On the sources of opacity in OT: Coda processes in German

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1. Introduction

Optimality Theory (OT) is built on output constraints.[1] These constraints impose conflicting demands on candidates and are all violable, with precedence regulated by universal and language-particular ranking specifications (see Prince & Smolensky 1993). As a result, constraints are minimally violated in winning candidates. An output-oriented theory of this kind needs to pay special attention to patterns of phonological opacity, arising out of generalizations that apparently need to be stated at some non-surface level of representation. Opacity constituted a central object of study in traditional generative phonology. In terms of the relevant portions of Kiparsky's (1973, 79) definition in (1) that formed the basis of most subsequent work on the topic, two different types of opacity can be distinguished.

(1) A phonological rule $\mathcal{P}$ of the form $A \rightarrow B$ / C___D is **opaque** if there are surface structures with any of the following characteristics:
  a. instances of A in the environment C___D.
  b. instances of B derived by $\mathcal{P}$ that occur in environments other than C___D.

On the one hand, there are patterns built on generalizations that are overtly violated in some output forms (1a); on the other hand, there are patterns built on generalizations whose environment is only covertly fulfilled (not in the output, but in some other representation associated with the output representation), derivationally or otherwise (1b). We will see later that this definition has its limitations for the way in which the opacity problem presents itself in OT: It does not cover some important types of cases (including the two interactions studied here) which are problematic for OT in the sense that the 'transparent' version of the theory (making use only of markedness constraints and standard faithfulness constraints) is unable to deal with them.

One can approach the study of opacity in OT from different angles. One possibility, vigorously pursued in the work of McCarthy (1997, 1998) and further explored by several other researchers[2], is to construct a theoretical device—"Sympathy"—that strives to cover the same ground as the well-known sequentialist account of opacity in rule-based generative phonology. Besides the empirical difficulties that Sympathy encounters if taken up on its claim to be a general-purpose opacity device,[3] there is a conceptual doubt about the very idea of a single tool in OT responsible for opacity. It is a priori quite unlikely that two radically different theoretical paradigms such as rule-based sequentialism and constraint-based parallelism would have mechanisms corresponding to each other in such a direct way, with ordered rules applying in a multi-stage derivation directly matched by sympathetic faithfulness to a specially selected candidate that fulfills the role of the abstract derivational stage. The problem lies not in the abstractness, but in the very direct one-to-one matching of mechanisms. What would be expected, rather, is a situation where opacity arises out of independently existing components of an OT-grammar, in such a way that there is no one-to-one correspondence to derivational theory.

Such considerations suggest a different kind of approach, which will be explored in this paper. Which elements of current OT-architecture can in principle give rise to opaque output patterns? To what extent do the patterns of opacity derivable in this way cover the empirically existing patterns? This is a more open-ended enterprise, and a number of potential sources of opacity come to mind. On the one hand, the issue of levels of representation remains open to a large extent. OT holds that grammatical computation proceeds through the simultaneous optimization of a set of conflicting and strictly ranked output constraints. Even though it is reasonable to pursue radical parallelism instead of sequentialism as a research strategy, this does not make it an established result. The fundamental tenets of OT are compatible with a partitioning of the total computation into sequential subparts, the theory is not intrinsically committed to a wholescale rejection of derivational levels.[4] In particular, the distinction between word phonology ("lexical") and phrasal phonology ("postlexical"), which has been a cornerstone of virtually every approach to phonological structure in modern linguistics, is likely to maintain a legitimate place within OT.

On the other hand, and this is the topic to be studied in this paper, there is an interesting class of constraints locally conjoining markedness and faithfulness studied by Lubowicz 1998 as sources of the derived environment syndrome. Here we show that this class of locally conjoined constraints is also responsible for opaque output patterns.

As its empirical basis, this paper studies the ways in which a group of coda conditions play out in the phonology of German (section 2), triggering processes that interact opaquely (section 3.1 and 3.4). Sympathy-based analyses are shown to be associated with unappealing stipulations and otherwise unmotivated rankings (section 3.2). The opacity is shown to arise, rather, in a very natural and simple way out of specific conjunctions of markedness and faithfulness constraints that are otherwise operative in German phonology (section 3.3). A few thoughts on the general status of opacity in OT and further theoretical ramifications conclude the paper (section 4).

2. Coda conditions as [M&M] conjunctions

Conditions on the syllable coda are responsible for a number of processes in German, both in the standard language and in regional varieties. We will here focus on the three coda processes illustrated in (2): the well-known process of coda devoicing (2a) turns underlying /ta:g/ into [ta:k]; spirantization (2b) applies to underlying /g/ in the syllable coda, resulting in the alternation between the plural .*Kö.ni*.[g]*e*. and singular .*Kö.ni*[ç]**.**; coda cluster simplification (2c), similar to the corresponding alternation in English, is responsible for the alternation between *Diphtho*[ŋ] and *diphtho*[ŋg]*ieren*.

(2) a. Devoicing:

/ta:g/	→	.ta:k.	'day'	cf. .ta:.gə.	'days'	.tɛ:k.lɪç.	'daily'
/li:b/	→	.li:p.	'dear'	cf. .li:.bən.	'to love'	.li:p.lɪç.	'lovely'
/moti:v/	→	.mo.ti:f	'motive'	cf. .mo.ti:.və.	'motives'	.mo.ti:fs.	'motive's'
/le:z/	→	.li:s.	'read', imp.	cf. .le:.zən.	'to read'	.le:.s.baʀ.	'readable'

b. Spirantization:[5]

/kø:nɪg/	→	.kø:.nɪç.	'king'	cf. .kø:.nɪ.gə.	'kings'
/ho:nɪg/	→	.ho:.nɪç.	'honey'	cf. .ho:nɪ.gə.	'honey', dat.
/ve:nɪg/	→	.ve:nɪç.	'little'	cf. .ve:nɪ.gə.	'few'
/aɪnɪgkaɪt/	→	.aɪ.nɪç.kaɪt.	'unity'	cf. .aɪ.nɪ.gən.	'to unite'
/ɛntʃʊldɪgt/	→	.ɛnt.ʃʊl.dɪçt.	'excuse', 3sg.	cf. .ɛnt.ʃʊl.dɪ.gən.	'to excuse'
/zɔnɪg/	→	.zɔ.nɪç.	'sunny', attrib.	cf. .zɔ.nɪ.gə.	'sunny', pred.
/laɪptsɪg/	→	.laɪp.tsɪç.	'Leipzig'	cf. .laɪp.tsɪ.gɐ.	'Leipziger'

c. Cluster Simplification:

/dɪftɔŋg/	→	.dɪf.tɔŋ.	'diphthong'	cf. .dɪf.tɔŋ.gi:.rən.	'to diphthongize'
/monɔftɔŋg/	→	.mo.nɔf.tɔŋ.	'monophthong'	cf..mo.nɔf.tɔŋ.gal.	'monophthongal'
/ʀɪŋg/	→	.ʀɪŋ.	'ring'		
/ɛŋg/	→	.ɛŋ.	'narrow'		
/laŋg/	→	.laŋ.	'long'		
/laŋgmut/	→	.laŋ.mu:t.	'patience'		

In so-called Standard German (henceforth, "SG"), the super-regional standard language codified in semi-official reference works such as the *Duden* and encountered in schools, much of the media, and other official venues, the spirantization process (2b) is limited to underlying /g/ in the syllable coda after the lax vowel /ɪ/. This limited spirantization is a faint echo of a more general spirantization process, illustrated by the examples in (3), that is encountered over large sections of the northern part of the German speaking area, in what might be characterized as a regional colloquial standard (henceforth abbreviated as "CNG" for "Colloquial Northern German"). Here /g/ is replaced by a dorsal spirant in all syllable codas regardless of the preceding vowel. In derivational terms (see e.g. Wiese 1996, 212), the immediate result of spirantization is [ɣ], which devoices to [x] and is further changed into [ç] everywhere except after back vowels by the well-known allophonic dorsal fricative alternation (*ich-Laut, ach-Laut*).[6] Such across-the-board spirantization is a characteristic of many varieties of Northern speech, and it is this general version of spirantization that we will concentrate on.

