To appear in *LI* **27.***4*

Alignment and fricative assimilation in German

Jason Merchant
Linguistics Board, Stevenson College
University of California, Santa Cruz
Santa Cruz, CA 95064
merchant@ling.ucsc.edu

An account of the distribution of the dorsal fricative in German has generally been assumed to require cyclic derivation and/or multiple phonological levels (Hall 1989, Moltmann 1990, Noske 1990, MacFarland and Pierrehumbert 1991, Iverson and Salmons 1992, Borowsky 1993). In this squib, I argue that the facts of fricative assimilation can be accounted for without cyclicity or separate phonological levels within Optimality Theory (OT) (Prince and Smolensky 1993) by employing a version of the theory of alignment proposed by McCarthy and Prince (1993b), which permits direct interaction between morphological and phonological structures. I propose that the fricative in these cases is ambisyllabic, permitting an account under which fricative assimilation occurs only tautosyllabically. My analysis assumes that alignment constraints proper are not violated in cases of multiple linking, supporting the premise that the satisfaction of alignment constraints is to be distinguished from satisfaction of constraints requiring prosodic units to have crisp edges (as argued for in Itô and Mester (in press)).

1 Background

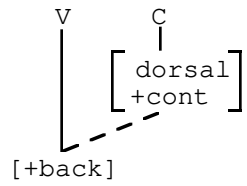
As is well known, the dorsal fricatives (the *ich-Laut* [ç] and *ach-Laut* [x]) stand in near-complementary distribution in Modern German. We find [x] after [+back] vowels, and [ç] elsewhere. The data in (1) illustrate this distribution; a first approximation of the constraint ranking deriving this alternation is given in (2a). In (2a), I use *Aç as an abbreviation for the relevant parameterization of a more general family of CVLINKAGE constraints -- here *Aç militates against the sequence of a back vowel followed by [ç][1]. The constraint *[x] is the segmental markedness constraint dispreferring [x]. The dominant *Aç in (2a) drives feature assimilation as illustrated schematically in (2b).

(1)

a. [x] after back vowels			b. [ç] elsewhere		
ach	[?ax]	'Oh!'	ich	[? ç]	'I'
Sprache	[Spra:x«]	'language'	sprecht	[SprEçt]	'speak!'
Koch	[kOx]	'cook'	Köche	[kflç«]	'cooks'
Buches	[bu:x«s]	'book-GEN'	Bücher	[by:çU]	'books'
rauchen	[ra x«n]	'to smoke'	riechen	[ri:ç«n]	'to smell'
			China	[çi:na]	'China'
			Chemie	[çEmi:]	'chemistry'
			durch	[durç]	'through'
			Milch	[m lç]	'milk'
			Kolchose	[kOlço:z«]	'collective farm'

(2) a. Fricative Assimilation constraint ranking (to be revised)
*Aç >> *[x] >> IDENT-IO([back])

b.



There are two types of problems for this analysis. The first, which I will call the *Frauchen* type, indicates the need to recognize morphological conditioning in stating the environment of fricative assimilation. This was discussed by Bloomfield (1930) and is illustrated by the *prima facie* counterexamples to (2a) in (3a). The initial /ç/ of the diminutive suffix *-chen* does not undergo fricative assimilation, although it follows a back vowel; the forms in (3a) form minimal and near-minimal pairs with those in (3b), differing only in their morphological constituency.

(3) a. [ç]

Frau–chen	[fra ç«n]	'mistress (of an animal); little woman'
Tau–chen	[ta ç«n]	'little rope'
Kuh–chen	[ku:ç«n]	'little cow'

b. [x]

rauch–en	[ra x«n]	'smoke-INF'[2]
tauch–en	[ta x«n]	'dive-INF'
Kuch–en	[ku:x«n]	'cake-EN'

Based on these data among others, Hall (1989) proposes restricting the application of fricative assimilation to within a single morpheme (also assumed in Dressler 1976 and Wurzel 1980); under this view, *Aç would not be relevant to the forms in (3a), since the suffix *-chen* constitutes a separate morpheme.

