants with a mean accuracy of 95%, whereas they realized target schwa as schwa only 42% of the time (category 5) and as a central vowel 46% of the time (category 4). The difference between percent production of schwa and syllabic consonants at time points 3 and 4 was statistically significant (time point 3 – $\chi^2(1) = 8.38 p < .01$; time point 4 – $\chi^2(1) = 36.74 p < .001$). This finding may suggest that syllabic consonants are articulatorily easier to produce than schwa vowels (i.e., a phonetic rather than phonological difference), or that

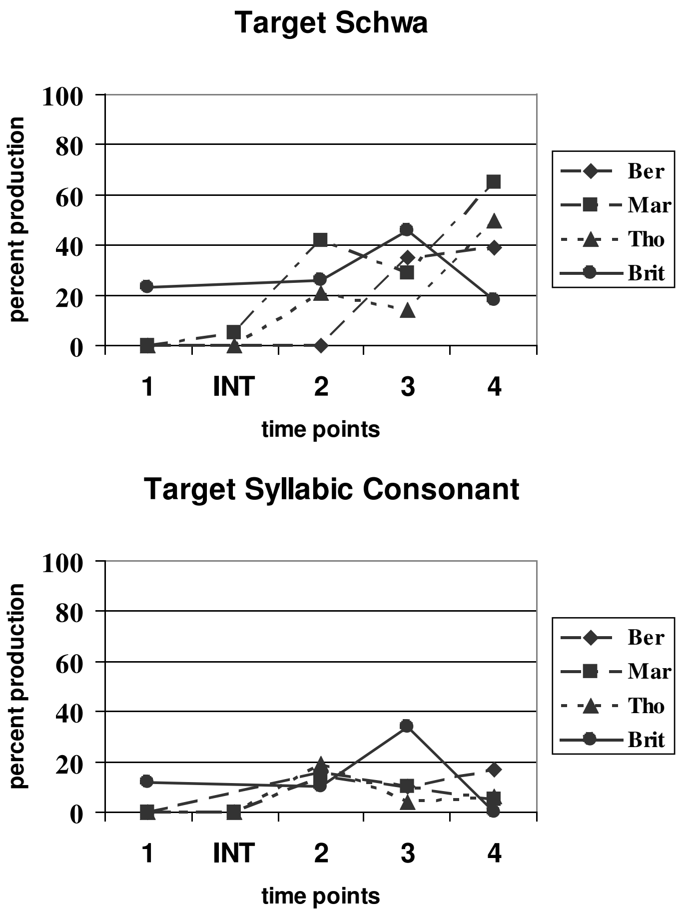


Figure 4: The percent production of category 4 patterns (centralized vowel or centralized vowel + consonant) across the four age levels (+ INT) for target schwa and syllabic consonants

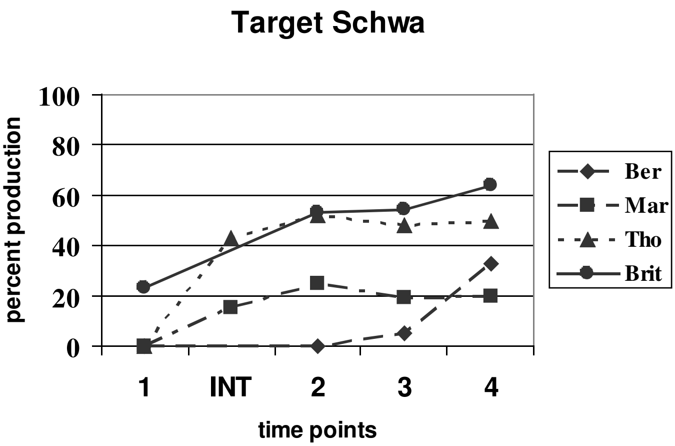
their phonological representation is acquired earlier than that of schwa. We will return to this issue in the discussion.

Examples of SCHWA realized as categories 4 and 5 are given in (22a) and (22b).

(22) Final phase of SCHWA acquisition:

	Orthography	Target form	Child output	Gloss	Child and age
a.	Category 4: Production of centralized vowel				
	Katze	[ˈkatsə]	[ˈkatsɛ̈]	‘cat’	Marion 2;4,26
	(nach)Hause	[ˈhaʊzə]	[ˈhaʊzɛ̈]	‘... home’	Thomas 2;5,10

. . .



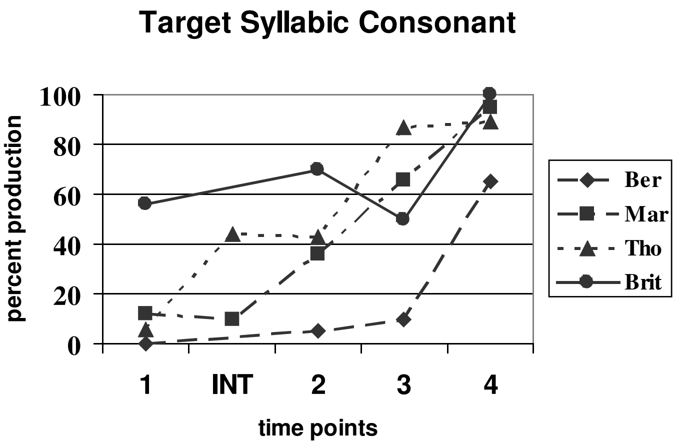


Figure 5: The percent production of category 5 patterns (schwa or syllabic consonant) across the four age levels (+ INT) for target schwa and syllabic consonants

b. Category 5: Production of schwa or syllabic consonant

essen	[ˈʔɛsn̩]	[ˈʔæːsn̩]	‘to eat’	Marion 2;3,25
Sonne	[ˈzɔnə]	[ˈzɔnə]	‘sun’	Marion 2;4,26
Wagen	[ˈvaːgn̩]	[ˈvagn̩]	‘wagon’	Thomas 2;4,13

5.2. Longitudinal analysis of word-final SCHWA: Bernd

Bernd’s production of SCHWA was somewhat different from the other children’s and, hence, will be discussed here in more detail. At time point 1 (onset to 1;8),[16]

[16] We extend time period 1 through to 1;08 for Bernd because he started producing words later than the other children.