(3) Spirantization in CNG

tʀu:gən	tʀu:x	'carried', 1pl/1sg
fʀa:gən	fra:x	'asked', 1pl/1sg
ly:gən	ly:çnɐ	'lie' / 'liar'
ʦo:gən	ʦo:x	'pulled', 1pl/1sg
ge:gən	ge:çnɐ	'against' / 'adversary'
ʀe:gən	ʀe:çnən	'rain' / 'to rain'
ze:gən	ze:çnən	'blessing' / 'to bless'
ve:gə	ve:ç	'way', pl/sg
fly:gə	flu:x	'flight', pl/sg
talgə	talç	'wax', dat/nom
zɛʀgə	zaʀç	'coffin', pl/sg
ʦvɛʀgə	ʦvəʀç	'dwarf', pl/sg
hambʊʀgɐ	hambʊʀç	'resident of Hamburg' / 'Hamburg'
taɪgə	taɪç	'dough', dat/nom
ʦvaɪgə	ʦvaɪç	'branch', pl/sg
ba:nʃtaɪgə	ba:nʃtaɪç	'platform', pl/sg[7]

Turning to the basic analysis of the three processes, to be further modified and developed below, all three are triggered by conditions on the syllable coda, informally summarized in (4).

(4) X is disallowed in the syllable coda, where X=
  a. voiced obstruents
  b. the segment [g]
  c. the cluster [ŋg]

We can understand such empirical generalizations about codas as positional markedness effects reducible to more elementary constraints, combined in a constraint-conjunctive way (Smolensky 1995). They are analyzable as [M&M] conjunctions, with the structural markedness constraint *COD locally conjoined with some segmental markedness constraint *X.[8] Here and throughout we understand *COD to be violated by any segment bearing a coda role.

Taking up our earlier work, we analyze the coda condition responsible for devoicing (4a) as an [M&M]-conjunction (5) (see Ito & Mester 1997b, 1998 and below for details of the constraint-conjunctive analysis, see also Féry 1998b and Kager 1999 for discussion).

(5) *VC: [*VoiObs&*Cod]

This conjoined constraint is violated by any voiced obstruent with a coda role. In order to simplify matters, we will set the local domain for the conjunction (5), and for the conjoined constraints to follow, as the syllable coda, defined as the sequence of postnuclear segments in a syllable (in some cases, as in (5), the segment would also be a suitable local domain).

Devoicing itself is the result of the ranking system in (6), where the conjoined constraint is crucially ranked higher than the relevant faithfulness constraint, which otherwise protects underlying voicing in obstruents.

(6) Ranking: *VC: [*VoiObs&*Cod] » Ident (voi) » *VoiObs, *Cod

The other two conditions have a similar constraint-conjunctive structure. Conjoining *DORSALPLOSIVE with (5), we arrive at the triply conjoined constraint (7) (assuming associativity of "&"), militating against *voiced coda dorsal plosives.*

(7) *VCD: [*VoiObs&*Cod&*DorsPlos]

Further conjoining the syllable margin constraint *COMPLEX[9] to (7), we have the quadruply conjoined constraint in (8) ruling out *voiced dorsal plosives in a complex coda.*

(8) *VCDC: [*VoiObs&*Cod&*DorsPlos&*Cmplx]

Conjoined constraints are intrinsically, and without loss of generality, ranked higher than the elementary constraints that they are composed of (Smolensky 1995). The intrinsic ranking of the three conjoined constraints is therefore as in (9).

(9) Markedness ranking:

*VCDC: [*VoiObs&*Cod&*DorsPlos&*Cmplx]

*VCD: [*VoiObs&*Cod&*DorsPlos]

*VC: [*VoiObs&*Cod]

*VoiObs *Cod *DorsPlos *Cmplx

In Optimality Theory, a phonological process is the result of a pair (M, F) of a markedness constraint M and a relevant faithfulness constraint F.[10] In this vein, the general ranking scheme (10) triggers the relevant process, depending on the type of faithfulness constraint (IDENT, MAX, DEP) being dominated by [*X&*COD] (see (11a,b,c)).

(10) [*X&*Cod] » F "X is changed in the coda, in violation of faithfulness constraint F."

(11)a. *VC » Ident(Voi) "Coda obstruents are devoiced."
b. *VCD » Ident(Cont) "Coda *g* is spirantized."
c. *VCDC » Max "Postnasal coda *g* is deleted.."

Illustrations of these preliminary analyses appear in (12a,b,c).

(12)a. *VC » Ident(voi)

/hand/ 'hand'	*VC	Ident(Voi)
hand	*!	
☞ hant		*

b. *VCD » Ident(cont)

/kø:nɪg/ 'king' .	*VCD	Ident(cont)
.kø:.nɪg.	*!	
☞ .kø:.nɪç.		*

c. *VCDC » Max

/ʀɪŋg/ 'ring'	*VCDC	Max
ʀɪŋg	*!	
☞ ʀɪŋ		*

In (12a), the coda condition against voiced obstruents dominates the faithfulness constraint against changes in voicing. The candidate [hant] wins because it fulfills the coda condition while [hand] violates it. In (12b), a coda condition against [g] dominates a faithfulness constraint militating against changes in continuancy, and the tableau shows the constraint interaction responsible for the selection of the spirantized output candidate. The tableau abstracts away from additional constraints leading to coda devoicing and dorsal fricative assimilation. In (12c), a coda condition against dorsal clusters of the form [ŋg] is violated in the first candidate [ʀɪŋg], and [ʀɪŋ] is the winner, at the price of a MAX-violation. There is more to say about spirantization and cluster simplification, in particular with respect to devoicing, and we return to these issues in section 3.

A possible (but on general grounds undesirable) ranking scheme literally depicting the three processes is given in (13), with each faithfulness constraint violated in the output immediately below the conjoined coda constraint to which it 'belongs'.

(13) *VCDC: [*VoiObs&*Cod&*DorsPlos&*Cmplx]
Max
*VCD: [*VoiObs&*Cod&*DorsPlos]
Ident(cont)
*VC: [*VoiObs&*Cod]
Ident(voi)
{*VoiObs, *Cod, *DorsPlos,*Cmplx}

*VCDC: [*VoiObs&*Cod&*DorsPlos&*Cmplx] » Max	Cluster Simplification (12c)
*VCD: [*VoiObs&*Cod&*DorsPlos] » Ident(cont)	Spirantization (12b)
*VC: [*VoiObs&*Cod] » Ident(voi)	Devoicing (12a)

This closely mimics traditional SPE-style rules, which literally amalgamate markedness (the 'structural description') with faithfulness (the 'structural change'). One of the important achievements of OT is the liberation of these components, so that there is no compulsion for the markedness constraint and the relevant faithfulness constraint to be adjacent to each other.

Another possible, and we will argue, superior ranking scheme is given in (14), with each faithfulness constraint ranked as low as possible, following a general M » F default ranking imperative.

(14)

Conjoined Markedness:	*VCDC: [*VoiObs&*Cod&*DorsPlos&*Cmplx]
	*VCD: [*VoiObs&*Cod&*DorsPlos]
	*VC: [*VoiObs&*Cod]
Faithfulness Constraints:	{Max, Ident(cont), Ident(voi)}
Elementary Markedness:	{*VoiObs, *Cod, *DorsPlos,*Cmplx}

The ranking "Faithfulness » Elementary Markedness" is obvious since German in general allows voiced obstruents, dorsals, and both simple and complex codas—the faithfulness constraints protect the marked elements from being changed. On the other hand, the conjoined markedness constraints are stronger, and faithfulness cannot demand their violation.

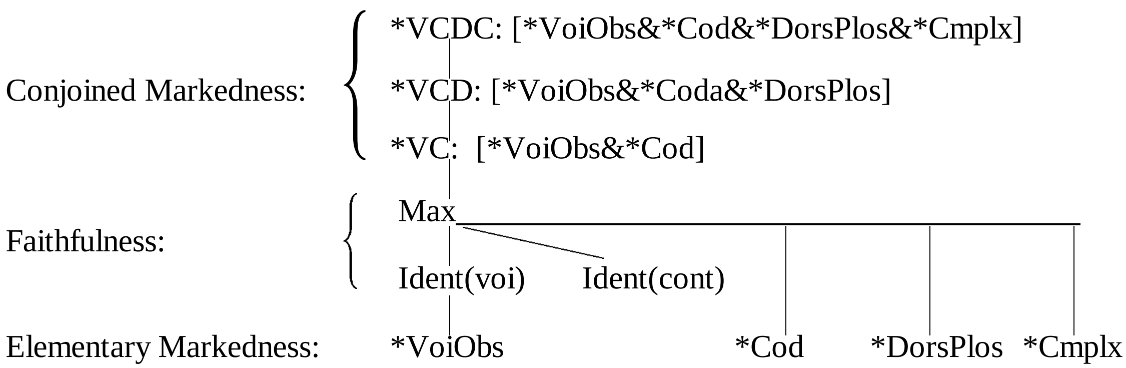
There are further rankings among the relevant faithfulness constraints themselves (to be motivated below), as indicated in (15).

