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Alignment and the distribution of German [ç] and [x]*

1 Introduction

This paper examines the distribution of the dorsal fricatives [ç] and [x] in Modern Standard German (MSG) within Optimality Theory (OT) (Prince & Smolensky 1993, McCarthy & Prince 1993a). The velar fricative [x] results from assimilation to a preceding back vowel, while the palatal fricative [ç] occurs elsewhere. Dorsal fricative assimilation does not apply in compounds or to the initial dorsal fricative of the diminutive suffix *-chen* which, though morphologically a suffix, is prosodically a separate phonological word of German (Iverson & Salmons 1992, Wiese 1996). This paper argues that dorsal fricative assimilation is constrained by CRISPEDGE (PrWd) which requires the prosodic word to have sharply-defined boundaries (Itô & Mester in press). I argue that spreading from a word-final back vowel to the initial dorsal of the following word results in a non-crisp word edge and so is ruled out, because CRISPEDGE (PrWd) ranks higher than the constraint governing spreading.

The paper is structured as follows: Section 2 introduces the data and reviews their treatment within the model of lexical phonology (Kiparsky 1982, 1985). Special emphasis is placed on the interaction of the rule of fricative assimilation and umlaut. Section 3.1 provides an account of the distribution of [ç] and [x] within the pre-correspondence version of Optimality Theory (McCarthy & Prince 1995). In that section I show that [x] is optimal after a back vowel and [ç] elsewhere, regardless of what assumptions we make about the underlying representation of the dorsal fricative, thus supporting Itô, Mester & Padgett's (1995) contention that underspecification is not a requirement on input forms in OT. Section 3.2 addresses the non-application of dorsal fricative assimilation in compounds and in diminutive constructions. In that section I argue that dorsal fricative assimilation is constrained by CRISPEDGE (PrWd). Independent support for the relevance of this constraint is provided from syllabification processes of German. Section 4 concludes.

2 Lexical phonology and the distribution of [ç] and [x] in MSG

Examples (1) demonstrate the complementary distribution of the palatal and velar fricative in MSG. The velar fricative [x] occurs only after a back vowel, while the palatal fricative [ç] is found after either a front vowel or a sonorant consonant.[1] These examples illustrate further that the distribution of these segments is independent of their syllabic position. The dorsal fricative can be either in the same syllable as the preceding vowel or form the onset of the next following syllable.

(1)

[x] after a non-low back vowel			[ç] elsewhere		
Buche	[bu:.xə]	'(s/he) searched'	riechen	[ʀi:.çən]	'to smell'
suchte	[zu:x.tə]	'(s/he) searched'	Nichte	[nɪç.tə]	'niece'
Knochen	[knɔ.xən]	'bone'	sprechen	[ʃpʀɛ.çən]	'to speak'
lochte	[lɔx.tə]	'(s/he) made a hole'	Rechte	[ʀɛç.tə]	'rights'
Sprache	[ʃpʀa:.xə]	'language'	durch	[dʊʀç]	'through'
machte	[max.tə]	'(s/he) made'	Dolche	[dɔl.çə]	'swords'
			manch	[manç]	'some'
			München	[mʏn.çən]	'Munich'

Word-initially, the palatal fricative [ç] is in free variation with either [ʃ] or [k] before front vowels, and with [k] before back vowels (Hall 1992, Wiese 1996):

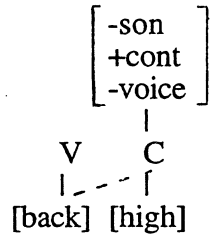
(2)

Chirurg	[çi:.ʀʊʀk]	~	[ki:.ʀʊʀk]	~	[ʃi:.ʀʊʀk]	'surgeon'
Chemie	[çe.mi:]	~	[ke.mi:]	~	[ʃe.mi:]	'chemistry'
China	[çi:.na]	~	[ki:.na]	~	[ʃi:.na]	'China'
Cholesterin	[ço:.lɛs.te.ʀi:n]	~	[ko:.lɛs.te.ʀi:n]			'cholesterol'
Charisma	[ça.ʀɪs.ma]	~	[ka.ʀɪs.ma]			'charisma'

For several decades the prevailing assumption was that the velar fricative [x] is the less marked and hence basic segment type; more recently [ç] has been considered basic, because of its wider range of distribution. Hall's (1989) approach to this problem is innovative in that he regards neither segment as

underlying; instead he proposes that the dorsal fricative is unspecified for backness underlyingly (/X/) and receives a specification for this feature either by spreading in (3) or by the default rule in (4).

(3) Fricative Assimilation (Hall 1989: 3)[2]



(4) [-back] default specification: [-son, +high, +cont] -> [-back]

Some well-known exceptions to the rule of fricative assimilation occur, however. FA does not apply in compounds (5a) or between words at the phrase level (5b).

(5)	a.	Biochemiker	[bi:oçe:mikʌ]	'bio-chemist'
		Indo-China	[ɪndoçi:na]	'Indo-china'
	b.	weil [du:çe:mi] studierst		'because you study chemistry'
		[zo: çi:ne:zɪʃə] Augen		'such chinese eyes'

There is yet another exception to FA which initially does not fall under this last generalization: The initial fricative of the diminutive suffix *-chen* surfaces as palatal and is thus invariant, even if preceded by a back vowel. The diminutive examples in (6a) contrast in this respect with the forms in (6b) in which the dorsal fricative and the preceding vowel are tautomorphemic.