The second problem, which I will call the *Masochist* type, is less well-known and highlights the syllable-structure conditioning required. The data in (4) (some from Moltmann 1990 and Kenstowicz 1994), where vowel-initial suffixes are attached to roots ending in /ç/, demonstrate that a restriction to tautomorphemic application is not enough. In (4a) (cf. the related forms in (4b)), the back vowel is tautomorphemic with the dorsal fricative, but the fricative remains [-back].[3,4]

(4) *root-attaching suffixes*

a. [ç]

Masoch+ist	[ma:zo:ç st]	'masochist'
Eunuch+ismus	[o nu:ç smus]	'eunuchism'
eunuch+isieren	[o nu:ç zi:r«n]	'make into a eunuch'
Paroch+ie	[paro:çi:]	'parish'
paroch+ial	[paro:çial]	'parochial'

b. [x]

Masoch	[ma:zo:x]	(name)
Eunuch	[o nu:x]	'eunuch'

These forms contrast with the ones in (5), where a vowel-initial suffix is attached to a stem ending in /ç/.

(5) *stem-attaching suffixes*

rauch–ig	[ra x ç]	'smoky'
Buch–ung	[bu:xuN]	'booking'

It is clear that a purely segmental account, as given by the constraint ranking in (2a), even if restricted to applying tautomorphemically, is unable to account for all of the data presented.

2 Ambisyllabicity and Alignment

The factor crucially missing in accounts of fricative assimilation employing constraints such as those in (2a) is syllabification. I propose that /ç/ will only surface as [x] when it is syllabified in a coda. Assimilation occurs only when a [+back] vowel is forced to spread this feature onto an immediately adjacent dorsal fricative *tautosyllabically*; this can be encoded in the CVLINKAGE constraint as *Aç]$_\sigma$, which militates against non-linkage only within a syllable. The ranking with the revised constraint is the same as in (2a), and is given in (6).

(6) Fricative Assimilation constraint ranking (tautosyllabic version)
*Aç]$_\sigma$ >> *[x] >> IDENT-IO([back])

This revised constraint must dominate the constraint IDENT-IO([back]), which penalizes any change in the underlying [back] value of the fricative[5]. This faithfulness constraint is violated by the winning candidates (7a) and (8a). The tableaux in (7) and (8) establish this ranking and show its effects for simple codas.

(7) *Aç]$_\sigma$ >> *[x], IDENT-IO([back]), from *Buch* 'book'

/bu:ç/	*Aç]$_\sigma$	*[x]	IDENT-IO([back])
a. ☞ .bu:x.		*	*
b. .bu: .	*!		

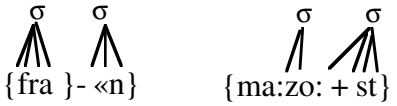
(8) *achten* 'to observe, pay attention to'

/açt-«n/	*Aç]$_\sigma$	*[x]	IDENT-IO([back])
a. ☞ .ax.t«n.		*	*
b. .aç.t«n.	*!		

Since the dorsal linkage requirement is always fulfilled in surface forms, *Aç]$_\sigma$ is undominated for our purposes, and will be omitted from following tableaux; only candidate forms which satisfy *Aç]$_\sigma$ will be considered.

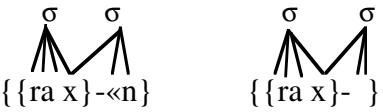
This analysis predicts that any dorsal fricative which is uniquely syllabified into an onset will not assimilate to a preceding back vowel; since the fricative in both *Frauchen* and *Masochist* is syllable-initial, as given in (9), we have a unitary explanation for the absence of fricative assimilation in both problematic types.

(9) a. *Frau-chen* b. *Masoch+ist*



A /ç/ that surfaces as [x] between vowels must therefore be syllabified into a coda in order for *Aç]$_{\sigma}$ to have any effect. I propose that these fricatives are in fact ambisyllabic, as in the representative forms given in (10).[6]

(10) a. *rauchen* *b. rauchig*



The task, then, reduces to finding what is responsible for the different syllabifications of (9) vs. (10).[7] These differences can be captured straightforwardly in terms of the alignment theory of McCarthy and Prince 1993b, assuming that the suffixes *-chen*, *-en*, and *-ig* attach to Stems and that *-ist* attaches to Roots (following the morphological hierarchy of Selkirk 1982, 1986). Turning first to the data in (3), let us examine how OT captures the difference between *Frauchen* and *rauchen*. Both *-chen* and *-en* attach to Stems, but in order for the feature-aligning constraint in (6) to have any effect on the output, the /ç/ of /ra ç/ must be syllabified into a coda. This syllabification is enforced by the Stem-aligning constraint ALIGNR, introduced in Prince and Smolensky (1993:103ff.) for Lardil and used in McCarthy and Prince's (1993a:35ff. and *passim*) analysis of Axininca Campa:

(11) ALIGNR: ALIGN (Stem, R, σ, R)

ALIGNR requires that the right edge of *every* Stem coincide with the right edge of *some* syllable. The alignment apparatus directly encodes the interaction of the morphology with the phonology, allowing such constraints to be ranked among the purely phonological constraints ONSET and NOCODA, which determine syllable wellformedness. ONSET is undominated in German (see McCarthy and Prince 1993b:49f.), while NOCODA is ranked low. We can rank ALIGNR with respect to these general syllabic constraints by examining the tableau in (12).

(12) ONSET, ALIGNR >> NOCODA, from [ra ç], Stem affix *-«n*

/[[ra ç]-«n]/	ONSET	ALIGNR	NOCODA
a.	*!		**
b. ☞			**
c.		*!	*

Candidate (a) is eliminated by virtue of the fact that it violates the undominated constraint ONSET, and differs from (b) only in this respect; therefore, ONSET must

dominate NOCODA. Both of the remaining candidates (b, c) satisfy ONSET by syllabifying the Stem-final /ç/ into an onset. Since (c) violates ALIGNR, the edge of its Stem not corresponding to the edge of a syllable, candidate (b) is adjudged optimal and surfaces correctly as the output form. The comparison of (b) with (c) shows that ALIGNR dominates NOCODA. No ranking can be established between ONSET and ALIGNR, since the winning candidate satisfies both.

In order for candidate (b) to be optimal, however, the linking of the [x] into the onset of the following syllable must not count as an ALIGNR violation. If such multiple or non-exclusive linking were in violation of ALIGNR, (c) would incorrectly be selected as the actually occurring form, since the decision would be passed down to NOCODA, where (c) incurs fewer violations (one coda against (b)'s two). Employing the revision of Alignment Theory argued for in Itô and Mester (in press), which distinguishes alignment constraints from crisp edge requirements, candidates (a) and (b) equally satisfy ALIGNR; they differ only in that candidate (a) also satisfies a lower-ranked constraint CRISP(σ), which requires that all segments be uniquely syllabified.

The underlying /ç/ in candidate (12b), although it is the onset of the following syllable (in satisfaction of ONSET), also is the coda of a syllable which dominates a [+back] vowel directly preceding it. Therefore *Aç]$_{\sigma}$ will require that the fricative surface as [x].

Observe the contrast, crucially due to ALIGNR, between the tableau in (12) and the one in (13) for *Frauchen*:

(13) Diminutive suffix *-chen*

/[[fra]-ç«n]/	ONSET	ALIGNR	NOCODA
a. σ σ {{fra }-x«n}	*!	*	**
b. σ σ {{fra }-x«n}		*!	**
c. ☞ σ σ {{fra }- «n}			*

In the optimal candidate (13c), the Stem boundary falls at a syllable boundary, satisfying ALIGNR; since the affix begins with a consonant which is uniquely syllabified into the onset of the second syllable, there will be nothing preferring ambisyllabicity and hence ALIGNBK will play no role in choosing the optimal output. Candidate (13b), the prosodic equivalent of the optimal (12b) above, differs in that the Stem [fra] is not the sole content of the first syllable, since this syllable also dominates the first segment of the diminutive suffix. ALIGNR is thus violated here, since the edge of the Stem does not coincide with the edge of a syllable. Ambisyllabicity will of course always be in violation of NOCODA -- it is only when not being ambisyllabic violates a higher-ranked constraint (here ALIGNR) that ambisyllabicity will result. In other words, in this case there is no advantage to be gained by syllabifying the /ç/ into a coda -- just the opposite, in fact, since doing so incurs violations of both ALIGNR and NOCODA.