(15) Faithfulness ranking:

Max
Ident(voi) Ident(cont)

The overall ranking scheme in (16) summarizes the preliminary analysis of the three processes.

(16) Overall ranking scheme:



3. [M&F] conjunctions and opacity

Having established the basic alternations to be studied, we are ready to turn to their interactions. They show opacity effects of a kind that leads us to cast a new look at the issue.

3.1. Opaque interactions I: Cluster simplification and devoicing

In rule terms (17), cluster simplification bleeds devoicing in Standard German (SG) in the singular form [dɪŋ] by removing a segment (/g/) that would otherwise be a target for devoicing. In the plural [dɪŋə], /g/ deletes as well before the ending /-ə/.

(17) SG: cluster simplification bleeds devoicing.

		/dɪŋg / 'thing', sg.	/dɪŋg+ə/ 'thing', pl.
cluster simplification:	g → Ø /[+nas] _]$_\sigma$	Ø	Ø
devoicing:	[-son] → [-voi]/_]$_\sigma$	–	–
		[dɪŋ]	[dɪŋə]

A few words are in order regarding the deletion of /g/ in the plural form [dɪŋə], which we will here, sidestepping further analysis that would take us too far afield, subsume under the rubric of "coda effects". Descriptively speaking, it is quite common in languages to find that the phonology of pre-schwa clusters is in many respects that of syllable codas (perhaps mediated through ambisyllabic parsing of pre-schwa consonants),[11] which has led analysts in the past to regard schwa as invisible for the earlier parts of the phonological derivation (see Kager 1989 and work cited there for further discussion). A more detailed analysis of German phonology would have to take full account of the fact that /ŋg/ reduces to /ŋ/ (and is in fact impossible) not only in syllable codas, but also before schwa (18a) and other reduced vowels (18b,c).

(18) a. before [ə]:

Zunge	[ʦʊŋə]	*[ʦʊŋgə]	'tongue'

Enge	[ɛŋə]	*[ɛŋgə]	'narrowness'

b. before the reduced low central vowel [ɐ]:

Finger	[fɪŋɐ]	*[fɪŋgɐ]	'finger'
Hunger	[hʊŋɐ]	*[hʊŋgɐ]	'hunger'

c. before reduced [ʊ], [ɪ]:

Bedingung	[bədɪŋʊŋ]	*[bədɪŋgʊŋ]	'condition'
abhängig	[aphɛŋɪç]	*[aphɛŋgɪç]	'dependent'

Different from English with its well-known contrasts of the *fi*[ŋg]*er* vs. *si*[ŋ]+*er* variety (19a,b), in German the ban against [ŋg] before reduced vowels holds even when no morphological boundary intervenes, as the parallel examples in (19) make clear.

(19)		**English**			**German**		
	a.	finger	*[fɪŋəɹ]	[fɪŋgəɹ]	Finger	[fɪŋɐ]	*[fɪŋgɐ]
	b.	singer	[sɪŋ+əɹ]	*[sɪŋg+əɹ]	Sänger	[zɛŋ+ɐ]	*[zɛŋg+ɐ]

Before full vowels (20a) there is no deletion of [g], and no [ŋ] in onset position, leading to contrasts as in (20b,c) (see Féry 1998a, Hall 1992, and Wiese 1996).

(20)	a.	Tango	*[taŋo]	[taŋgo]	'tango'
	b.	Inge	[ɪŋə]	*[ɪŋgə]	(woman's name)
		Ingo	*[ɪŋo]	[ɪŋgo][12]	(man's name)
	c.	Angelsachse	[aŋəlzaksə]	*[aŋgəlzaksə]	'Anglo-Saxon'
		Anglo	*[aŋlo:]	[aŋglo:]	'Anglo'

Variant pronunciations such as [gaŋgɛs]~[gaŋəs] for *Ganges*, where the absence of [g] depends on the reduction of the second syllable, make the same point. All of this shows that a strictly phonological markedness effect relating to differences between prosodically reduced and unreduced syllables is involved, not (or at least not exclusively) a faithfulness effect of the Output-Output ('cyclic') variety.

Returning to the opacity issue, a further twist adds extra interest to the cluster simplification case. (17) shows the output found in Standard German (SG). In Colloquial Northern German (CNG), another outcome is usually encountered, as illustrated in (21). Here devoicing takes precedence over cluster simplification, resulting in a (historically older) [ŋk]~[ŋ] alternation ([dɪŋk], [dɪŋə], etc.). In rule terms, devoicing bleeds cluster simplification.

(21)	CNG:		/dɪŋg / 'thing'	/dɪŋg+ə/ 'things'
	devoicing:	[-son] → [-voi]/_]$_\sigma$	k	–
	cluster simplification:	g → Ø /[+nas] _]$_\sigma$	–	Ø
			[dɪŋk]	[dɪŋə]

Since Kiparsky 1971 (see also Lass 1984 for detailed discussion), the relation between cluster simplification and devoicing in SG and CNG has served as one of the textbook examples for a relation of the mutually bleeding variety.

What demands our attention, from an OT-perspective, is the fact that one of the two varieties of German, namely SG (17), cannot be analyzed in transparent OT (understood here as consisting of nothing except markedness constraints and standard faithfulness constraints).
Before showing why this is the case, it is worth pointing out that neither (17) nor (21) exhibit opacity in the sense of the formal definition given above in (1) (repeated in (22)), showing its limited usefulness in an OT-context.

(22) A phonological rule $\mathcal{P}$ of the form *A → B / C___D* is **opaque** if there are surface structures with any of the following characteristics:
a. instances of *A* in the environment *C___D*.
b. instances of *B* derived by $\mathcal{P}$ that occur in environments other than *C___D*.

Consider the output [dɪŋ] in (17): It does not show [g] in the environment /[+nas]_]$_\sigma$ and hence does not fall under (22a). Cluster simplification is surface-true, in McCarthy's 1998 terminology. Even though it is formally not quite clear how (22) identifies deletion sites in surface structures, we observe that [dɪŋ] does not show deletion of /g/ due to cluster simplification in some other environment and therefore does not fall under (22b) either—the environment of cluster simplification is surface-apparent. Turning to devoicing, we find neither a voiced obstruent syllable-finally, nor a voiceless segment derived by devoicing in some other environment. The upshot is that (17) shown no opacity at all, in terms of the definition (the same holds for (21), as the reader can verify): Mutual bleeding, in these terms, is not an issue of opacity, but of paradigm uniformity. This way of partitioning the facts makes some sense from the perspective of rule ordering (since mutual bleeding cannot be cured by reordering), but it has no general claim to validity.[13]

In what way, then, does the opacity issue come up in the context of OT? In terms of the basic description arrived at in section 1 (see (11)), we need to combine two subrankings. On the one hand, there is the ranking responsible for devoicing (expanded in (23) to show the position of MAX).

(23) devoicing (see (2) above): *VC: [*VoiObs&*Cod]
|
Max
|
Ident(voi)

Crucial for the analysis is the low position of IDENT(VOI), which is dominated by both *VC and MAX. The ranking *VC » MAX follows from the general M»F ranking scheme (see below for further arguments). The basic effects of this ranking are illustrated in (24).

(24)

/taːg/ 'day'	*VC	Max	Ident(voi)
taːg	*!		
☞ taːk			*
taː		*!	

The second ingredient is the ranking responsible for cluster simplification (25).

(25) *VCDC: [*VoiObs&*Cod&*DorsPlos&*Cmplx]
|
Max

Given that *VCDC contains *VC as a constituent constraint, *VCDC »*VC holds on general grounds (Smolensky 1995). Overlaying the two partial rankings in a single unified hierarchy produces (26).