(6)	a.	Kuh+chen	[ku:çən]	'cow, dim.'
		Pfau+chen	[pfao:çən]	'peacock, dim.'
		Tau+chen	[tao:çən]	'rope, dim.'
	b.	Kuchen	[ku:xən]	'cake'
		pfauch+en	[fao:xən]	'to hiss'
		tauch+en	[tao:xən]	'to dive'

Under the model of lexical phonology the exceptionality of this suffix suggests that FA is a lexical rather than a post-lexical rule, since only lexical rules admit of exceptions. If FA were post-lexical, it would be expected to apply "across-the-board", i.e., regardless of the morphological structure of the word. Hall (1989) hence considers FA a lexical rule and assigns it to level II of the lexical phonology of MSG.[3] The assumption that FA is a level II rule is based on its interaction with umlaut. MSG has several suffixes which cause fronting (and in case of a low vowel also raising) of a preceding stem vowel, as shown in (7).[4]

(7)	a.	Bach	[bax]	'brook'
		Bäch+lein	[bɛçlain]	'little brook'
	b.	back+en	[bakən]	'to bake'
		Bäck+er	[bɛkʌ]	'baker'
	c.	schwach	[ʃvax]	'weak'
		schwäch+er	[ʃvɛçʌ]	'weaker'

Hall (1989) argues that umlaut takes place before FA, so that all suffixes that induce umlaut (including those of level II) must be in place before FA has its first chance to apply. If FA were to apply before umlaut (for example at level I), a dorsal fricative would agree with a preceding vowel in backness before umlaut were able to front that vowel.

(8)		
		[b a X]
	level I	
	FA	[b a x]
	level II	
	morphology:	
	add *-lein*	[[b a x] l a i n]
	phonology:	
	umlaut	[[b e x] l a i n]
		* [bɛxlain] 'brook, dim.'

If FA applied after umlaut (for example late at level II, as suggested by Hall) this problem would not arise.

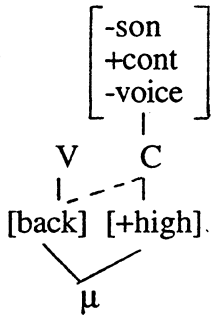
Hall recognizes that there is a problem with his proposal, however: If FA were a late level II rule, it would apply to the dorsal fricative of the diminutive suffix *-chen*. As a stress-neutral derivational affix, *-chen* belongs to level II of the lexical phonology of MSG and so is in principle subject to FA, as shown below.

(9)

	[k u:]
level I	
level II	
morphology:	
add *-chen*	[[k u:] X ə n]
phonology:	
FA	[[k u:] x ə n]
	* [ku:xən] 'cow, dim.'

To prevent the dorsal fricative from assimilating to a preceding back vowel, Hall stipulates that FA applies only to tautomorphemic sequences of segments, revising his original formulation as in (10).

(10) Fricative Assimilation



The restriction of FA to morpheme-internal environments is, however, at odds with the model of lexical phonology. Lexical phonology incorporates morphological restrictions on the application of phonological rules through level ordering. A lexical rule can be limited in its effect by introducing it with a given level of morphemes and by assuming that it ceases to apply before the next layer of formatives is added to the word. The application of FA to the diminutive suffix should hence be blocked by assigning it to an earlier level than the diminutive suffix *-chen*, and not by placing special restrictions on the rule of FA.

The conditioning of FA to tautomorphemic contexts is indeed unnecessary, since there is no need for umlaut to apply before FA. Umlaut is a typical example of a qualitative rule which applies on the melodic tier, regardless of the syllabic position of the segment it affects, and is thus not subject to Inalterability (Hayes 1986b).[5] That is, umlaut changes a [+back] feature to [-back], regardless of whether that feature is associated with a single vowel or a vowel plus a following dorsal fricative. There is thus no need for umlaut to apply before FA and FA can be treated as a level I rule.

(11)

	[b a X]
	[+back]
level I	
FA	[b a x]
	[+back]
level II	
morphology:	
add *-lein*	[[b a x] l a i n]
	[+back]
phonology:	
	[[b ɛ ç] l a i n]
umlaut	[-back]
	[bɛçlain] 'brook, dim.'

With FA applying at level I, the dorsal fricative of the diminutive suffix *-chen* would be exempt from assimilating simply by being attached to the stem after FA has ceased to apply. It could thus surface with the default value [-back], even if preceded by a back vowel.

(12)

	[k u:]
level I	
FA	-
level II	
morphology:	
add *-chen*	[[k u:] X ə n]
phonology:	
default	[[k u:] ç ə n]
	[ku:çən] 'cow, dim.'

Assigning FA to level I, we can furthermore account for its non-application in compounds. Assuming with Wiese (1986) that compounds are formed at level II, they would fail to undergo FA simply because FA is no longer effective at this level.