Bernd, like the other children, reduplicated the stressed vowel or occasionally produced schwa as a short full vowel. He attempted target syllabic consonants only towards the end of this time period and they were produced as vowel plus consonant (e.g., *Brötchen* [ˈbʀøːtçn̩] → [ˈpʌtːiŋ] ‘breadroll’ 1;08,06). At the second time point (1;10 to 2;0), all target SCHWA forms were produced with the templatic form V + [n] (e.g., [in], [ɛn], [æn], [an]), regardless of whether the target syllable contained schwa only or a syllabic consonant (/n/ or /l/). Not only common nouns but also proper nouns (*Simone* [siˈmoːnə] [ʀaˈmoːnɛːn] girl’s name) were produced with this templatic syllable. Unstressed syllables containing full vowels were not subject to this pattern (*Oma* [ˈʔoːma] → [ˈʔoma] ‘grandmother’; *Auto* [ˈʔaʊto] → [ˈʔaʊto] ‘car’). At time point 3 (2;3–2;6), Bernd no longer used the templatic form; however, target SCHWA was frequently rendered heavy either by lengthening the vowel or by producing a vowel and consonant.[17] There were some quantitative differences, however, between the realization of target schwa and syllabic consonants. Target schwa syllables were also realized as a short full vowel (or centralized vowel) some of the time whereas target syllabic consonants were invariably produced as a full vowel plus consonant. Finally, at time point 4 (2;11–3;1), Bernd frequently realized SCHWA correctly (as schwa or syllabic consonant) although, in the case of target schwa syllables, he still occasionally substituted them with a full (or centralized) vowel. The full vowel was now phonetically short. Bernd’s patterns across the four time points are exemplified in (23).

(23) Bernd’s production patterns:

	Orthography	Target form	Child output	Gloss	Child and age
a.	Time point 1: Reduplication or substitution of short full vowel				
	danke	[ˈdankə]	[ˈdɛða]	‘thank you’	Bernd 1;6,10
	Flasche	[ˈflaʃə]	[ˈpaβæ]	‘bottle’	Bernd 1;6,10
	Brötchen	[ˈbʀøːtçn̩]	[ˈpʌtːiŋ]	‘breadroll’	Bernd 1;08,6
b.	Time point 2: Production of templatic syllable [V + n]				
	Ente	[ˈʔɛntə]	[ˈʔaːtan]	‘duck’	Bernd 1;10,23
	Puppe	[ˈpʊpə]	[ˈpʊpɛːn]	‘doll’	Bernd 2;0,23
	Esel	[ˈʔeːzl̩]	[ˈʔeːðæn]	‘donkey’	Bernd 1;10,20
c.	Time point 3: Substitution of full vowel (heavy syllable)				
	Puppe	[ˈpʊpə]	[ˈpʊpɛː]	‘doll’	Bernd 2;4,12
	Löwe	[ˈløːvə]	[ˈløbɛː]	‘lion’	Bernd 2;5,3
	Esel	[ˈʔeːzl̩]	[ˈʔeːdɛl]	‘donkey’	Bernd 2;5,3

. . .

[17] Acoustic analysis confirmed the phonetic transcription. Phonetically long vowels were typically 300ms long in comparison to short vowels which were 200ms long or less. One possibility is that the vowel lengthening effect was due to a phonetic tendency (e.g., phrase final lengthening). However, if this were the case, it would be difficult to explain why this was not seen more commonly across all tokens and time periods.

d. Time point 4: Full and reduced vowels

Ente	[ˈʔɛntə]	[ˈʔantɛ̈]	‘duck’	Bernd 3;0,30
Pilze	[ˈpɪltsə]	[ˈpɪːtsə]	‘mushroom’	Bernd 3;0,30
Augen	[ˈʔaʊgn̩]	[ˈʔaʊdn̩]	‘eyes’	Bernd 3;0,30

5.3. Analysis of compound SCHWA

Target words containing compound SCHWA appeared in the database later than target words containing final SCHWA, generally after the age of 1;10. All children, with the exception of Bernd, produced compound SCHWAs with a high degree of accuracy by age 1;10 to 2;0. SCHWA was occasionally produced as a full vowel, as shown in the examples in (24).

(24) Compound SCHWA: Full vowel substitutions

Orthography	Target form	Child output	Gloss	Child and age
Rasenmäher	[ˈʀaːzn̩ˌmɛːɐ̯]	[ˈʔazaˌha]	‘lawn-mower’	Thomas 1;10,4
Eisenbahn	[ˈʔaɪzn̩ˌbaːn]	[ˈʔaɪzeˌbanə]	‘railroad’	Thomas 1;11,2
Eisenbahn	[ˈʔaɪzn̩ˌbaːn]	[ˈʔadaˌβan]	‘railroad’	Bernd 1;11,20

SCHWA was also occasionally deleted, but most of these cases were segmentally conditioned, tending to occur when a syllabic consonant followed a sonorant onset (e.g., *Sonnenbrille* [ˈzɔnn̩ˌbʀɪlə] → [ˈzɔnˌpʀɪlə] ‘sunglasses’ Britta 2;1,14).

Table 1 compares the findings on word-final and compound SCHWA for the last three time periods. Accuracy scores are based both on category 4 and 5 error patterns (i.e., production of centralized vowel (+consonant) and/or production of schwa or syllabic consonant) and on target schwa and syllabic consonants combined. The findings suggest a tendency for SCHWA to be realized earlier in compound nouns, a pattern consistent with Levelt’s (2000) finding in Dutch. Levelt observed that phrase-medial schwa was realized earlier than phrase-final schwa. For example, Dutch children, after a period in which SCHWA was not produced in any position, passed through a stage in which they substituted final schwa with a full vowel, but produced medial schwa accurately (e.g., *kleine vlieger* /ˈklɛinəˈvlixər/ → [ˈtɛinəˈhɪχɑ] ‘small kite’ Noortje 2;8–2;8,24). Similarly, in our study, Bernd went through a period of producing word-final SCHWA as heavy, but producing compound SCHWA accurately (compare: *Purzel* [ˈpʊʀtsl̩] → [putˈtɛl] proper name vs. *Apfelsaft* [ˈʔapfl̩ˌzaft] → [ˈʔadəˌdaːp] ‘apple juice’ Bernd 2;3,22). Statistical analysis, however, indicated no significant difference in percentage scores between the two word positions at any of the three age levels (1;10–2;0: χ^2 (1) = 3.27 $p > .05$; 2;3–2;6: χ^2 (1) = 0.046 $p > 0.05$; 2;11–3;1: χ^2 (1) = 0.97 $p > 0.05$). Therefore, while we acknowledge that there may be some differences between the acquisition of schwa in different word or phrase positions, these effects were relatively subtle in our data. We thus leave a more indepth discussion of the effects of word or phrase position for later research.