(26) *VCDC: [*VoiObs&*Cod&*DorsPlos&*Cmplx]
|
*VC: [*VoiObs&*Cod]
|
Max
|
Ident(voi)

The results seen are illustrated in (27). For the input /dɪŋg/, the winner is [dɪŋk].

(27)

/dɪŋg/		*VCDC	*VC	Max	Ident(voi)
	dɪŋg	*!	*		
☞CNG	dɪŋk				*
☹ SG	dɪŋ			*!	

This analysis chooses the correct winner [diŋk] for CNG, but fails to select the correct winner [dɪŋ] for SG. The only way for [dɪŋ] to come out as the winner in SG is to rerank MAX and IDENT(VOI), but this is not feasible: MAX » IDENT(VOI) is basic for both SG and CNG since it determines the correct way of dealing with syllable-final voiced obstruents (see (24): by devoicing, not by deletion). This illustrates again the familiar failure of the basic model of OT

(Prince & Smolensky 1993) to come to terms with opaque interactions, such as the one resulting in the SG form. Thus, an important result here is that the expectation that rule-reordering analyses (see (17) vs. (21)) will readily translate into straightforward constraint-reranking analyses turns out to be too naive.

3.2 Nonsolutions to opacity

At first glance, one might hope to make the whole opacity problem disappear by forcing inputs to be in some sense more concrete, more similar to the output. And indeed, once /dɪŋ/ is posited as the input for SG instead of /dɪŋg/,[14] the opacity issue for this and similar examples goes away. This is certainly true—but such legislation on inputs fails to take into account *Richness of the Base* (Prince & Smolensky 1993), which requires grammars to be able to deal with all inputs, including /...ŋg/-inputs such as /dɪŋg/. Nothing in an OT-grammar is able to restrict the set of inputs to those with certain desirable properties. It is important to reason carefully at this point, since *Richness of the Base* is a concept that can be misunderstood. It does not per se require a grammar of SG to turn a hypothetical input /dɪŋg/ into [dɪŋ]—everything else being equal, any other phonotactically wellformed output would also do, including [dɪŋk], as in (27). But in this case, everything else is not equal since there are further demands on the grammar that disqualify [dɪŋk] as the output assigned to the input /dɪŋg/: We know from overt alternations such as *diphtho*[ŋg]*al* ~ *Diphtho*[ŋ] that the outcome for actual /...ŋg/ inputs is in fact [... ŋ]. This is what a transparent analysis along the lines of (27) cannot deliver, as shown above, and the insistence on /dɪŋ/ as the underlying form for surface [dɪŋ] does not change this.

The concretist attempt to solve the opacity problem by denying it thus falters because of the presence of overt alternations. In keeping with one of the most basic insights of modern linguistics, we take such entirely regular cases of allomorphy to demand inputs that are potentially more abstract than any particular surface allomorph, in order to be able to express the constant morphemic element underlying its various surface exponents (see Kenstowicz and Kisseberth 1979 for a survey of the arguments, whose fundamental validity is not affected through the shift of perspective that comes with the ascent of OT as the guiding framework).

How, then, can the opaque interaction be captured in OT? One line of attack consists in recreating the conditions under which the alternation is obtained in a sequential system. Concretely speaking, one might try to set things up in such a way that devoicing does not come in the way of cluster simplification. The most direct method of achieving this is to import sequentialism into OT by setting up a word-internal level (by pure stipulation, it appears) where cluster simplification takes place, but not devoicing. This requires two different constraint systems for the two levels, with different rankings, as in (28) and (29). The output of level 1 serves as the input to level 2.

At level 1 devoicing is turned off, but cluster simplification is in operation, so /dɪŋg/ will turn into /dɪŋ/ but /taːg/ remains /taːg/ as the output of level 1. At level 2, devoicing is active, so the final outputs emerge correctly as [dɪŋ] and [taːk], respectively. This setup produces the right outcome and may sound attractive, but problems are not far afield. "Switching off" devoicing while keeping cluster simplification in operation at level 1 appears innocuous as long as one thinks of them as traditional phonological operations, each with its own structural change and structural description. Operations are independent of each other, and it is natural that they should be assignable to different levels, as in rule-based Lexical Phonology. But OT is more interactive than that, and it turns out, as indicated in (28), that something more is needed besides the minimal reranking of the crucial faithfulness constraint IDENT(VOI) above *VC to 'turn off' devoicing.

(28) Level 1:

*VCDC:[*VoiObs&*Cod&*DorsPlos&*Cmplx]
|
→Ident(voi)
| (↕!!)
→Max
|
*VC:[*VoiObs&*Cod]

Input-Output mappings at level 1:/dɪŋg/→/dɪŋ/, /taːg/→/taːg/

(29) Level 2:

*VCDC:[*VoiObs&*Cod&*DorsPlos&*Cmplx]
|
*VC:[*VoiObs&*Cod]
|
Max
|
Ident(voi)

Input-Output mappings at level 2:/dɪŋ/→[dɪŋ], /taːg/→[taːk]

Not only must MAX move along with IDENT(VOI) (otherwise all voiced coda obstruents would be deleted at level 1 instead of waiting to be devoiced at level 2)—in moving up the hierarchy together, the two faithfulness constraints must in addition be flipped in their ranking (as indicated by the arrows in (28)).[15] Otherwise the /g/ of /ŋg/-clusters in codas would not be deleted, but, somewhat ironically, still be devoiced at level 1.

Besides the deus-ex-machina character of the level distinction itself, the additionally necessary manipulations indicate that this mode of phonological analysis, in spite of time-honored tradition, holds little promise as far as further insight into opaque interactions is concerned. Such are the reasons, more than any a priori objections to levels and derivations, that have led researchers to become widely disenchanted with sequential level analyses.[16]

Surprisingly, the attempt to preserve the gist of the sequentialist account in a strictly parallelist setup by means of sympathy (McCarthy 1997, 1998) fares little better than the sequential level account. We argue elsewhere (Ito & Mester in prep.) that Sympathy Theory is in principle unable to deal with all opacity phenomena and will therefore keep our remarks here to a minimum. The general problem lies, in a nutshell, in the restriction limiting the constraints responsible for selecting sympathy candidates to the class of faithfulness constraints.[17] This predicts that opaque interactions should always feature winners that are hyperfaithful to the input (more faithful than what the transparent faithfulness system predicts). Opacity as hyperfaithfulness works for many examples from the phonological literature involving morphophonemic processes, but it fails for a subclass of the perhaps most solid group of opaque interactions—those involving at least one allophonic alternation. The reason is that allophonic alternations involve features whose input specifications do not matter in OT (e.g., /x/ vs. /ç/ are both viable inputs for the German dorsal fricative) and are therefore 'free'. This means that an opaquely appearing [ç] (i.e., in a surface context where [x] is expected) cannot be obtained by hyperfaithfulness to any input—there is no 'right' input to inspect since nothing fixes the input specification as /ç/. An attempt to derive such effects by Sympathy would necessitate imposing specific constraints on inputs, contrary to the fundamental OT-principle of *Richness of the Base*. Although Sympathy remains a candidate for the more modest role of a partial theory, it seems clear that it cannot be an exhaustive theory of opacity.

The opacity case under discussion here does not belong to this intractable variety. Even so, a sympathy analysis has problems of its own in terms of gratuitous stipulations that are quite similar to the sequentialist level account. We do not have space here for a full exposition of the case, but the basic line of analysis is clear enough. In order to produce a more favorable playing field for *VCDC (disallowing voiced dorsal coda complexes) where devoicing does not interfere, the sympathy candidate should be chosen among the non-devoicing candidates, which points to IDENT(VOI) as the selector constraint (indicated by superscripted ❀ in (30). Since the intended sympathy candidate shows deletion of /g/ instead of devoicing, we set the sympathetic faithfulness constraint as ❀O-DEP (in the notation introduced in Ito & Mester 1997b and used in a number of the works cited earlier).

We continue to abide by the general ranking principle proposed and argued for in Ito & Mester (to appear), viz., that faithfulness constraints are—ceteris paribus— always ranked as low as possible. Loosely speaking, the system always assumes the state with the lowest possible level of energy. In (30), the ranking responsible for the actual absence of [g] in the output is ❀O-DEP » MAX (since the MAX-violation in (27) of the deletion-candidate [dɪŋ] in SG has to be matched by a higher violation mark in [dɪŋk]).