Finally, observe that for affixes that attach to a Root, not to a Stem, ALIGNR has no jurisdiction over their internal structure, because ALIGNR requires only that every Stem be

aligned with a syllable at its right edge. This is the determining difference between *rauch–en* [x] and *Masoch+ist* [ç]. Since there exist both Stem- and Root-attaching suffixes which are vowel-initial, no attempt to reduce the differences to purely syllabic or prosodic well-formedness can be successful -- reference to morphological constituency is crucial. ALIGNR is included in the tableau solely for comparison:

(14) Root affix *-ist*

/[ma:zo:ç+ st]/	ONSET	ALIGNR	NOCODA
a. {ma:zo:x+ st}	*!		**
b. {ma:zo:x+ st}			*!*
c. ☞ {ma:zo: + st}			*

Because there is no Stem boundary between the Root and the affix, the final /ç/ of the Root is free to be uniquely syllabified into the following syllable, yielding alignment of all syllables, with no ambisyllabicity. It is only through examination of forms like (14) that one is forced to the conclusion that morphological constituency is crucial in determining syllabification.[8]

In the system presented above, ambisyllabicity is never the most harmonic candidate with respect only to the syllable well-formedness constraints, as is to be expected, since NOCODA penalizes the syllabification of segments into a coda. Only because ALIGNR outranks NOCODA in German is ambisyllabicity possible.[9,10]

3 Conclusion

We have seen that an account of the near-complementary distribution of the allophones of the German dorsal fricative, although until now universally assumed to require some form of cyclic derivation, is not only possible in a non-derivational OT framework, but leads to a significant simplification and extension of the analysis. My analysis relied on three elements, each supported elsewhere in the literature: (i) a morphological Root/Stem distinction, (ii) the syllabic constraints ONSET and NOCODA, and (iii) the MCat-PCat alignment constraint ALIGNR.

Using these basic tools to derive the morphologically determined syllabification, fricative assimilation was simply stated as a constraint barring [ç] immeditately following a tautosyllabic back vowel; ambisyllabicity was forced by the combined effects of ONSET and ALIGNR in those cases where vowel-initial suffixes attached to Stems. Since ALIGNR does not apply to Root edges, vowel-initial suffixes that attach to Roots were free to uniquely syllabify a Root-final consonant as an onset. The apparatus of alignment captures the differing interactions of phonological structures and morphological constituents without the need for phonological derivational levels or for cyclic resyllabification.

References

Beckman, Jill, Laura Walsh Dickey, and Suzanne Urbanczyk (eds.). 1995. *Papers in Optimality Theory*, UMOP 18. GLSA, University of Massachusetts, Amherst.

Benua, Laura. 1995. Identity effects in morphological truncation. In Beckman et al. (eds), pp. 77-136.

Bloomfield, Leonard. 1930. German ç and x. *Le maître phonétique 3*, 20:27-28.

Booij, Geert. 1995. *The phonology of Dutch.* Oxford University Press, Oxford.

Borowsky, Toni. 1993. On the word level. In S. Hargus and E. M. Kaisse (eds.), *Studies in Lexical Phonology: Phonetics and phonology* 4:199-234. Academic Press: San Diego.

Dressler, Wolfgang. 1976. Morphologization of phonological processes: are there distinct morphological processes? In A. Juilland (ed.), *Linguistic studies offered to Joseph Greenberg*, vol. 2: 313-337. Saratoga: Anma Libri.

Eisenberg, Peter, Karl Ramers, and Heinz Vater (eds.). 1992. *Silbenphonologie des Deutschen.* Gunter Narr Verlag: Tübingen.

Féry, Caroline. 1994. Umlaut and inflection in German. Ms., Universität Tübingen.

Féry, Caroline. 1995. *Alignment, syllable and metrical structure in German.* SfS-Report-02-95. Seminar für Sprachwissenschaft, Universität Tübingen.

Hall, Tracy Alan. 1989. Lexical Phonology and the distribution of German [ç] and [x]. *Phonology* 6:1-17.

Itô, Junko, and Armin Mester. 1995. The Core-Periphery structure of the lexicon and constraints on reranking. In Beckman et al. (eds.), pp. 181-210.

Itô, Junko, and Armin Mester. In press. Realignment. In R. Kager, H. v. d. Hulst, and W. Zonneveld (eds.), *Proceedings of the Utrecht Workshop on Prosodic Morphology.* Mouton: The Hague.

Iverson, Gregory, and Joe Salmons. 1992. The place of Structure Preservation in German diminutive formation. *Phonology* 9: 137-143.