While the present analysis is internally coherent and consistent with the level ordering hypothesis of the model of lexical phonology, it is not consistent with other predictions that this model makes. FA introduces the feature [back] onto a segment for which this feature is not contrastive in MSG and so should be considered a post-lexical rule.[6] If FA applied post-lexically, however, we are at a loss as to how to explain the exceptional behavior of the diminutive suffix. Since all morpheme boundaries are erased by the time a representation enters the post-lexical component of grammar, the non-application of FA cannot be accounted for on morphological grounds.

There is, however, an alternative interpretation of these data which brings their phonological and not their morphological structure to bear on the analysis. Bloomfield pointed out in 1930 that forms like *Omachen* [omaçən] 'grandma, dim.' resemble compounds in not undergoing fricative assimilation and so could be analyzed as a sequence of two phonological words: ω'[ω[oma] ω[çən]]. A similar claim has been made in more recent times by Iverson & Salmons (1992), and is also at the heart of Borowsky's (1993) and Wiese's (1996) analysis of this phenomenon.[7] Integrating this insight into the model of lexical phonology, Iverson & Salmons (1992) suggest that FA operates in the post-cyclic lexical component at which structure preservation ceases to be in effect (Booij & Rubach 1984, 1987). Since post-cyclic rules apply only word-internally, the dorsal fricative of the diminutive suffix *-chen* is exempt from assimilation, if it is a "non-cohering" suffix and hence a prosodic word of German.

One fact that is problematic for the assumption that *-chen* is a prosodic word is that it can cause umlaut of a preceding back stem vowel. The noun roots in (13) which display umlaut in the diminutive form contrast in this respect with the examples in (14) in which umlaut fails to apply.

(13)	Schuh	[ʃu:]	'shoe'	Schüh+chen	[ʃy:çən]	'shoe, dim.'
	Haus	[haos]	'house'	Häus+chen	[hɔøsçən]	'house, dim.'
	Sohn	[zo:n]	'son'	Söhn+chen	[zø:nçən]	'son, dim.'

(14)	Mama	[mama]	'mom'	Mama+chen	[mamaçən]	'mom, dim.'
	Auto	[aoto]	'car'	Auto+chen	[aotoçən]	'car, dim.'
	Oma	[oma]	'grandma'	Oma+chen	[omaçən]	'grandma, dim.'

If *-chen* were a "non-cohering" suffix, we would expect it to leave the base of suffixation alone, phonologically speaking. That it can cause umlaut suggests instead that *-chen* forms a single phonological word with the base.

To solve the umlaut problem, Iverson & Salmons (1992) claim that there are two formatives of the shape *-chen* in MSG: An umlaut-inducing one which can potentially undergo FA and which indicates the diminutive only, and a variant with an affective connotation that does not cause umlaut and that fails to undergo FA. The first suffix is "relatively deep in the lexicon [...]," while the second instance of *-chen* is "[...] closer to the surface" (Iverson & Salmons 1992:42). Despite the fact that they assign these two suffixes to different strata of the lexicon of MSG, which invites an analysis in terms of the (cyclic) lexical phonology of this language, Iverson & Salmons ultimately seek an explanation for their different behavior in their phonological properties. They claim that only the first type of suffix is fused with the base to form a single phonological word, while the second type of affix forms a phonological word of its own.

However, the semantic distinction that justifies this classification is not supported by the German data at large. According to Fleischer (1975) diminutive forms like *Städtchen* [ʃtɛtçən] 'town, dim.' *Sümmchen* [zʏmçən] 'sum, dim.', *Mütterchen* [mʏtʌçən] 'mother, dim.' and *Küsschen* [kʏsçən] kiss, dim.' do not only express the diminutive, but often have an affective connotation. The problem that these and similar forms pose for an analysis along the lines of Iverson & Salmons is that they have an affective connotation and show umlaut. There is hence no clear semantic distinction between forms with umlaut which have a pure diminutive meaning and forms without umlaut with an affective connotation. Instead the affective connotation is found with both umlauted and non-umlauted stems, making a distinction between a diminutive, umlauting version of *-chen* and an affective, non-umlauting version of *-chen* untenable.

Assuming, then, that there is only a single suffix of the shape *-chen* in MSG, an analysis in terms of the model of prosodic lexical phonology is faced with a dilemma, the umlaut dilemma. The diminutive suffix forms a single

phonological word with respect to umlaut, but a separate phonological word inasfar as dorsal fricative assimilation is concerned. We will see in section 3.2 that the contradictory behavior of the diminutive suffix finds a straightforward explanation if analyzed in terms of Generalized Alignment (McCarthy & Prince 1993b).

3 Optimality theory and the distribution of [ç] and [x] in MSG

3.1 Underspecification and Faithfulness

Optimality Theory (OT) (Prince & Smolensky 1993, McCarthy & Prince 1993a) assumes that a phonological grammar consists of a set of universal constraints which evaluate a representation with respect to its well-formedness. Constraints are ranked on a language-particular basis. They are violable, but violation is minimal; i.e., that candidate that best fits the well-formedness conditions expressed by the constraints will emerge as optimal, even though it might violate one or more of the existing constraints. A key element of this model is the assumption of a generator function Gen; for any given input form Gen produces a set of output candidates by making any number of changes to the input. These candidates are evaluated "in parallel"; i.e., unlike the model of lexical phonology which allows word formation rules and phonological rules to interact cyclically, OT assumes that all morphemes are part of the input.