(30) *VCDC:[*VoiObs&*Cod&*DorsPlos&*Cmplx]
|
❀O-Dep
|
*VC:[*VoiObs&*Cod]
|
Max
|
IO-Ident(voi)❀

Under this analysis, the sympathy candidate itself turns out to be the winner (31a).

(31)

a. /dɪŋg/	*VCDC	❀O-Dep	*VC	Max	IO-Ident (voi)❀
dɪŋg	*!	*	*		
dɪŋk		*!			*
☞ ❀ dɪŋ				*	

b. /taːg/					
[taːg]		*!	*		
☹ [taːk]		*!			*
☞!! ❀ [taː]				*	

☞!! wrong winner selected by the competition in the tableau
☹ actual output form (a loser in the tableau)

But as (31b) shows, in order for the straightforward case of devoicing (/taːg/ → [taːk], etc.), which involves no opaque interaction, to come out correctly, the ranking in (30) will not do, since the deleting sympathy-candidate (here, *taː*) again self-selects as the overall winner. It needs to be ensured, therefore, that [taːg] becomes the ❀-candidate and not [taː]. This can be accomplished by ranking MAX above *VC, deviating from the default ranking in (30), where MAX is ranked as low as possible.

(32) *VCDC:[*VoiObs&*Cod&*DorsPlos&*Cmplx]
|
❀O-Dep
|
Max
|
*VC:[*VoiObs&*Cod]
|
IO-Ident(voi)❀

Tableau (33) shows how this ranking manages to produce the right winner for simple devoicing examples.

(33)

/taːg/	*VCDC	❀O-Dep	Max	*VC	IO-Ident (voi)❀
❀ [taːg]	*!			*	
☞ [taːk]					*
[taː]			*!		

The crucial point here is that the ranking MAX »*VC is imported into the system from outside in order to be able to choose the sympathy candidate, and is not pre-established by the transparent phonology (in fact, as pointed out above, default M»F ordering pre-establishes the opposite ranking).

(32) and (33) highlight the considerable cost incurred by the attempt to come to terms with phonological opacity by means of sympathy. Upon closer inspection, sympathy turns out to be not simply additive to the basic setup of the grammar induced on the basis of the transparent phonology (which surely takes acquisitional precedence). Rather, in order to be workable, sympathy requires further reranking of constraints in order to ensure that basic properties of the language to be generated are still correctly captured. Looking beyond the not insignificant analytical accomplishment of producing the right result, the fundamental problem in terms of

explanation is similar to the one encountered by the sequential level approach (which is not too surprising, since sympathy simulates sequentialism). Taken together with the fact that Sympathy Theory, in spite of its claim to provide a general solution to all of opacity, falls short of achieving this goal (see the earlier discussion and Ito & Mester (in preparation)), this appears to be sufficient grounds to look for an explanation elsewhere.

3.3. Opacity as a constraint conjunction effect

In order to get started, let us approach the opacity issue from a new angle. The basic trouble is created by the fact that deletion is supposed to affect /g/ after /ŋ/, but in the output /g/ would independently turn into [k] by devoicing, so why delete anything? The sequentialist's answer: Because at the point of deletion, the devoicing option is still hidden behind the veil of ordering. A fundamentally different perspective emerges in cases such as this one by asking a different question: Why is the phenomenon under discussion conceived of as deletion specifically of /g/ in the first place? Why not instead as deletion of any dorsal plosive? After all, we find pervasive [k]~Ø alternations in CNG ([dɪŋk]~[dɪŋə], etc.), and it would be natural to look at the SG variants as arising through deletion of [k] in these cases.

At first glance, the idea behind the question seems hopelessly naive. Generalized post-ŋ deletion of dorsals simply cannot work since we know that deletion only affects those [k] that derive from underlying /g/, not [k] deriving from underlying /k/ (/baŋk/→[baŋk], *[baŋ], etc.). This is what the sequentialist approach to opaque interactions capitalizes on, thriving on the hidden potentials of long and complex derivations, with operations applying to certain elements before they have turned into other elements (deleting post-ŋ /g/ before it has turned into /k/, etc.).

The way we just stated the issue suggests another line of attack, however. Deletion applies to *phonologically derived* dorsals (derived by violating voicing faithfulness), it does not affect *phonologically underived* dorsals. Loosely speaking, instead of deleting /g/ before it turns into [k], one can also delete all post-ŋ dorsal plosives in syllable codas, whether voiced or voiceless, provided they are phonologically derived. We see here a new connection between two classical themes of phonological theory, opacity and phonological derivedness, that is worth exploring. Of course, the notion 'phonologically derived' is itself a liability for an output-oriented framework like OT. To the extent that the theory can deal with the phonological derivedness issue, it can also deal with opaque interactions that can be characterized in such terms. It is at this point that recent work by Lubowicz 1998 on derived environments in OT becomes important.

Consider first the generalization of the constraint against [ŋg]-codas to a constraint against all dorsal complexes in codas in (34). This is a conjunction of the three constraints *COD, *DORSPLOS, and *CMPLX (i.e., without *VOIOBS), ruling out both [ŋg] and [ŋk] as complex codas.[18]

(34) *CDC: [*Cod&*DorsPlos&*Cmplx]

Substituting the new constraint *CDC for the previous *VCDC constraint, we derive the correct winner [dɪŋ] for SG, as shown in (35).[19]

(35)

/dɪŋg/ 'thing'	*CDC	*VC	Max	Ident(voi)
dɪŋg	*!	*		
dɪŋk	*!			*
☞ dɪŋ			*	

As already pointed out above, generalizing the constraint in this way and ruling out both [ŋg] and [ŋk] is problematic for underlying [ŋk], which wrongly also loses its final dorsal:

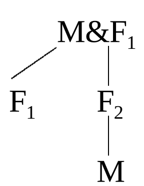
(36)

/baŋk/ 'bank'	*CDC	*VC	Max	Ident(voi)
baŋg	*!	*		
☹ baŋk	*!			*
☞!! baŋ			*	

But all is not lost since the relevant distinction here can be made in terms of the notion 'phonologically derived': Voiceless complex dorsal codas are disallowed when derived by devoicing (i.e., *[dɪŋk] from /dɪŋg/), but not when they are underlying (i.e., [baŋk] from /baŋk/). In OT, an output candidate's profile of faithfulness violations is a direct and complete record of its derivedness. Lubowicz's 1998 proposal makes use of this fact. Her idea is, in a nutshell, that a markedness constraint M will appear to apply only in phonologically derived environments when it is conjoined with some faithfulness constraint F. The crucial point is that the output candidates violating such an [M&F] constraint are those unfaithful candidates (i.e., not faithful to the input candidate with respect to F) that are in addition burdened with a violation of M. Phonological derivedness always involves a faithfulness violation: a segment has changed some of its properties from is input state. For the case at hand, the relevant [M&F] conjunction is [*CDC&IDENT(VOI)], conjoining *CDC, the constraint against coda dorsal complexes, with IDENT(VOI), the faithfulness constraint against a change in voicing. It is clear that [ŋk]-codas 'derived' by devoicing (i.e., [dɪŋk] from /dɪŋg/) will violate this conjoined constraint, but underlying ('underived') [ŋk]-codas (i.e., [baŋk] from /baŋk/) will not, since they do not violate the faithfulness constraint IDENT(VOI).

How do such conjoined constraints have an effect? Consider the constraint ranking configuration in (37). F_1 and F_2 are faithfulness constraints; M is a markedness constraint crucially dominated by F_2, which will make M inactive under normal circumstances. M&F_1, a conjunction of the markedness-cum-faithfulness variety, takes precedence over F_2. This has an important consequence for situations where F_1 is bound to be violated under the pressure of higher constraints (these situations include the derived environments that are of interest here): With M&F_1 » F_2 and F_1's violation unavoidable, it becomes more important to fulfill M than F_2. In other words, M has in effect been promoted beyond F_2—is 'active'—in derived environments (i.e., when F_1 is violated), and remains otherwise inactive because of F_2 »M.