Table 1: Comparison of schwa accuracy in word-final and compound SCHWA

Time points		Target SCHWA syllable: Word-final e.g., Ap<u>fel</u>		Target SCHWA syllable: Compound e.g., Ap<u>fel</u>saft	
2 (1;10–2;0)	Ber	26%	(8/31)	0%	(0/4)
	Mar	61%	(28/46)	88%	(7/8)
	Tho	72%	(36/50)	81%	(17/21)
	Brit	87%	(34/39)	100%	(9/9)
3 (2;3–2;6)	Ber	38%	(15/40)	69%	(22/32)
	Mar	67%	(28/42)	83%	(5/6)
	Tho	82%	(36/44)	50%	(7/15)
	Brit	88%	(51/58)	92%	(11/12)
4 (2;11–3;1)	Ber	80%	(33/41)	100%	(6/6)
	Mar	95%	(39/41)	89%	(8/9)
	Tho	97%	(37/38)	100%	(9/9)
	Brit	96%	(44/46)	100%	(9/9)

5.4. Presence of filler SCHWA

A final observation concerning SCHWA is that the children occasionally produced filler or epenthetic syllables containing SCHWA. They produced filler SCHWAs even during the phase in which they substituted target SCHWAs with full vowels (and consonants). Bernd's productions in (25) show that, in the same utterance, he produces target SCHWA with a full vowel but inserts a schwa syllable in word-initial position.

(25)

Orthography	Target form	Child output	Gloss	Child and age
Nudeln	[ˈnuːdl̩ n]	[ʔəˈnːuːnan]	'noodles'	Bernd 1;10,20
baden	[ˈbaːdn̩]	[ʔɐˈbaːtɛn]	'to bathe'	Bernd 1;10.20
Seife	[ˈzaifə]	[ʔəˈdadɪn]	'soap'	Bernd 1;11,25

6. PHONOLOGICAL ACCOUNT OF SCHWA ACQUISITION

The principal goal of this section is to provide a phonological account of SCHWA acquisition. If we consider the differences observed between schwa and syllabic consonants, the main data to be accounted for are summarized in Table 2.

In the case of target schwa syllables, these phases correspond to the categories 1 to 5, respectively; in the case of target syllabic consonants, as noted above, categories 3 and 4 were less often attested. The main differences between schwa and syllabic consonants can be further summarized in the following points: 1. target syllabic consonants were produced as heavy (i.e., category 2) for a longer period than target schwa syllables; 2. target syllabic sonorants were produced accurately

Table 2: Summary of SCHWA acquisition stages

Phases of acquisition		Target schwa *Puppe* [ˈpʊpə] 'doll'	Target syllabic consonant *Apfel* [ˈʔapfl̩] 'apple'	
Early	1.	[ˈpʊpʊ], [ˈpʊp]	[ˈʔapa], [ʔap]	All children
Middle	2.	[ˈpʊpɛː]	[ˈʔapɛl]	Bernd mainly
	3.	[ˈpʊpɛ]	[ˈʔapɛl]	All children
Late	4.	[ˈpʊpɛ̈]	[ˈʔapl̩]	All children
	5.	[ˈpʊpə]	[ˈʔapl̩]	All children

(i.e., as syllabic consonants) following the stage in which they were produced as heavy, whereas target schwa syllables were produced as a short full vowel following the stage during which they were produced as heavy; 3. in the latter stages of acquisition, target schwa syllables were often produced as a centralized vowel whereas target syllabic consonants were realized accurately.

6.1. Stages of acquisition

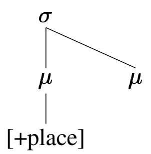
These stages will be discussed in more detail in the following subsections.

6.1.1. Early phase: Category 1

We interpret the earliest word attempts by all of the German children as being consistent with a bimoraic word maximum (see phonological accounts of this stage by Demuth and Fee 1995, Fee 1995, Demuth 1996). The children's productions of target words containing schwa consisted of either a closed monosyllable or a disyllable, the latter composed of a reduplicated vowel. In both situations, the schwa syllable was not attempted; only the stressed syllable was realized. In the cases where bimoraicity was reached by means of reduplication, the reduplicated syllable taking the place of the schwa syllable is a type of default strategy: the resulting vowel does not have any independent segmental specification, since its value is defined by copying. Thus, the representation in (26b) shows the moraic but not the segmental specification of the unstressed syllable (i.e., there is no place specification under the second mora).

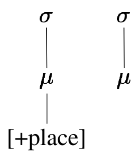
(26) Deletion of SCHWA and reduplication of stressed vowel:

a. Monosyllables:



[ʔaf] *Apfel* Marion 1;7,1
[dak] *Socke* Marion 1;7,1

b. Disyllables:



[no no] *Sonne* Marion 1;6,7
[ʔa fa] *Apfel* Thomas 1;7,1

6.1.2. Middle phase: Category 2

Bernd proceeded through two time points in which SCHWA syllables were produced as heavy. The other children tended to produce only target syllabic consonants as heavy. We refer to this pattern as moraic or prosodic augmentation. The moraic content of Bernd's productions (at time point 3) and of the other children's productions is illustrated in (27) and (28) respectively, where it is assumed that productions of long vowels or of vowel plus coda consonant are bimoraic.[18]

(27) Moraic augmentation: Bernd time point 3

a.

σ	σ
μμ	μμ
[+place]	[+place]
[ˈpʊ	pɛː]

Puppe 'doll'

b.

σ	σ
μμ	μμ
[+place]	[+place]
[ˈʔeː	dɛl]

Esel 'donkey'

(28) Moraic augmentation (target syllabic consonants): Other children

σ	σ
μμ	μμ
[+place]	[+place]
[ˈka	bɛl]

Kabel 'cable'

Note that moraic augmentation implies segmental augmentation since it wasn't schwa that was lengthened (or produced with a consonant); rather, a full vowel was produced. Thus, the vowel (and coda consonant) is shown to be segmentally specified by the notation "[+place]".

Bernd's templatic pattern (V + [n]) offers some evidence that SCHWA syllables formed a single class in this child's phonology because it was only target SCHWA and not other unstressed syllables that were subject to this pattern (compare *Oma* [ˈʔoːma] → [ˈʔoma] 'grandmother' vs. *Puppe* [ˈpʊpə] → [ˌpʊˈpɛn] 'doll'). Additional evidence that SCHWA syllables were rendered as heavy comes from the fact that, on several occasions, the unstressed syllable was produced with primary stress, as shown in (29).

[18]For purposes of simplicity, we indicate the segmental specification [+place] of the syllable nucleus only. The reader should keep in mind that the complete representation would include place specifications for all segments. As mentioned in the text, we also show the moraic specification of the stressed syllable as bimoraic (Féry 1995; Wiese 1996). This representation assumes acquisition of phonological vowel length and ambisyllabicity, features which are not the focus of the current study (see Kehoe and Lleó 2003, however, for more information on the acquisition of phonological vowel length in German).