It is the function of faithfulness constraints to insure that every element of the input is contained in every output candidate. Depending on the ranking of these constraints in the overall constraint hierarchy, either a minimal or maximal deviation of output from input is possible. Faithfulness constraints figure prominently in the following discussion of the underlying representation of dorsal fricatives in MSG and thus merit a brief review. Prince & Smolensky (1993) introduce two faithfulness constraints, PARSE and FILL, which militate against the deletion and insertion of input elements from the output. Itô, Mester & Padgett (1995) extend the use of these constraints to cover both features and association relations between elements in the input form, grouping them under the common name FAITH:

(15) FAITH (Feature Faithfulness) (Itô, Mester & Padgett 1995: 586)

PARSEFEAT

All input features are parsed.

FILLFEAT

All features are part of the input.

PARSELINK

All input association relations are kept.

FILLLINK

All association relations are part of the input.

In their view, not only the insertion of a feature, but also the insertion of an association line into a candidate form constitutes a violation of FAITH.

Let us begin the analysis of dorsal fricative assimilation in MSG by considering what the underlying representation of dorsal fricatives is. The discussion in the previous section assumed that dorsal fricatives are unspecified for backness underlyingly and that they receive a specification either by spreading or by default. Itô, Mester & Padgett (1995) maintain that OT does not require underspecification of input forms, since output constraints and their ranking alone provide an account of the pattern of segmental distribution. Using as an example the feature [voice] in sonorants and sonorant-obstruent clusters in Japanese, they show that, given a set of input forms which differ minimally in the specification of one of their segments and a fixed ranking of the constraints, the same output candidate emerges as optimal. Underspecification is thus not a necessary requirement of input forms.

The same conclusion could be reached regarding the underlying representation of dorsal fricatives in MSG. The following discussion will show that we can account for the distribution of [ç] and [x] without assuming that dorsal fricatives are unspecified for backness (/X/) in the input. As a matter of fact, we can even account for the occurrence of these segments under the assumption that dorsal fricatives are specified as [+back] underlyingly (/x/). For the purposes of this discussion let us distinguish between two kinds of environments, namely those in which the realization of the dorsal fricative is context-dependent and those in which it is not. As the earlier examples in (1) and (2) show, a dorsal fricative surfaces as [-back] in any environment other than after a back vowel. If we want to entertain the hypothesis that dorsal fricatives can be specified as [+back] in the

input and account for their realization only in terms of the constraint hierarchy of MSG, we need to assume the existence of a constraint which bans the co-occurrence of the feature values [+back] and [+continuant] in dorsal consonants: *[x]. Assuming that this constraint is ranked higher than the constraint FAITH [αback] which preserves the underlying backness specification of a dorsal fricative, a [+back] dorsal fricative is excluded in a position such as word-initial, for example.

Consider first the form /xemi:/ 'chemistry' in table (16) below, whose initial fricative is specified as [+back] underlyingly. If *[x] is ranked above FAITH [αback], then the faithful candidate (a) is excluded due to its violating the co-occurrence constraint. Of the non-faithful candidates, (c) wins over (b), because it violates FAITH [αback] in only two instances. I will follow Itô, Mester & Padgett's use of rendering inserted features in italics, but use bold type-face to mark inserted association lines. The insertion or deletion of a feature, as well as any addition or deletion of an association line registers for one FAITH [αback] violation.

(16) Input: /x e m i:/ 'chemistry'
+bk

candidates	*[x]	FAITH [αback]
a. x e m i: | +bk	*!	
b. ç e m i: | *-bk* <+bk>		****!
c. ☞ X e m i: <+bk>		**

The winning candidate (c) demands some further explanation. Specifically, we need to consider how output forms with an unspecified dorsal are to be interpreted. Itô, Mester & Padgett (1995) argue that output underspecification is possible within the framework of OT. Infact, a key element of their analysis of sonorant voicing in Japanese is that sonorants are specified for [voice] in some contexts, namely if followed by an obstruent, while they are unspecified for this

feature in other environments. Since sonorants are phonetically voiced, there must be either a statement or a rule which relates the incompletely specified output to the features of the phonetic signal. We could similarly assume that a dorsal fricative that is unspecified for backness in the output is realized at a palatal place of articulation. As regards their phonetic realization, there are thus no substantive differences between the forms (16b) and (16c) and I will treat both candidates as well-formed output representations corresponding to the phonetic form [çemi:] 'chemistry'.

Table (17) presents the other possible input form /çemi:/ with a [-back] word-initial dorsal. Of the candidates that are associated with this input, (a) is excluded because it violates the highest ranking constraint *[x]. The choice between the remaining two candidates therefore falls onto FAITH [αback]. As expected, the faithful candidate (b) wins over the non-faithful candidate (c).

(17) Input: /ç e m i:/ 'chemistry'
-bk

candidates	*[x]	FAITH [αback]
a. x e m i: +*bk* <-bk>	*!	****
b.☞ ç e m i: -bk		
c. X e m i: <-bk>		**!