(37)



Returning to the concrete case at hand, our proposal appears in (38). It involves a conjunction of Markedness (*CDC: [*COD&*DORSPLOS&*CMPLX]$_{coda}$) and Faithfulness (IDENT(VOI)), ranked in the following way:

(38) *VC:[*VoiObs&*Cod]
 [***CDC**:[*Cod&*DorsPlos&*Cmplx] **& Ident(voi)**]
 Max
 ***CDC**:[*Cod&*DorsPlos&*Cmplx]
 Ident(voi)

*CDC is ranked *below* MAX, making segment deletion impossible in the general case. But [*CDC & IDENT(VOI)], its conjunction with the voicing faithfulness constraint, is ranked *above* MAX. For a segment forced to violate IDENT(VOI) (because of *VC » IDENT(VOI)), an additional violation of *CDC would trigger a violation of the conjoined constraint. It is therefore preferable to violate MAX in this case. As a result, we find deletion of derived [k] in complex dorsal codas (cf. the diphthongization and palatalization cases in Lubowicz 1998). This M&F analysis is illustrated in (39).

(39)

/dɪŋg/	*VC	[*CDC&Ident(voi)]	Max	*CDC	Ident(voi)
dɪŋg	*!			*	
dɪŋk		*!		*	*
☞ dɪŋ			*		

(40), the control case, shows that no deletion takes place when *CDC is not activated as part of the high-ranking M&F-conjunction (because no violation of voicing faithfulness is forced in the winning candidate).

(40)

/baŋk/	*VC	[*CDC&Ident(voi)]	Max	*CDC	Ident(voi)
baŋg	*!	*		*	*
☞ baŋk				*	
baŋ			*!		

For northern German (CNG), the conjoined constraint ranks below MAX, so segments are preserved in both cases, resulting in /dɪŋg/ → [dɪŋk] alongside /baŋk/ → [baŋk].

The [M&F] conjunction analysis of the /dɪŋg/→[dɪŋ], /baŋk/→[baŋk] case brings out a crucial difference between the classical cases of phonologically derived environment effects reconsidered by Lubowicz 1998 and the general [M&F] situation (markedness constraints promoted by faithfulness). Note that the [M&F] analysis given above has no direct counterpart in a sequentialist rule approach: The mere fact that a /k/ has been derived from /g/ does not produce a phonologically derived environment for a general dorsal deletion process of the form: [+dorsal] → Ø / ŋ_ $]_\sigma$. The fact that the structural description of the rule is met by some /k/ has nothing to do with whether or not this /k/ has been derived from /g/ by an earlier application of a phonological rule. This would only be the case if the dorsal deletion rule were stated in a redundant way so as to specifically apply to /k/ and not to /g/, i.e., by adding a (process-wise superfluous) reference to [−voiced]: [+dors, -voi] → Ø / ŋ_ $]_{\sigma}$. On the other hand, in parallelist OT a devoiced [k] in the output corresponding to a /g/ in the input triggers a faithfulness violation. This activates the markedness constraint *CDC through [M&F] conjunction even though the markedness constraint does not refer to the feature [voice]. It is perhaps an advantage of the parallelist [M&F] approach that it derives the result through the activity of the more general constraint.

3.4. Opaque interactions II: spirantization and devoicing

Devoicing also enters into an opaque interaction with spirantization. Concentrating again on the general and fully productive spirantization process (see (3) above), we find this manifested in the fact that, instead of devoicing to [k], syllable-final /g/, if not post-nasal, turns into a dorsal fricative (which is of course also devoiced). In rule terms, this is a counterbleeding interaction (41).

(41)			/hoːnɪg/ 'honey'	/fluːg/ 'flight'
	spirantization:	g → [+cont] / _ $]_{\sigma}$	ɣ	ɣ
	devoicing:	[-son] → [-voi] / _ $]_{\sigma}$	x	x
	(dorsal fricative allophony)		[hoːnɪç]	[fluːx]

Since the contrast between /g/ and /k/ is neutralized to /k/ syllable-finally, we note immediately, in the light of the previous section, that the crucial point to be captured is that spirantization only affects [k] derived from underlying /g/ (41), not to [k] derived from underlying /k/ (42).

(42)			
	Derri[k]	*Derri[ç]	(name of television detective)
	Bati[k]	*Ba:ti[ç]	'batik'
	dick	*di[ç]	'fat'
	Plasti[k]	*Plasti[ç]	'plastic'

The parts of the hierarchy developed in section 2 relevant for spirantization (*VCD » IDENT(CONT)) and coda devoicing (*VC » MAX » IDENT(VOI)) are repeated in (43).

(43) *VCD: [*VoiObs&*Cod&*DorsPlos]
|
*VC: [*VoiObs&*Cod]
|
Max
|
Ident(cont)   Ident(voi)

Tableau (44) shows how this transparent analysis fails. The wrong winner [hoːnik] is selected by the competition, and no reranking of constraints can ameliorate the situation since the violations of the wrong winner (IDENT(VOI)) constitute a proper subset of the violations of the actual output form (IDENT(VOI) and IDENT(CONT)).[20]

(44)

/hoːnɪg/	* VCD	*VC	Max	Ident(cont)	Ident(voi)
[hoːnɪg]	*!	*			
[hoːnɪγ]		*!		*	
[hoːnɪ]			*!		
☞ !! [hoːnik]					*
☹ [hoːnɪç]				*!	*

At first glance, a workable sympathy analysis appears within reach. If the spirantized non-devoiced candidate [ho:nɪγ] is the ❀-candidate, then a sympathetic faithfulness constraint ❀O-IDENT(CONT) chooses the correct winner [ho:nɪç]. However, as things stand, no selector constraint picks out [ho:nɪγ] as the ❀-candidate, as inspection of (44) makes clear. MAX and IDENT(CONT) select [ho:nɪk], and IDENT(VOI) selects [ho:nɪ] (the latter does not violate IDENT(VOI)). In order for the selector constraint IDENT(VOI) to pick out the desired ❀-candidate, the ranking between *VC and MAX would have to be reversed, against the general M»F scheme. The same kind of issue arose in the previous section in connection with cluster simplification, and it appears that we are dealing with a problem of some generality.

Even granting the ranking adjustment, the sympathy analysis has another problem, which it shares with the derivational counterpart that it simulates. The segment [ɣ], which is not a possible surface segment in any of the varieties of German under consideration, appears at the intermediate stage of the derivational analysis (41), and in the ❀-candidate in the sympathy analysis (45). This abstractness problem manifests itself in an odd property of the sympathy analysis: The markedness constraint *ɣ must be dominated by *VCD (ruling out [g] in codas) in order for the desired ❀-candidate [ho:nɪɣ] to win over [ho:nɪg]—but *ɣ is otherwise entirely undominated in the language, whereas the segment [g] occurs freely outside of coda contexts.

(45)

/hoːnɪg/	*VCD	Max	*VC	❀O-Ident(cont)	IO-Ident(cont)	IO-Ident(voi)
[hoːnɪg]	*!		*	*		
❀ [hoːnɪγ]			*!		*	
[hoːnɪ]		*!				
[hoːnik]				*!		*
☞ [hoːnɪç]					*!	*

A far superior way of resolving the opacity issue is provided by the [M&F] approach developed earlier. The first step is to generalize the constraint *VCD (46) targeting [g] in codas to *CD (47) targeting both [g] and [k] in codas.

(46) *VCD: [*VoiObs&*Cod&*DorsPlos]

(47) *CD: [*Cod&*DorsPlos]

With this generalized constraint *CD, tableau (48) shows how the correct winning candidate is chosen.

(48)

/hoːnɪg/	*VC	*CD	Max	Ident(cont)	Ident(voi)
[hoːnɪg]	*!	*	*		
[hoːnɪɣ]	*!			*	
[hoːnɪ]			*!		
[hoːnik]		*!			*
☞ [hoːnɪç]				*!	*

As before, this transparent analysis goes wrong for input /k/ (49).