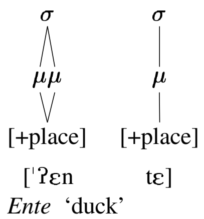
(29)

Orthography	Target form	Child output	Gloss	Child and age
Purzel	[ˈpʊʀtsl̩]	[ˌboˈdaːn]	proper name	Bernd 1;10,23
Puppe	[ˈpʊpə]	[ˌpʊˈpɛːn]	‘doll’	Bernd 2;0,23
Tasse	[ˈtasə]	[ˌtaˈtɛː]	‘cup’	Bernd 2;0,23

6.1.3. Middle phase: Category 3

Unlike Bernd, the other children did not pass through an extended period of producing target schwa syllables as heavy but, instead, frequently substituted a short full vowel for schwa. The same pattern was observed by Bernd at later stages of development. We refer to this phase as segmental augmentation. The substituted vowel is shown in (30) as monomoraic but specified for place.

(30) Segmental augmentation: All children



Whereas the moraic content of the unstressed vowel has not changed from the earlier to the middle phase (compare (26b) with (30)), the phonetic realization has changed: schwa is now realized most of the time as the full vowel [ɛ]. Thus, the vowel in (30) is shown to be specified as [+place], in constrast to (26b). The choice of [ɛ] as vowel may arise for phonological or phonetic reasons. Given the vowel system of German, [ə] distinguishes itself from [ɛ] only by the feature [+front]. Therefore, substitution of [ɛ] for schwa involves only a minimal change.[19] Furthermore, as argued by Wiese (1996), schwa is perceptually closer to the mid-front vowel [ɛ] than to the corresponding back vowels [o, ɔ].

6.1.4. Final phase: Category 4

All of the children at the final stages of schwa development frequently produced target schwa syllables as centralized full vowels. We may interpret this output pattern in one of two ways. The first is that the difference between schwa and a centralized vowel is simply one of phonetic implementation and not phonologically relevant. The second is that the difference is one of phonological representation. Under the No Mora account, [ɛ̈] would distinguish itself from [ə] by being moraic

[19]Note that in the Projection account (van Oostendorp 2000), schwa has no place specification, and thus, substitution of [ɛ] would involve more featural differences than the additon of [+front]. The choice of [ɛ] would then be conditioned by markedness rather than by featural similarity.

in contrast to schwa which would be nonmoraic; under the Projection account, [ɛ̈] would distinguish itself from [ə] by being segmentally specified in contrast to schwa which would be minimally specified, that is, specified for [−cons] only. The representation of the centralized vowel pattern is shown in (31).

(31) Representation of centralized vowel:

$$\begin{array}{c} \sigma \\ | \\ \mu \\ | \\ \text{[+place]} \\ \text{[ɛ̈]} \end{array}$$

[ɛ̈] would be further differentiated from the full vowel substitute [ɛ] by the additional specification of [+low].[20] We simplify the notation, however, by showing the specification [+place] only in (31).

In this analysis, we will argue that the centralized vowel pattern is phonologically distinct from schwa realization. If the centralized vowel were simply a phonetic variant of schwa, it would be difficult to explain why it was not attested in both target schwa and syllabic sonorants to a similar degree. As noted earlier, an output pattern containing a centralized vowel was a minor pattern for target syllabic consonants.[21] Furthermore, although it has been observed that some German dialects employ [ɛ̈] instead of [ə] in specific speech registers (Maas 1999:245), the children in this study were recorded in Hamburg, where target schwa is pronounced as [ə]. Thus, the expectation is that these children should eventually produce schwa.

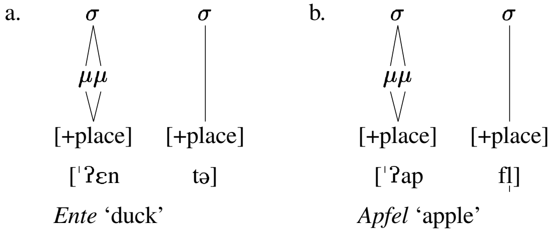
6.1.5. Final phase: Category 5

The final pattern for all children is the realization of target schwa syllables as schwa and target syllabic consonants as syllabic consonants. Under the No Mora account, we would now have the representation in (32), in which both schwa and syllabic consonants are non-moraic but specified for place.

[20] Note that [ɛ̈] has more featural specifications than [ɛ] ([+front, +low] vs. [+front], respectively). It is thus a challenge to determine why children add rather than remove place features in their development of schwa, given that their ultimate goal is to produce a maximally unspecified vowel. We assume that vowel development is characterized by the acquisition of finer vocalic distinctions. Once a feature is acquired, children will tend to use it to represent other sounds that they are acquiring. This may partly explain the tendency for children at intermediate stages in development to produce a more rather than less specified vowel.

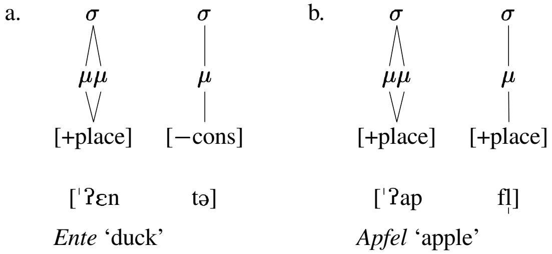
[21] The only exception to this trend is Britta who, at time point 3, produced approximately 30% of target syllabic consonants with a central vowel + consonant.

(32) Representation of SCHWA: No Mora account



Under the Projection account, we would have the representation in (33), in which schwa and syllabic consonants are represented differently.

(33) Representation of SCHWA: Projection account



In this view, both schwa and syllabic consonants are moraic, but while syllabic consonants remain segmentally specified, schwa is only minimally specified, as [−cons].

6.2. Processes of vowel reduction

In this section, we evaluate the two approaches to schwa representation employing the German child data. We will conceptualize the acquisition of SCHWA in terms of two reduction processes: quantitative reduction and qualitative reduction. Quantitative reduction involves loss of a mora rendering heavy syllables monomoraic. Qualitative reduction involves detachment of the vowel place feature from the root node resulting in a placeless vowel. Such reduction processes have been discussed in the diachronic literature when accounting for the change from full vowels in Old High German to schwa in Middle High German (Löhken 1997). The two forms of reduction are illustrated in (34).

(34) a. Quantitative reduction: b. Qualitative reduction:

The figures in (34) are adapted from Löhken (1997:170). “σ_{w}” refers to an unstressed syllable and the bracketing indicates the detached element.