The same result obtains when the dorsal fricative is unspecified for backness in the input, as shown in table (18). While candidate (a) is eliminated by the co-occurrence constraint, the faithful candidate (c) emerges as the winner over the non-faithful candidate (b).

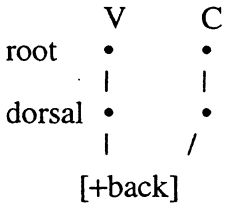
(18) Input: /X e m i:/ 'chemistry'

candidates	*[x]	FAITH [αback]
a. x e m i: | +*bk*	*!	**
b. ç e m i: | -*bk*		**!
c. ☞ X e m i:		

Hence, we can account for the occurrence of [ç] in word-initial position without having to assume that either /ç/ or /X/ underlies this segment. This "freedom of analysis" is not without consequences, however: In order to maintain the assumption that surface [ç] can correspond to a [+back] dorsal fricative /x/ underlyingly, we need to appeal to the constraint *[x] which bans the occurrence of the feature value [+back] in dorsal fricatives. By contrast, if we assumed that either /ç/ or /X/, but not /x/ were basic, there would be no need to invoke this constraint. Instead of limiting the range of possible surface forms by assuming a close featural relationship between input and output, OT allows input forms that can drastically vary from the corresponding output forms, placing the burden of choosing the correct output on the constraint hierarchy. In the absence of an accompanying theory that assesses the cost-effectiveness of these analytical choices, it remains to be seen what the advantage of an OT approach is over an approach that favors minimization in the choice of features at the underlying level.

We can now turn to those examples in which the realization of the dorsal fricative is predictable through context. As already outlined in section 2, a dorsal fricative surfaces as [+back] after a back vowel. Invoking the important insight of autosegmental phonology that assimilation is feature spreading (Hayes 1986a), I posit the constraint in (19) which requires a back vowel and a following dorsal consonant to share a single specification [+back] (Itô & Mester 1995).[8] Since CVLINKAGE requires double linking of the feature value [+back], a VC sequence whose individual segments are specified as [+back] violates this constraint.

(19) CVLINKAGE:



If CVLINKAGE is ranked higher than FAITH [αback], only a candidate in which the feature [+back] is doubly linked emerges as optimal, regardless of what assumptions we make about the underlying representation of the dorsal fricative. Also, since [+back] is a possible feature in dorsal consonants after a back vowel, the constraint CVLINKAGE must rank higher than *[x].

Suppose that the dorsal fricative is specified as [-back] underlyingly, as shown in table (20). Gen submits, as members of the candidate set associated with this input, the output (a) in which the dorsal fricative agrees with the preceding vowel in backness. Despite the fact that it violates *[x] and FAITH [αback], it is the only form that satisfies the higher ranking constraint CVLINKAGE, and so emerges as the winner.

(20) Input: /k u: ç ə n/ 'cake'
+bk -bk

candidates	CVLINKAGE	*[x]	FAITH [αback]
a. ☞ k u: x ə n +bk <-bk>		*	***
b. k u: x ə n +bk *+bk* <-bk>	*!	*	****
c. k u: ç ə n +bk *-bk* <-bk>	*!		****
d. k u: ç ə n +bk -bk	*!		
e. k u: X ə n +bk <-bk>	*!		**

Consider now the table in (21) which evaluates candidates based on the input /ku:xən/ with a [+back] dorsal fricative. All candidates except (a) fall victim to CVLINKAGE and so are non-optimal.

(21) Input: /k u: x ə n/ 'cake'
| | |
+bk +bk

candidates	CVLINKAGE	*[x]	FAITH [αback]
a. ☞ k u: x ə n | / +bk <+bk>		*	***
b. k u: x ə n | | +bk +*bk* <+bk>	*!	*	****
c. k u: ç ə n | | +bk -*bk* <+bk>	*!		****
d. k u: x ə n | | +bk +bk	*!	*	
c. k u: X ə n | +bk <+bk>	*!		**

The last input to consider, (22), has an unspecified dorsal fricative. Even in this case, candidate (a) emerges as the winner due to CVLINKAGE outranking the co-occurrence and faithfulness constraints.

(22) Input: /k u: X ə n/ 'cake'
|
+bk

candidates	CVLINKAGE	*[x]	FAITH [αback]
a. ☞ k u: x ə n | / +bk		*	*
b. k u: x ə n | | +bk +*bk*	*!	*	**
c. k u: ç ə n | | +bk -*bk*	*!		**

d. k u: X ə n | +bk	*!		

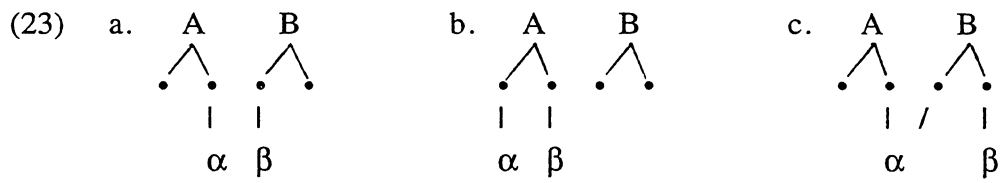
A comparison of tables (20) through (22) shows that we can account for the occurrence of [x] in a position after a back vowel without having to assume that dorsal fricatives are unspecified in the input. Furthermore, we have seen that we can account for the occurrence of [ç] in all other positions on the basis of the ranking *[x] >> FAITH [αback]. In the remainder of this paper I assume that dorsal fricatives are specified as [-back] underlyingly and so will omit the constraint *[x] from the following tables.