Kager, René. 1989. A metrical theory of stress and destressing in English and Dutch. Ph.D. dissertation, University of Utrecht.

Kenstowicz, Michael. 1994. *Phonology in generative grammar.* Cambridge, Mass.: Blackwell.

Macfarland, Talke, and Janet Pierrehumbert. 1991. On ich-Laut, ach-Laut and Structure Preservation. *Phonology* 8: 171-180.

McCarthy, John. 1993. A case of surface constraint violation. *Canadian Journal of Linguistics* 38: 169-195.

McCarthy, John. 1995. Extensions of faithfulness: Rotuman revisited. Ms., University of Massachusetts, Amherst.

McCarthy, John, and Alan Prince. 1993a. Prosodic morphology I: Constraint interaction and satisfaction. Ms., University of Massachusetts, Amherst, and Rutgers University, New Brunswick, N.J. [Forthcoming, MIT Press.]

McCarthy, John, and Alan Prince. 1993b. Generalized Alignment. *Yearbook of morphology 1993,* 79-154.

McCarthy, John, and Alan Prince. 1995. Faithfulness and reduplicative identity. In Beckman et al. (eds.), pp. 249-384.

Moltmann, Friederike. 1990. Syllabification and Lexical Phonology in German. Ms., MIT.

Noske, Manuela. 1990. Harmonic phonology and the distribution of Northern German [ç] and [x]. *Proceedings of the Chicago Linguistics Society*, pp. 333-348.

Pierrehumbert, Janet, and Mary Beckman. 1988. *Japanese Tone Structure.* Cambridge, Mass.: MIT Press.
Prince, Alan, and Paul Smolensky. 1993. Optimality Theory: Constraint interaction in generative grammar. Ms., Rutgers University, New Brunswick, N.J., and University of Colorado, Boulder. [Forthcoming, MIT Press.]
Ramers, Karl Heinz. 1992. Ambisilbische Konsonanten im Deutschen. In Eisenberg et al. (eds.), pp. 246-283.
Selkirk, Elisabeth. 1982. *The syntax of words.* Cambridge, Mass.: MIT Press.
Selkirk, Elisabeth. 1986. *Phonology and syntax: The relation between sound and structure.* Cambridge, Mass.: MIT Press.
Wurzel, W. U. 1980. Phonologie: segmentale Struktur. In K.E.Heidolph et al. (eds.), *Grundzüge einer deutschen Grammatik*: 898-1003. Berlin: Akademie Verlag.

This work has benefited from discussions with Junko Itô, Armin Mester, Jaye Padgett, Paul Smolensky, Rachel Walker, and in particular from the detailed comments of four anonymous LI reviewers. I am also grateful to audiences at UCSC and at TREND 3 (Stanford 1994) for helpful suggestions. Remaining errors are my own. This work was supported in part by NSF grant SBR-9510868.

[1] The underlyingly status of the dorsal fricative has been the focus of some debate (see Hall 1989 for references and discussion). For the purposes of this squib, I follow current approaches to Lexicon Optimization, and derive the allophonic variation from the interaction of CVLINKAGE and markedness constraints; see Itô and Mester 1995:195-205 for extensive discussion of this approach to allophony. The crucial point of this squib, however, is unaffected if one adopts another analysis of the assimilation instead (e.g., by means of a direct spreading requirement, along the lines of AlignR([+back], σ)) -- in either case, morphologically-influenced syllabification must play a role.

[2] INF = infinitival suffix, EN = nominalizing suffix.

[3] For clarity, I will use the plus sign [+] for the morpheme boundary preceding root-attaching affixes as in (4a) (which are Latinate and take primary stress), and a dash [–] for stem-attaching and other affixes (which never take primary stress). The stress facts are highly suggestive of possible foot structures for these forms. A welcome extension of the present analysis may be to derive the distribution of the fricatives from footing, with this footing being determined in part by the morphological configurations employed here. In other words, the effects derived here directly from morphological considerations may ultimately be mediated

by foot structure (see Féry 1994 for an analysis of several other processes along these lines). Thanks to John Goldsmith and an LI reviewer for discussion.