The first two phases of SCHWA acquisition receive similar interpretations under the No Mora and Projection accounts. Target SCHWA syllables are substituted by segments which are both prosodically and segmentally specified. These phases are schematized in (35).

(35) Early and middle phases of SCHWA acquisition:

		Target schwa		Target syllabic consonants	
		Puppe [ˈpʊpə] 'doll'		*Apfel* [ˈʔapfl̩] 'apple'	
a.	Early	Initial representation (category 1)			
		σ	σ	σ	σ
		μ	μ	μ	μ
		[pʊ	pʊ]	[ʔa	pa]
b.	Middle	Bernd: Moraic and segmental augmentation (category 2)			
		σ	σ	σ	σ
		μμ	μμ	μμ	μ μ
		[+place]	[+place]	[+place]	[+place]
		[ˈpʊ	pɛː]	[ˈʔap	fɛl]
c.	Middle	Other children: Moraic and/or segmental augmentation (category 3 — schwa; category 2 — syllabic consonants)			
		σ	σ	σ	σ
		μμ	μ	μμ	μμ
		[+place]	[+place]	[+place]	[+place]
		[ˈpʊ	pɛ]	[ˈʔap	fɛl]

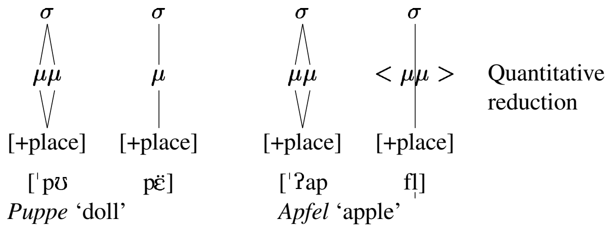
The early phase represents the initial state in which SCHWA syllables are represented as monomoraic (35a). We do not consider the minority pattern of SCHWA deletion here, which was only attested in Marion's outputs. The middle phase (35b) illustrates moraic (and segmental) augmentation by Bernd in which both target schwa and target syllabic consonants were augmented to two moras. The middle phase (35c) illustrates moraic (and/or segmental) augmentation for the other children in which target syllabic consonants were augmented to two moras and target schwa syllables were segmentally augmented to a full vowel. Quantitative reduction (loss of mora as in (34a)) then applies to Bernd's target schwa syllables resulting in the realization of schwa syllables as monomoraic.

The last phase of SCHWA acquisition receives differing interpretations under the two accounts. Under the No Mora account, in order to acquire SCHWA, children must acquire an additional weight distinction (i.e., moraic vs. non-moraic). Under the Projection account, by contrast, children do not need to acquire a new prosodic distinction; rather, they must learn to associate a minimally specified segment to a prosodic position. However, the minimally specified segment refers to schwa only and not to syllabic consonants, as the latter are specified for place. We now discuss the last two phases of acquisition in more detail.

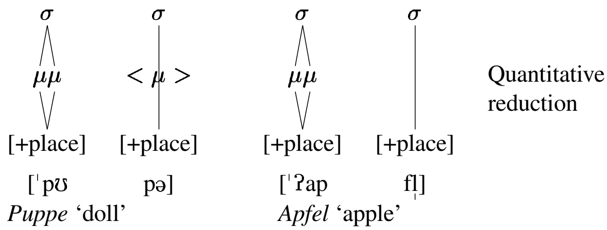
The representation of the final phase of SCHWA acquisition under the No Mora account is given in (36).

(36) Final phase of SCHWA acquisition: No Mora account

a. Centralized vowel and syllabic consonants:



b. Schwa and syllabic consonants:



In the first part of the final phase (36a), target schwa syllables are produced as centralized vowels whereas target syllabic consonants are realized accurately. This means that the representation of target schwa syllables remains similar to that of the previous stage (i.e., they are specified both moraically and segmentally, with minor featural differences), whereas target syllabic consonants are now realized as non-moraic. Under this view, quantitative reduction has applied to target syllabic consonants but not to target schwa syllables. Furthermore, target syllabic consonants have proceeded directly from a phase in which they were realized as bimoraic to a phase in which they are realized as non-moraic. In the second part of the final phase (36b), quantitative reduction applies to target schwa syllables resulting in both types of SCHWA being non-moraic.

The representation of the final phase of SCHWA acquisition under the Projection account is shown in (37).

(37) Final phase of SCHWA acquisition: Projection account

a. Centralized vowel and syllabic consonants:

σ	σ	σ	σ	
μμ	μ	μμ	μ < μ >	Quantitative reduction
[+place]	[+place]	[+place]	[+place]	
[ˈpʊ	pɛ̈]	[ˈʔap	fl̩]	

Puppe 'doll' *Apfel* 'apple'

b. Schwa and syllabic consonants:

σ	σ	σ	σ	
μμ	μ	μμ	μ	Qualitative reduction
[+place]	<[+place]>	[+place]	[+place]	
	[−cons]			
[ˈpʊ	pə]	[ˈʔap	fl̩]	

Puppe 'doll' *Apfel* 'apple'

In the first part of the final phase (37a), quantitative reduction applies to target syllabic consonants. In contrast to the No Mora account, however, the reduction process removes one mora (not two) since syllabic consonants are moraically specified. Given this, one may wonder why a consonantal rather than a vocalic mora remains (i.e., why [ʔapl̩] and not [ʔapɛ]). Here we must assume that faithfulness constraints between segments in the child's input (i.e., adult production [ˈʔapfl̩]) and output outweigh markedness constraints relating to whether vocalic versus consonantal elements appear in the nucleus. In the second part of the final phase (37b), all SCHWA syllables are realized accurately. Qualitative reduction now applies to target schwa syllables resulting in the removal of place features. The root node specified as [−cons] still remains. Target syllabic consonants are represented as they were at the previous phase; that is, they are specified both moraically and segmentally.

6.3. Comparison of the No Mora versus Projection accounts

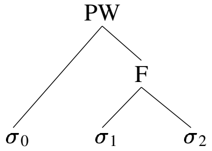
We now examine which of the two approaches to schwa representation best accounts for the German child data, taking into consideration not only the development of schwa and syllabic consonants but also the presence of filler SCHWA (see earlier (25)). The preceding discussion suggests that the Projection account provides a superior account of the findings. First, it explains why syllabic consonants are realized earlier than schwa. Syllabic consonants are marked elements, in the sense that a consonantal element occupies a nuclear position; however, they are specified for place. In contrast, schwa is not specified for place. Learning to associate a placeless segment to a prosodic position creates considerable difficulties in acquisition accounting for a long period in which schwa is realized as a full vowel, that is, as a vowel with place features. The No Mora account is unable to explain the different acquisition schedule of schwa versus syllabic consonants because both segments are represented similarly.