(49)

/plastɪk/	*VC	*CD	Max	Ident(cont)	Ident(voi)
[plastɪg]	*!		*		
[plastɪɣ]	*!			*	
[plastɪ]			*!		
☹ [plastɪk]		*!			*
☞!! [plastɪç]				*!	*

The [M&F] strategy is clear: The markedness constraint *CD is active only in conjunction with the faithfulness constraint IDENT(VOI)—i.e., only when we encounter a derived [k] stemming from /g/ (48), and not from /k/ (49). The ranking in (50) places IDENT(CONT) between the conjoined constraint [*CD & IDENT(VOI)] and the unconjoined markedness constraint *CD, with the result that spirantization is forced by the [M&F] conjunction, but not by the unadorned markedness constraint.[21]

(50) *VC [***CD**:[*Cod&*DorsPlos] **& Ident(voi)**]

Max

Ident(cont)

***CD**: [*Cod&*DorsPlos]

Ident(voi)

The workings of this analysis can be verified in tableaux (51) and (52).[22]

(51)

/hoːnɪg/	*VC	[*CD&Ident(voi)]	Max	Ident(cont)	*CD	Ident(voi)
[hoːnɪg]	*!				*	
[hoːnɪγ]	*!			*		
[hoːnɪ]			*!			
[hoːnik]		*!			*	*
☞ [hoːnɪç]				*		*

(52)

/plastɪk/	*VC	[*CD&Ident(voi)]	Max	Ident(cont)	*CD	Ident(voi)
[plastɪg]	*!				*	*
[plastɪγ]	*!			*		*
[plastɪ]			*!			
☞ [plastɪk]					*	
[plastɪç]				*!		

The full constraint ranking for the two opaque interactions studied in this section and the previous one is given in (53).

(53)

*VC: [*VoiObs&*Cod]
|
[*CDC:[*Cod&*DorsPlos&*Cmplx] & Ident(voi)]
|
[*CD:[*Cod&*DorsPlos] & Ident(voi)]
|
Max
|
Ident(cont)
|
*CDC:[*Cod&*DorsPlos&*Cmplx]
|
*CD:[*Cod&*DorsPlos]
|
Ident(voi)

*VC, as a pure markedness constraint, is ranked highest for perspicuity. Ident(cont) must be ranked above *CDC so that /baŋk/ does not become *[baŋx]. All other rankings are either intrinsic or motivated above.

In a final step, we can now divorce empirical processes (such as dorsal spirantization or dorsal deletion) and the grammatical constraints underlying them even further, resulting in a significant simplification of the analysis. Looking at the integrated hierarchy in (53), we see that both alternations can be reduced to the action of the same constraint, *CD. The duplication in our analysis, made obvious in (53), arose because the constraint-based analysis was too closely modeled on processual precursors, usually a less than optimal way of proceeding. Reducing everything to *CD requires steering the outcome towards the right kind of repair in each case: The way to comply with the ban against codaic dorsal plosives, with the derived-environment proviso discussed, is in general by spirantization, but post-nasally by deletion. If spirantization also affected post-nasal dorsals in codas, the result would be a dorsal cluster of the form nasal+fricative (most plausibly, ŋç]$_{\sigma}$),[23] violating a stricture-related ban against such sequences (see Padgett 1995). Pending further study of the clustering restriction, we invoke the composite constraint *NASFRIC&*COD&*DORS against codaic dorsal complexes of the form nasal+fricative. Ranking this constraint above MAX, the hierarchy in (54) achieves the desired results.

(54) *VC: [*VoiObs&*Cod] *NFCD: [*NasFric&*Cod&*Dors]

[*CD:[*Cod&*DorsPlos] & Ident(voi)]

Max

Ident(cont)

*CD:[*Cod&*DorsPlos]

Ident(voi)

*CD is the trigger of all dorsal plosive processes under investigation. As seen earlier, its effects are limited by *CD&IDENT(VOI) (faithlessness-enhanced markedness), restricting its scope to voice-wise derived [k]. The canonical way of resolving *CD-violations falls to IDENT(CONT), unless forstalled by *NFCD. We conclude with the two tableaux in (55) and (56) showing how the simplified hierachy derives the examples *Honig* and (Standard German) *Ding*.

(55)

/hoːnɪg/	*VC	*NFCD	[*CD&Id(voi)]	Max	Id(cont)	*CD	Id(voi)
[hoːnɪg]	*!					*	
[hoːnɪɣ]	*!				*		
[hoːnɪ]				*!			
[hoːnik]			*!			*	*
☞ [hoːnɪç]					*		*

(56)

/dɪŋg/ SG	*VC	*NFCD	[*CD&Id(voi)]	Max	Id(cont)	*CD	Id(voi)
[dɪŋg]	*!					*	
[dɪŋɣ]	*!				*		
☞ [dɪŋ]				*!			
[dɪŋk]			*!			*	*
[dɪŋx]		*!			*		*
[dɪŋç]		*!			*		*

4. Conclusion

We have attempted to use a small portion of the syllable-related phonology of German to cast some light on the general issue of opacity in phonology: How can opacity arise in an output-oriented framework such as Optimality Theory? Our investigation underscores, first of all, the general finding that opacity is a solid fact of phonological life. It cannot be set aside as a phenomenon restricted to morphophonemic alternations of limited productivity, but is found in interactions involving entirely productive and otherwise surface-true generalizations (see also McCarthy 1998).

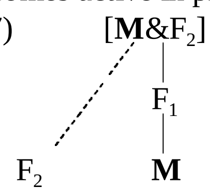
We have argued that the quest for a catch-all mechanism able to deal with all facets of opacity—be it a scaled-down version of sequentialism imported into OT (McCarthy & Prince 1993, Kiparsky 1998), or Sympathy Theory (McCarthy 1998)—has remained unsuccessful and might be in principle incorrect. What emerges instead is a picture with several sources of opacity, where different components of an optimality-theoretic grammar contribute to the appearance of opaque patterns in outputs.

On the one hand, we continue to assume that, within the overall computation of phonological form, word phonology and phrase phonology constitute separate modules whose interaction is serial. This immediately entails that some opaque patterns will find their explanation in the interaction of these two different phonological modules, much as in traditional derivational phonology (see Ito & Mester (in preparation) for possible examples of this kind). Identifying the serial character of the word/phrase interface with the specific framework of Lexical Phonology would be misleading, it harks back, rather, to a fundamental distinction made by most past and present models of phonology. Most importantly, it provides no grounds to expect that word phonology itself should have an internal serial ('level-ordered') articulation.

On the other hand, there are sources of opacity within OT's parellelist architecture itself. Sympathy remains a live issue, even though fraught with problems, as we have shown. The most interesting result of our study is that certain types of constraint conjunction of the [M&F] type (markedness locally conjoined with faithfulness) that were originally studied for altogether different purposes turn out to be responsible for a certain type of opacity effect.

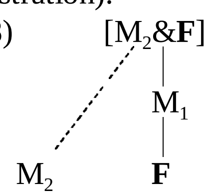
Needless to say, many open questions remain. Most pressing, perhaps, is the further study of the power and limits of local constraint conjunction. Besides issues of conjoinability and locality (what kinds of constraints can be conjoined, and what are the local domains?), more specific questions arise in the area of [M&F]-conjunctions studied here and in Lubowicz's 1998 work. The cases studied here all have the character of "M-over-F promotion", as schematically indicated in (57): M, through conjunction with F_2 whose violation is in certain environments unavoidable, becomes active in precisely those environments at the cost of F_1.

(57)



Pursuing an independent line of investigation, Ito & Mester 1998 found that the opposite kind of effect, "F-over-M-promotion" (58), does not seem to be attested (see the work cited for an illustration).[24]

(58)



In (58), F is normally made inactive by M_1, with one exception: When an M_2 violation is unavoidable, it is being compensated for by extra F-faithfulness. This kind of "faithfulness-for-markedness"-exchange is apparently absent from the phonologies of natural languages.
What is needed, then, is a way of constructing composite constraints out of elementary constraints from which it naturally, not stipulatorily, follows that (57) is licit, but (58) is not.
This task, however, we must leave to future endeavors.

Notes

1. This material was presented at the 1998 Tübinger Silbenkonferenz, the 1998 Berlin Prosodic Phonology Workshop, the 1998 Kobe Phonology Forum, and the 1999 Tsukuba Phonology Workshop, as well as in seminars at Tübingen University (Summer 1998) and UC Santa Cruz (Fall 1998). We would like to thank the participants at these arious occasions for helpful comments, in particular, Stuart Davis, Caroline Féry, Tracy Hall, Shosuke Haraguchi, Paul Kiparsky, Ursula Kleinhenz, Haruo Kubozono, John McCarthy, Jaye Padgett, Alan Prince, Philip Spaelti, Hubert Truckenbrodt, Ruben van de Vijver, Sten Vikner, and Richard Wiese. A revised version of the paper will appear in a volume on the structure and typology of the syllable edited by Féry and van de Vijver based on the contributions to the Tübingen conference.