[4] These transcriptions follow Moltmann 1990; see also Kenstowicz (1994: 308). There is some variation among speakers in the pronunciation of these forms; the discussion in this squib will be limited to my informants who have [ç] in the relevant environments. Most speakers have [x] even for the words in (4a); clearly the analysis will not apply for these speakers. Many of these speakers in fact seem to have a short vowel preceding the fricative, i.e. [ma:zox st], though this impression should be confirmed by experimental data, and is partially contingent on the analysis adopted for the lax/tense distinction in German (see Féry 1995 for a recent account). That [x] should surface in this environment is unsurprising, given the general prohibition of short open syllables in German, requiring that [x] be syllabified into the coda regardless of morphological considerations. Where a short vowel is present in all pronunciations, only [x] is possible even before Root-attaching suffixes, e.g. *epochal* [epOxa:l], *[epOça:l]. Other words of varying morphological constituencies, brought to my attention by a reviewer, illustrate the distribution of this phonotactically-driven ambisyllabification as well: *Rachel*, *Bacchus*, *Tachometer*, *Zacharias*, and *Trochäus*, all of which show [x] following a short vowel. This type of ambisyllabicity as well as a more general account of syllabification in German must remain outside the purview of this squib due to space limitations (see Eisenberg et al. 1992 and especially Ramers 1992 for discussion).

[5] Since both *Aç]$_\sigma$ and *[x] outrank the relevant Faithfulness constraints, the character of the input (palatal /ç/, velar /x/, or underspecified) is irrelevant in this analysis. For a parallel case in Japanese, see McCarthy and Prince 1995:353f. For convenience, I show dorsal fricatives in input forms as palatal /ç/.

[6] Since German does not have geminates, I assume that such ambisyllabic consonants will phonetically be interpreted as singletons. An independent reason for believing these consonants to be codas comes from their interaction with syllable weight restrictions; see Kager 1989 for discussion of this kind of evidence in Dutch. A reviewer points out that the present analysis also works if [x] is only in the coda, leaving the Stem suffixes onsetless. McCarthy and Prince 1993b, following Booij 1995, argue that onsetless syllables

following a consonant in a coda are not tolerated in German, forcing epenthesis of a glottal stop (or glottal narrowing). I take the absence of this effect in the forms above (*[ra x?«n], *[ra x? ç]) to be evidence that these consonants act as onsets as well.

[7] I am grateful to an LI reviewer for providing me with a copy of Moltmann's (1990) unpublished manuscript, which proposes a similar syllable-based account in a rule-based derivational model, with level-ordering and cyclic resyllabification. In the present analysis, which shares the crucial reference to syllabification, a single (and independently supported) ALIGNR constraint takes the place of the detailed derivational machinery of previous accounts whose fine-tuning has remained problematic.

[8] The account given above based on the ambisyllabicity of [x] being forced by ALIGNR would seem to have difficulty accounting for seemingly monomorphemic forms in which [x] surfaces after a long vowel, such as *Sprache* 'language', *Buche* 'beech-tree', *Bochum*, and *Aachen* (city names). I suggest two approaches to these data. For words like *Sprache* and *Buche*, it seems plausible that the relevant Stem edge is in fact present, making these *Sprach-e* and *Buch-e*. This analysis is supported by independent evidence that words ending in *-e* are morphologically complex, since we often find the base to which *-e* attaches alone in compounds, here e.g. *Sprach-gefühl* 'language-feeling' and *Buch-ecker* 'beech-nut'. For the names, one of the simplest options would be to claim that these forms are underlyingly prespecified with /ç/ linked to a mora, reflecting their peripheral status within the lexicon. If the relevant Faithfulness constraints are highly ranked, ambisyllabicity would be forced without a Stem boundary.

[9] Parallel to the interaction between ALIGNL and ONSET in Axininca Campa (McCarthy and Prince 1993a).

[10] An alternative that might be considered would be to claim that *rauchig* 'smoky' shows [x] because *Rauch* 'smoke' does, and not require ambisyllabicity at all, i.e. a type of output-output correspondence like those in McCarthy 1995 and Benua 1995. This approach would in a sense reconstruct a cyclic derivational approach; further, it is not clear how this would make the right prediction with respect to the *Masochist*

type problem, nor even whether the kind of correspondences proposed by those authors should extend to the kind of alternations considered here. See especially Benua 1995:125-129 for interesting discussion.