Associated with this argument, the stages in acquisition documented in this study are also difficult to explain under the No Mora account. Why do target syllabic consonants proceed directly from being bimoraic (category 3) to being non-moraic (category 5)? This reduction process appears abrupt and entirely unmotivated. In contrast, under the Projection account, reduction processes apply gradually. Quantitative reduction (loss of one mora) applies first to target schwa syllables (Bernd mainly), then to target syllabic consonants, and finally, qualitative reduction (loss of place features) applies to target schwa syllables. The sequence of qualitative reduction following quantitative reduction parallels the emergence of target schwa syllables in diachronic change (Löhken 1997).

A second major argument in favour of the Projection account relates to the presence of filler SCHWA. As we saw above in (25), filler syllables containing SCHWA are frequently attested in early child speech. Bernd substituted target SCHWAs with full vowels (+consonant) but inserted filler SCHWAs in word initial position (e.g., *Nudeln* [ʔəˈnːuːnan] ‘noodles’ Bernd 1;10,20). These examples present us with a paradox, because it is difficult to explain why target SCHWAs pose difficulty for some children, whereas at the same time, filler SCHWAs do not. Interestingly, Bernd, who had the most difficulty learning SCHWA, was also the child who produced the greatest number of filler SCHWAs. Bernd’s preferred prosodic structure was a trochee, in which both syllables had to be associated to segmentally specified positions. A filler syllable, being outside the trochee, is extraprosodic,[22] and it is, thus, filled by the least marked segment, one specified for [−cons] only. Such fillers typically contain a single schwa or are preceded by a laryngeal. The latter constitutes the consonantal counterpart of schwa, the minimal consonantal segment, devoid of [+place]. According to the PROJECT constraints applied to the syllable domain (see (5)–(6) above), the filler syllable is a defective syllable lacking a “P” (Prosodic position) and, thus, it can consist of a placeless vowel, preceded or not by a defective onset, as illustrated in (38). In short, the syllable is defective at both the prosodic and segmental levels.

[22] We use the term extraprosodic for convenience. In actual fact, the syllable is linked to the Prosodic Word, but it is weakly layered (or incurs a violation of EXHAUSTIVITY), as illustrated in (38) in the text.

(38)



Syllables σ_1 and σ_2 require full vowels in the children's systems at the earliest stages, whereas σ_0 can only be associated with [−cons]. In acquiring schwa, it is the mismatch between prosodic and segmental structure, the former normally specified and the latter defective, which constitutes the greatest difficulty for children. Children must learn that it is possible to associate a defective segment (schwa) with a non-defective prosodic position (i.e., σ_1, σ_2) and this association may take some time. In contrast, associating a defective segment with a defective prosodic position does not take time, as in the case of filler SCHWA.

It is precisely the contrast that children seem to establish between target and filler SCHWA that poses difficulty for the non-moraic treatment of SCHWA. According to the non-moraic analysis, both types of schwa constitute defective segments, lacking prosodic positions (moras), and their acquisition requires the reduction processes we have seen above. There is no principled reason for the fact that in unfooted position (i.e., σ_0 in (38)), schwa can be produced by some children, although it is not present in the target language, whereas in footed position, schwa is not produced, even though it is present in the target language. Such a distinction argues against an undifferentiated treatment of these two types of schwa, as in the non-moraic analysis.

6.4. Outstanding issues

The preceding analysis poses some immediate questions. One is why Bernd proceeded through an extended period of making all SCHWA syllables heavy. A second question is why the other children did not. Concerning the first question, Bernd's initial strategy may have been one of assuming that all syllables are bimoraic. This is a reasonable assumption given the prosody of German: stressed syllables and word-final unstressed syllables are minimally bimoraic (Féry 1995). However, by assuming a bimoraic constraint in Bernd's phonology, we are also ascribing to Bernd some knowledge of moraic contrast. Additional analyses show that by the beginning of Bernd's heavy schwa phase (1;10–2;0), he has already acquired a distinction between long and short vowels (Kehoe and Lleó 2003) suggesting that the necessary moraic distinction is already available to him. Examples of near minimal pairs are provided in (39).

(39) Productions of target long and short vowels by Bernd:

Orthography	Target form	Child output	Gloss	Child and age
Sieb	[ziːp]	[diːp]	'sieve'	Bernd 1;11,25
Schiff	[ʃɪf]	[tɪt]	'ship'	Bernd 1;11,25
Buch	[buːχ]	[buːχ]	'book'	Bernd 2;0,23
Bus	[bʊs]	[bʊs]	'bus'	Bernd 2;0,23

In the case of SCHWA, because the production of a short lax vowel (i.e., [ɛ]) will not satisfy the bimoraic constraint, Bernd produces either an additional consonant or a long vowel in order to satisfy this constraint. It is not clear why Bernd initially chooses V + [n] as a templatic syllable. This may reflect some initial hypothesis formation on his part whereby the frequency of V + [n] syllables in the ambient language leads him to overgeneralize this pattern. In addition, Bernd's choice of [n] is consistent with this segment being the preferred coda cross-linguistically.

Concerning the second question, analysis of several areas of phonological development (especially segmental) show that Bernd is delayed relative to the other German children in this study. We may interpret Bernd's slower pace in one of two ways, either that his system represents a minority pattern in acquisition or that it represents a majority pattern, which is slowed down relative to other children. The latter is akin to Fikkert and Penner's (1998) notion of "prosodic stagnation", in which they observe that some children dwell longer at certain stages but nevertheless provide evidence for the normal processes of acquisition. Some evidence for this view comes from examining the production patterns of the other children alongside those of Bernd. The patterns form three main groups: 1. an extreme pattern for Bernd in which the majority of errors (at 1;10) were heavy syllables; 2. a middle pattern for Marion and Thomas in which approximately 20–30% of syllables (at 1;8) were produced as heavy; and 3. a low pattern for Britta, in which there was little tendency for target schwa to be produced as heavy. These findings suggest that Bernd's system does not reflect a minority pattern but, rather, that it represents the extreme (or "stagnated") case of a tendency that is seen in other children as well. That is, all children acquiring German may, to a greater or lesser degree, pass through a stage in which target schwa syllables are produced as heavy. We believe this pattern arises because there are two types of unstressed syllables in German, bimoraic and SCHWA, the latter being defectively monomoraic. Accordingly, children may initially be "misled" to produce target schwa syllables as bimoraic.