3.2 Alignment and Crisp Edges

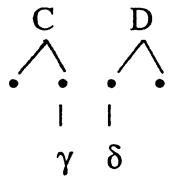
We now turn to the focus of this analysis, namely the non-application of dorsal fricative assimilation in compounds and the diminutive construction.

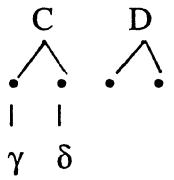
The notion of alignment developed by McCarthy & Prince (1993b) requires that a specified edge of a morphological constituent (a root, stem or affix) coincide with a specified edge of a prosodic constituent (a syllable, foot or prosodic word). The relationship between these categories is exclusive; i.e., no multiple linking of a feature across a boundary may occur. Itô & Mester (in press) propose a revision of alignment theory which distinguishes alignment proper from the requirement of prosodic constituents to have "crisp edges". In an effort to account for cases in which a consonant, for example, syllabifies into both the coda and the onset across a juncture, they claim that instances of multiple linking satisfy alignment. Consider the structures in (23) below, where A and B represent two morphological constituents, and α and β two prosodic constituents. Assuming that the right edge of A has to coincide with the right edge of α, then on Itô & Mester's view neither the structure in (23a) nor the one in (23c) violates ALIGN-R.

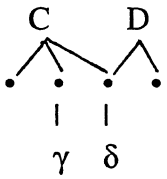
(23)



Alignment differs from the requirement of prosodic constituents to have "crisp edges"; i.e., the condition that every prosodic element is incorporated into a single higher prosodic unit which is captured by a family of CRISPEDGE constraints. CRISPEDGE rules out any linking across the boundary of a prosodic constituent. Assuming that C and D are prosodic categories, then the constraint CRISPEDGE (C) is violated by the structure in (24c), because element δ is linked to both prosodic categories C and D.

(24) a. 

b. 

c. 

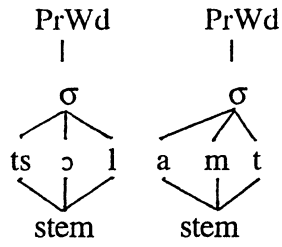
CRISPEDGE (PrWd) plays a crucial role in accounting for the non-application of dorsal fricative assimilation in German compound and diminutive constructions. This constraint is independently motivated in the analysis of syllabification in German.

McCarthy & Prince (1993b) observe that the left stem boundary in German is opaque to syllabification. The examples in (25) demonstrate that the final consonant of a prefix or the first constituent of a compound syllabifies into the coda, rather than into the onset of the following syllable, satisfying ALIGN (Stem, L, PrWd, L). The insertion of a glottal stop before the second vowel-initial morpheme is a consequence of the undominated position of ONSET in German.[9]

(25)	a.	auf+essen	[ʔauf.ʔɛsn]	'to eat up'
		ver+irren	[fʌ.ʔɪʀn]	'to lose one's way'
	b.	Zoll+amt	[tsɔl.ʔamt]	'customs-house'
		berg+ab	[bɛʀk.ʔap]	'downhill'

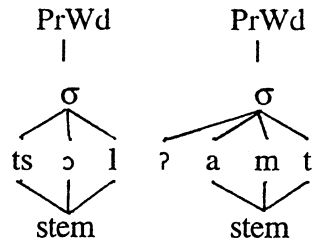
Consider the candidates in (26), all of which are built on the same input /tsɔl+amt/ 'customs-house'.

(26) a.



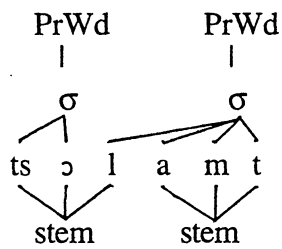
ONSET: *
ALIGN-L: √
FAITH: √

b.



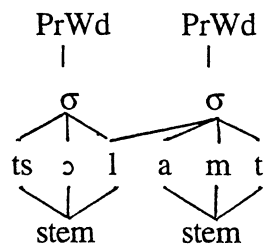
ONSET: √
ALIGN-L: *
FAITH: *

c.



ONSET: √
ALIGN-L: *
FAITH: √

d.



ONSET: √
ALIGN-L: √
FAITH: √

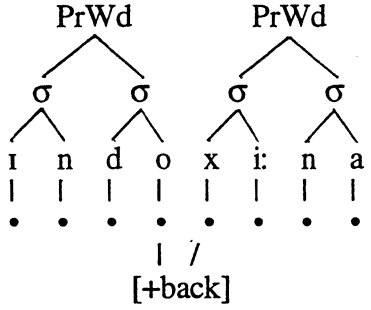
While the ranking of ONSET above ALIGN-L rules out the properly aligned but onsetless candidate (26a), under Itô & Mester's interpretation of alignment the ambisyllabic candidate (26d) also satisfies ALIGN-L and so would be given preference over the correct output form (26b), if no constraints other than ONSET and ALIGN-L are taken into consideration.[10] The difference between the optimal candidate (26b) and the suboptimal candidate (26d) is that the former has crisp word edges, justifying the appeal to the constraint CRISPEDGE (PrWd). If CRISPEDGE (PrWd) is ranked above ALIGN-L, candidate (26b) will emerge as the winner.