7. CONCLUSION

The analysis of SCHWA by four German-speaking children from the onset of word production to 3;1 has shown that SCHWA, in spite of its lack of phonetic specification, is a difficult sound for some children, not being learned until about 2;3–2;6. Children acquiring German go through several stages before they produce schwa in a targetlike manner. We have argued that the development of SCHWA through these different stages, especially the tendency of all children to substitute SCHWA by a full vowel (+consonant), can best be accounted for by the Projection Theory of van Oostendorp (2000). According to this theory, schwa violates a projection constraint with scope over syllables. This markedness constraint, which requires that only specified segments project to prosodic positions, is initially highly ranked in children's phonologies.

A comparison of this approach with the non-moraic treatment of SCHWA reveals the superiority of the Projection account on the basis of the child language data. Children acquire syllabic consonants earlier than schwa. This is consistent with there being two different representations for syllabic consonants and schwa, the former being specified for place. Children also make a distinction between two types of schwa — target and filler SCHWA — a distinction that the non-moraic approach is unable to make. Another pattern, in which schwa is substituted by a long full vowel, is especially long-lasting in one child who, in addition to producing long vowels, also substitutes SCHWA by a full short vowel followed by a nasal consonant. This solution indicates that this child needs more time to acquire SCHWA, because he has acquired another aspect of German prosody, the fact that German syllables are minimally bimoraic. A syllable with a single mora is not sufficient, because the bimoraicity constraint compels him to moraic augmentation of SCHWA.

Bernd's development is interesting in a further sense. Impressionistically, his development was slow. This impression, however, was based on segmental development, where he advanced slowly as regards place of articulation in consonants. It could be argued that his prosodic development was targetlike and relatively fast. When assessing pace in acquisition, both aspects — prosodic and segmental development — should be taken into consideration. In other studies on Spanish-speaking children, a mismatch between these two aspects of development has also been pointed out (Lleó 1996, 2002): one child, José, produced long words very early but was not advanced in the acquisition of place features; another child, Miguel, truncated words for a long period, but developed place contrasts very early. Mismatches of this type furnish support for the need for analyses of child phonology which are based on multilayered representations. In terms of the theme of the current volume, "segmental/prosodic interaction", SCHWA provides convincing evidence that vocalic feature composition and prosodic structure are different but related levels of representation (van Oostendorp 2000).

The protracted acquisition of a sound that by phonetic criteria should be very simple makes clear that more than phonetics is involved in segmental acquisition. Without denying the importance of taking phonetics into consideration, child language data show that phonological representation, prosodic as well as segmental, plays an essential role. In fact, it is the interaction between these two levels of structure, prosodic and segmental, that plays a decisive role in development from the initial to target language states.

REFERENCES

Allen, George, and Sarah Hawkins. 1978. The development of phonological rhythm. In *Syllables and segments*, ed. Alan Bell and Joan B. Hooper, 173–185. Amsterdam York: North Holland.

Becker, Thomas. 1998. *Das Vokalsystem der deutschen Standardsprache*. Frankfurt am Main: Peter Lang Gmbh.

Browman, Catherine, and Louis Goldstein. 1992. "Targetless" schwa: an articulatory analysis. In *Papers in Laboratory Phonology* II: *Gesture, Segment, Prosody*, ed. Gerald Doherty, Robert Ladd, Mary Beckman, and John Kingston, 26–56. Cambridge: Cambridge University Press.

Davis, Barbara, and Peter MacNeilage. 1990. Acquisition of correct vowel production: A quantitative case study. *Journal of Speech and Hearing Research* 33:16–27.

Delattre, Pierre. 1965. *Comparing the phonetic features of English, German, Spanish and French: An interim report*. Heidelberg: Julius Groos.

Demuth, Katherine. 1996. Alignment, stress and parsing in early phonological words. In *Proceedings of the UBC International Conference on Phonological Acquisition*, ed. Barbara Bernhardt, John Gilbert, and David Ingram, 113–124. Somerville: Cascadilla Press.

Demuth, Katherine, and E. Jane Fee. 1995. Minimal words in early phonological development. Ms., Brown University and Dalhousie University.

Fee, E. Jane. 1995. Segments and syllables in early acquisition. In *Phonological acquisition and phonological theory*, ed. John Archibald, 43–61. Hillsdale: Lawrence Erlbaum.

Féry, Caroline. 1995. Alignment, syllable, and metrical structure in German. Seminar für Sprachwissenschaft. SFS-Report-02-95.

Féry, Caroline. 2000. Phonologische und graphematische Silbenanstze. Paper presented at the Deutsche Gesellschaft für Sprachwissenschaft (DGfS), Marburg.

Féry, Caroline. 2002. Nonmoraic syllables in German. In *The syllable in Optimality Theory*, ed. Caroline Féry and Ruben van de Vijver, 213–237. Cambridge: Cambridge University Press.

Fikkert, Paula. 1994. *On the acquisition of prosodic structure*. Dordrecht: Holland Institute of Generative Linguistics.

Fikkert, Paula, and Zvi Penner. 1998. Stagnation in prosodic development of language-disordered children. In *Proceedings of the 22nd Annual Boston University Conference on Language Development*, ed. Annabel Greenhill, Mary Hughes, Heather Littlefield, and Hugh Walsh, 201–212. Somerville: Cascadilla Press.

Fischer-Jørgensen, Eli. 1969. Untersuchungen zum sogenannten losen und festen Anschluss. In *Kopenhagener Germanistische Studien* 1. *Peter Jørgensen zu seinem 70 Geburtstag am 12.9.1969 gewidmet*, ed. Karl Hyldgaard-Jensen and Steffen Steffensen, 138–164. Kopenhagen: Akademisk Forlag.

Goad, Heather. 2002. Markedness in right-edge syllabification: parallels across populations. *Canadian Journal of Linguistics* 47:151–186.

Hall, Tracy Alan. 1992. Syllable final clusters and schwa epenthesis in German. In *Silbenphonologie des Deutschen*, ed. Peter Eisenberg, Karl Heinz Ramers, and Heinz Vater 208–245. Tübingen: Gunter Narr Verlag.

Hall, Tracy Alan. 2002a. Against extrasyllabic consonants in German and English. *Phonology* 19:33–75.

Hall, Tracy Alan. 2002b. The distribution of superheavy syllables in standard German. *The Linguistic Review* 19:377–420.

Hammond, Michael. 1997. Vowel quantity and syllabification in English. *Language* 73:1–17.

Jensen, John. 2000. Against ambisyllabicity. *Phonology* 17:187–235.