That it is indeed the prosodic word and not the syllable that is required to have crisp edges follows from the fact that multiple linking across a syllable boundary is not generally excluded in German. There is evidence from the distribution of long and short vowels that medial consonants in forms like *Hölle* [hœlə] 'hell' or the name *Otto* [ɔto] are ambisyllabic (Vennemann 1972, 1982;

Benware 1986; Wiese 1986; Ramers 1992, Féry 1995). Short lax vowels cannot occur in word-final position which suggests that German syllables are at least bimoraic. Word-medial consonants that are preceded by a short lax vowel must therefore be in the coda to satisfy the bimoraic requirement. Since they also form the onset of the following syllable they are ambisyllabic. That gemination is inhibited across a compound boundary is therefore not motivated by a restriction on German syllable structure, but must be rooted in the more specific requirement of prosodic words to have crisp edges.

Let us now consider the process of dorsal fricative assimilation in greater detail. As already mentioned above, dorsal fricative assimilation is strictly limited to word-internal contexts; i.e., it fails to apply in compounds or between words at the phrase level. Since assimilation applies freely across a syllable boundary, as demonstrated earlier by the form *Kuchen* [ku:.xən] 'cake', we cannot call upon a syllable structure requirement of German to explain why dorsal fricative assimilation fails to apply in compounds. We suggest instead that the non-application of fricative assimilation follows from the constraint CRISPEDGE (PrWd). Assuming that assimilation is feature spreading, the propagation of [+back] from the stem vowel in (27) to the following dorsal results in a multiply linked structure and consequently a non-crisp word edge.

(27)



*[ɪndoxi:na] 'Indo-china'

Provided CRISPEDGE (PrWd) ranks higher than CVLINKAGE, the initial dorsal fricative of the second stem fails to undergo assimilation and so surfaces as front.

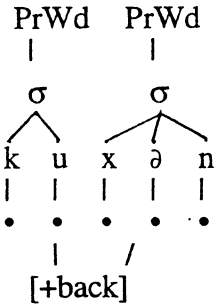
(28) Input: /ɪ n d o + ç i: n a/ 'Indo-china'

+bk -bk

candidates	CRISPEDGE	CVLINKAGE	FAITH [αback]
a. ɪ n d o x [i: n a | / +bk <-bk>	*!		***
b. ☞ ɪ n d o [ç i: n a | | +bk -bk		*	
c. ɪ n d o [x i: n a | | +bk *+bk* <-bk>		*	****
d. ɪ n d o [X i: n a | +bk <-bk>		*	**

If we assume that *-chen* is a prosodic word of German, we can furthermore explain why its initial dorsal fricative escapes assimilation. Assimilation is blocked in this environment, because it results in a non-crisp word edge.

(29)



*[ku:xən] 'cow, dim.'

(30) Input: /k u: + ç ə n/ 'cow, dim.'
+bk -bk

candidates	CRISPEDGE	CVLINKAGE	FAITH [αback]
a. k u: x [ə n | / +bk <-bk>	*!		***
b. ☞ k u: [ç ə n | | +bk -bk		*	
c. k u: [x ə n | | +bk *+bk* <-bk>		*	****

d. k u: [X ə n | +bk <-bk>		*	**

Finally, let us reconsider the umlaut problem. As already pointed out in section 2, the fact that the diminutive suffix *-chen* causes umlaut of a preceding stem vowel is difficult to reconcile with the assumption that it is a "non-cohering" suffix or prosodic word of German. However, under the present approach, the claim that the diminutive suffix is a separate prosodic word of German can be maintained despite the fact that it causes umlaut of the base of affixation. Since umlaut consists of the anchoring of an underlyingly floating feature value [-back] with a back root vowel in the output (Klein 1995), it violates neither ALIGN-L nor CRISPEDGE (PrWd). As a matter of fact, the advantage of the alignment approach over an approach within prosodic lexical phonology emerges most clearly in the analysis of the interaction of dorsal fricative assimilation and umlaut in MSG. By focusing on the edge of the prosodic word, alignment theory is able to make use of a qualitative difference between these two processes to explain why assimilation fails to apply between two prosodic words, while umlaut can take place in this context: Fricative assimilation is a spreading operation, which results in blurred word edges; umlaut is a feature insertion process. Note that I am not claiming that umlaut can apply between words; I am claiming that umlaut simply does not bear on the question of what a phonological word is.

4 Conclusion

In this paper I have presented novel solutions to the invariance of the German diminutive suffix *-chen* within the model of lexical phonology and within optimality theory. In section 2 I have argued that the invariance of the diminutive suffix can be accounted for by assuming that dorsal fricative assimilation applies at level I, before the diminutive morpheme is suffixed. The solution within optimality theory, on the other hand, depends on the recognition of *-chen* as a separate prosodic word of German. If *-chen* is a prosodic word, the constraint CRISPEDGE (PrWd) accounts for the non-application of fricative assimilation to its initial dorsal fricative.