Kager, René. 1989. *A metrical theory of stress and destressing in English and Dutch*. Dordrecht: Foris Publication.

Kager, René, and Wim Zonneveld. 1986. Schwa, syllables, and extrametricality in Dutch. *The Linguistic Review* 5:197–221.

Kehoe, Margaret. 2002. The acquisition of unstressed syllables in monolingual and bilingual children with a particular focus on reduced syllables. Paper presented at the Deutsche Gesellschaft für Sprachwissenschaft (DGfS), Mannheim.

Kehoe, Margaret, and Conxita Lleó. 2003. The acquisition of nuclei: A longitudinal analysis of phonological vowel length in three German-speaking children. *Journal of Child Language* 30:527–556.

Kehoe, Margaret, and Carol Stoel-Gammon. 2001. Development of syllable structure in English-speaking children with particular reference to rhymes. *Journal of Child Language* 28:393–432.

Kloeke, Wus van Lessen. 1982. *Deutsche Phonologie und Morphologie: Merkmale und Markiertheit*. Tübingen: Niemeyer.

Koopmans-van Beinum, Florien. 1994. What's in a schwa? Durational and spectroanalysis of natural continuous speech and diphones in Dutch. *Phonetica* 51:68–79.

Levelt, Clara. 2000. Schwa-schma: The development of /ə/ in Dutch child language. Paper presented to the 16th IATL conference, Tel Aviv.

Lindblom, Björn. 1963. Spectrographic study of vowel reduction. *Journal of the Acoustical Society of America* 35:1773–1781.

Lleó, Conxita. 1996. To spread or not to spread: different styles in the acquisition of Spanish phonology. In *Proceedings of the UBC International Conference on Phonological Acquisition*, ed. Barbara Bernhardt, John Gilbert, and David Ingram, 215–228. Somerville: Cascadilla Press.

Lleó, Conxita. 2001a. The transition from prenominal fillers to articles in Spanish and German. In *Proceedings of the 8th Conference of the International Association for the Study of Child Language: Research on child language acquisition* , ed. Margareta Almgren, Andoni Barrena, María-José Ezeizabarrena, Itziar Idiazabal, and Brian MacWhinney. Somerville: Cascadilla Press, CD-ROM edition.

Lleó, Conxita. 2001b. Determining the acquisition of determiners: On the innateness of functional categories. In *Features and interfaces in Romance: Essays in honor of Heles Contreras*, ed. Julia Herschensohn, Enrique Mallén and Karen Zagona, 189–202. Amsterdam: John Benjamins.

Lleó, Conxita. 2002. The role of markedness in the acquisition of complex prosodic structures by German-Spanish bilinguals. *International Journal of Bilingualism* 6:291–313.

Löhken, Sylvia. 1997. *Deutsche Wortprosodie. Abschwächungs und Tilgungsvorgänge*. Tübingen: Stauffenburg.

Lohuis-Weber, Heleen, and Wim Zonneveld. 1996. Phonological acquisition and Dutch word prosody. *Language Acquisition* 5:245–283.

Low, Ee Ling, Esther Grabe, and Francis Nolan. 2001. Quantitative characteristics of speech rhythm: Syllable timing in Singapore English. *Language and Speech* 43:377-401.

Maas, Utz. 1999. *Phonologie*. Opladen, Wiesbaden: Westdeutscher Verlag.

Moulton, William G. 1956. Syllabic nuclei and final consonant clusters in German. In *For Roman Jakobson*, ed. Morris Halle, Horace G. Lunt, Hugh McLean, and Cornelis van Schooneveld, 372–381. The Hague: Mouton.

Nittrouer, Susan. 1993. The emergence of mature gestural patterns is not uniform: Evidence from an acoustic study. *Journal of Speech and Hearing Research* 36:959–972.

Neef, Martin, and Moritz Neugebauer. 2002. Beschränkte Korrespondenz: Zur Alternation von Schwa und silbischen Sonoranten im Deutschen. *Zeitschrift für Sprachwissenschaft* 21:234–261.

Paradis, Carole, and Jean-François Prunet, eds. 1991. *The special status of coronals: Internal and external evidence*. San Diego: Academic Press.

Peters, Ann. 2001. Filler syllables: What is their status in emerging grammar? *Journal of Child Language* 28:229–242.

Peters, Ann, and Lise Menn. 1993. False starts and filler syllables: Ways to learn grammatical morphemes. *Language* 69:742–777.

Piggott, Glyne. 1999. At the right edge of words. *The Linguistic Review* 16:143–185.

Ramers, Karl-Heinz. 1992. Ambisilbische Konsonanten im Deutschen. In *Silbenphonologie des Deutschen*, ed. Peter Eisenberg, Karl-Heinz Ramers, and Heinz Vater, 246–283. Tübingen: Narr.

Rose, Yvan. 2000. Headedness and prosodic licensing in the L1 acquisition of phonology. Doctoral dissertation, McGill University.

Stoel-Gammon, Carol, and Paula Herrington. 1990. Vowel systems of normally developing and phonologically disordered children. *Clinical Linguistics and Phonetics* 4:145–160.

Taelman, Helena, and Steven Gillis. 2001. Variation in children's early production of multisyllabic words: The case of truncations. In *Proceedings of ELA 2001*, ed. Sophie Kern. Université Lumière, Lyon 2. CD-ROM.

Van Oostendorp, Marc. 1995. Vowel quality and phonological projection. Doctoral dissertation, Tilburg University. [ROA-84-000.]

Van Oostendorp, Marc. 1998. Schwa in phonological theory. *GLOT International* 3:3–8.

Van Oostendorp, Marc. 2000. *Phonological projection: A theory of feature content and prosodic structure*. Berlin: Mouton De Gruyter.

Veneziano, Edy. and Hermine Sinclair. 2000. The changing status of "filler syllables" on the way to grammatical morphemes. *Journal of Child Language* 27:461–500.

Vennemann, Theo. 1991. Syllable structure and syllable cut prosodies in Modern Standard German. In *Certamen Phonologicum* II: *Papers from the Cortona Phonology Meeting*, ed. Piermarco M. Bertinetto, Michael Kenstowicz, and Michele Loporcaro, 211–243. Turin: Rosenberg and Sellier.

Wiese, Richard. 1988. *Silbische und lexikalische Phonologie: Studien zum Chinesischen und Deutschen*. Tübingen: Niemeyer.

Wiese, Richard. 1996. *The phonology of German*. Oxford: Clarendon Press.

Wurzel, Wolfgang. 1970. *Studien zur Deutschen Lautstruktur*. Berlin: Akademie-Verlag.