NOTES

* I would like to thank Lise Dobrin, Caroline Féry, Tracy Alan Hall, Ursula Kleinhenz and Sylvia Löhken for comments on an earlier draft of this paper.

[1]According to Kohler (1977), the velar variant [x] is found after the back tense vowels [u:] and [o:], the uvular fricative [χ] after the low vowel [a], while either [x] or [χ] can occur after the non-low back lax vowels [ʊ] and [ɔ]. This distinction will be ignored here.

[2]Hall (1989) includes the specification [-voice] in order to distinguish the voiceless dorsal fricative /X/ from /j/. Unlike Hall, I assume that /j/ is a glide and not a fricative, making any reference to the feature value [-voice] unnecessary. In the remainder of this paper I will refer to /X/ as simply the dorsal fricative. Also, note that Hall uses [back] to refer to both values [+back] and [-back]; hence, on Hall's account vowels are specified as either [+back] or [-back] when FA applies.

[3]Wiese (1986) assumes that there are three lexical strata in MSG: Stratum I consists of the stress-attracting derivational affixes, stratum II of the stress-neutral derivational affixes and compounding, and stratum III of the inflectional affixes.

[4]I assume that umlaut is induced by suffixes which contain a floating feature [-back] underlyingly (Lieber 1987, 1992).

[5]This fact was brought to my attention by John Goldsmith.

[6]Alternatively, we could assume that FA is a lexical rule that operates in violation of the principle of structure preservation. Much has been said in the literature about the implications this assumption has for the model of lexical phonology, cf. Borowsky (1986), Macfarland & Pierrehumbert (1991) among others.

[7]Wiese (1996) provides interesting evidence from a class of 'gapping' phenomena in favor of the assumption that *-chen* is an independent phonological word of MSG. He observes that the suffix *-chen* can be deleted from conjoined expressions such as *Väter- und Mütter**chen*** 'father-dim. and mother-dim.' or *Brüder- und Schwester**chen*** 'brother-dim. and sister-dim.'. A comparison with ill-formed examples like **Komponist- und Lehrer**in*** 'composer-fem. and teacher-fem.' or **Versicher-*

und Verwaltung 'insurance and administration' shows that this is by no means a property of all derivational suffixes in German. One condition on deletion is that the suffix must be co-extensive with a syllable. Not just any syllable can be deleted, however, as evidenced by **male- oder wählerisch* 'picturesque or choosy'. Wiese (1996) concludes that only suffixes that form independent words can be deleted and *-chen* is one of those.

[8]Alternatively, we could formulate a constraint ALIGN-R ([+back], dorsal C) which requires the feature value [+back] to align with a dorsal consonant on its right (Kirchner 1993). However, since the domain of alignment is not a prosodic constituent, but simply the linear string VC, an analysis in terms of a linked VC domain appears more appropriate.

[9]To account for the contrastive pattern of epenthesis in the monomorphemic forms below, Féry (1995) - following Hall (1992) and Yu (1992) - suggests that the foot and not the prosodic word boundary is the location for glottal stop insertion. While the examples in (a) consist of two feet, the examples in (b) consist of a single foot.

a.	Ruin	[(ʀu:.)$_{Ft}$(ʔí:n)$_{Ft}$]	'ruin'
	Theater	[(te:.)$_{Ft}$(ʔá:tʌ)$_{Ft}$]	'theater'
b.	Fluor	[(flú:.ɔʀ)$_{Ft}$]	'fluorine'
	Boa	[(bó:.a)$_{Ft}$]	'boa'

On Féry's account it is the left edge of the foot that needs to align with the left edge of the syllable, ALIGN (Foot, L, σ, L). It could be argued that the constraint ALIGN (Stem, L, PrWd, L) is needed independently to account for glottal stop insertion in compounds like *Zollamt* [tsɔl.ʔamt] 'customs-house' or *Bauamt* [bau.ʔamt] 'building office'. According to Féry (1995) these forms consist of two feet, motivating the insertion of a glottal stop before the vowel of the second morpheme. The argument that the second stem in *Zollamt* [tsɔl.ʔamt] 'customs-house' forms a metrical foot of its own is in part based on the assumption that it carries secondary stress. It contrasts in this respect with the second syllable in words like *Hering* [hɛ.ʀɪŋ] 'herring' or *König* [køniç] 'king' which are unstressed. As Wiese (1996: 275) points out, however, speakers of German have no clear intuition about the stress patterns of bisyllabic words with a strong-weak pattern, making a distinction between syllables with secondary stress and unstressed syllables doubtful. This in turn removes some of the motivation for assuming that the second syllable in *Zollamt* [tsɔl.ʔamt] 'customs-house' forms an independent foot in German, leaving this issue

unsettled.

[10]Candidate (26b) is ultimately chosen over (26c), because ALIGN-L is evaluated gradiently. The insertion of an empty position, which is filled out by a glottal stop in German, constitutes a less severe violation of ALIGN -L than syllabifying the liquid into the onset of the second syllable.

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