2. Including Davis 1997, Dinnsen et al.1998, Ito & Mester 1997a,b, Karvonen & Sherman 1997, Katayama 1998, Walker 1998, and the papers collected in Karvonen, Katayama, and Walker 1997.

3. The most serious problem arises with allophonic alternations involving featural distinctions whose input specifications do not matter in OT (see section 3.2 below for discussion).

4. See McCarthy and Prince 1993 for an early OT model with levels, and Kiparsky 1998 for recent further developments.

5. There are many further examples of of the syllable-final sequence [ɪç] deriving from /ɪg/, such as (in orthography) *Essig* 'vinegar', *sechzig* 'sixty', *ewig* 'eternal', *Hallig* (small island in the North Sea), *Hedwig* (pers. name), *Käfig* 'cage', *Schleswig* (name of province), *Pfennig* 'penny', *Venedig* 'Venice', etc. A recent computer-based backwards dictionary of German lists almost 5000 examples where this replacement is found in word-final position alone. Note that there are underlying /ç/'s that do not alternate with [g], such as *Krani*[ç], *Krani*[ç]*e* 'crane, sg./pl.' (**Krani*[g]*e*), or the adverb suffix *-lich* (e.g., *freund-li*[ç], *freund-li*[ç]*e* 'friendly, attr/pred').

6. Interestingly, one of the intermediate steps, namely /ɣ/, is not a licit segment in the varieties of German under discussion here. Historically speaking, the [g]~[x/ç] alternation seems to have developed in varieties of German that had a broader weakening of velars, not only in coda position. In these dialects, syllable-final [x/ç] corresponds to [ɣ/j] in other environments: [tʀuːɣən]~[tʀuːx], [fʀaːɣən]~[fʀaːx], [lyːjən]~[ly:çnɐ] etc. The modern northern colloquial language has inherited only part of this transparent allophonic setup, lacking the segment [ɣ] (probably under the pressure of the standard)—hence the opacity of the interaction. Situations

such as this one are routinely found in sociolinguistic and dialect studies and show that phonology must be able to come to terms with opaque interactions, which requires a theory with a certain degree of abstraction and formal structure.

7. The last three examples might also belong in the /ɪg/-group for many speakers of the standard dialect, see Wiese 1996.

8. For an alternative approach making use of positional faithfulness (where onset, as a prominent position, bestows higher faithfulness on segments than nonprominent positions), see Lombardi (to appear), Beckman 1997, among others. As Zoll 1998 and Kager 1999 have shown, positional markedness is necessary independent of positional faithfulness. For the type of case under investigation here, laryngeally marked codas are avoided independent of faithfulness considerations. Thus different from onsets, codas are not suitable targets for the association of mobile aspiration or other laryngeal features in systems with "floating autosegments". This can not be understood as enhanced faithfulness in onsets (in fact, positional faithfulness makes counterfactual predictions in this area), and shows, rather, that the common thread uniting the greater inventory found in prominent positions and their greater capacity to absorb superimposed features must be sought not in faithfulness, but in a more basic phonetic/phonological factor, viz., the markedness differential between the two kinds of positions.

9. Even through we will refrain from doing so in the interest of perspicuity, *COMPLEX can be reduced to then local conjunction of *COD&*COD, with *COD understood as a constraint on segments with coda roles, as mentioned above.

10. We assume that F is the lowest-ranking relevant faithfulness constraint, the one whose violation leads to a satisfaction of M. This will be the case if the following holds (letting $\mathscr{F}$ stand for the set of faithfulness constraints conflicting with M): $\forall G \in \mathscr{F}[G \gg F \vee G=F]$. We will henceforth presuppose such obvious ancillary ranking conditions.

11. Not in every respect, though. For example, there is no variety of German where one finds devoicing instead of deletion before schwa in cases like (21) below (*[dɪŋkə]). The absence of the devoicing option again makes sense from the perspective of the traditional ambisyllabic analysis of consonants before schwa (see van der Hulst 1984 for the first analysis of syllable-final devoicing along such lines).

12. There is also a pronunciation [ɪŋo] in the case of this personal name—but interestingly the reduction of the [ŋg]-clusters to [ŋ] must go hand-in-hand with a strong reduction of the second syllable, as predicted by the basic prosodic generalization.

13. In rule terms, the reordering of the processes in SG cannot be understood in terms of maximization of rule application. The driving force, according to Kiparsky 1971, is rather paradigm uniformity, with the singular (isolation) form [dɪŋ] analogically remodeled on the plural [dɪŋə]. Whatever the merits of this analogical account from a diachronic perspective, incorporating it directly into OT as a synchronic analysis is not possible under the more restrictive

theories of OO (Output-Output) correspondence (e.g., Benua 1997) where the morphologically derived form (here, the plural) cannot serve as a base for the morphologically underived isolation form (here, the singular). Compare also the genuine OO-driven English case in (19) (*si*[ŋ]~*si*[ŋ]+*er*, etc), which shows the expected direction (from base to derived form).

14. CNG, with its [ŋk]~[ŋ] alternations, would probably still need a more abstract input.

15. Note that strong versions of Lexical Phonology, such as the one developed in the work of Kiparsky 1985 and Borowsky 1986, do not allow any reordering of rules between levels. Rather, the phonological component consisted of a single ordered set of rules whose applicability at different levels is determined, besides the possibility of turning off rules, by independent principles such as structure preservation or the Strict Cycle Condition.

16. We are not assuming, on some a priori grounds, that OT-grammars have no place whatsoever for derivational levels—in other words, our argumentation is not based on some kind of radical parallelism. In particular, the serial distinction between a lexical (word) level and a postlexical (sentence, phrasal) level seems well-founded. But this is a different matter entirely from the postulation of word-internal levels, with little independent justification beyond the phenomenon under discussion.

17. This restriction does not hold in the variant of Sympathy Theory proposed in Ito & Mester 1997b (see also Walker 1998). While such richer variants do not suffer in the same way from insufficient coverage, they have the opposite problem of excessive power.

18. A background assumption here is that MAX-PLACE is high-ranking, so that dorsals do not delete in other complex codas such as the heterorganic clusters [lk] and [rk].

19. There is now no longer an intrinsic ranking between *CDC and *VC (since the latter is not included in the former), hence the broken lines between the two constraints.

20. Again we find that the rule-based conception of opacity diagnoses this case as opacity-free (see (22) above): In [hoːnɪç], spirantization and devoicing are both surface-true (no syllable-final [g], no syllable-final voiced obstruent) and surface-apparent (their environments are visible on the surface). The diagnosis here is very much dependent on how the rule is written (i.e., what appears to the left of "→" and what to the right of "/"), creating ambiguities in the usual rule-based conceptions of opacity encountered in the literature.

21. Direct ranking argumentation supports only MAX » IDENT(VOI)—the ranking of IDENT(VOI) at the bottom of the hierarchy below *CD again follows the default M»F scheme.

22. This is another case where the parallelist [M&F] analysis has no direct counterpart in a sequentialist rule approach, since the arguments given for cluster simplification hold here as well. The rule cannot be stated simply as [+dorsal] → [+cont] /_]$_\sigma$ but would need to be the voicing-specific [+dorsal, -voiced] → [+cont] / _]$_\sigma$. The advantage of the parallelist [M&F] approach in permitting the formulation of general constraint/process is again evident here.

23. The velar version of the fricative [ŋx] is already excluded by the general restrictions on the occurrence of [x], which is found only after back vowels. The underived sequence [nç] occurs (*manch* 'many a', *Mönch* 'monk'), but neither [mç] nor [ŋç] are found syllable-finally.

24. Baković 1999 proposes that local conjunctions must be *co-relevant* in the sense that each conjunct makes explicit mention of a particular feature mentioned by the other conjunt, and goes on to point out that this explains the the problematic local conjunction found in (Ito & Mester 1998:14-15), that is, the conjuncts are in this case not *co-relevant*. This is a very natural and attractive idea promising a reasonable solution to the overgeneration problem connected with M&F conjunctions. Unfortunately, it appears to err on the side of undergeneration, by excluding some attractive cases of M&F conjunctions—such as those proposed in this paper, which capture otherwise problematic opacity effects. None of the crucial conjunctions are co-relevant in the sense defined by Baković 1999. In fact, the analyses hinge on the very fact that the markedness constraint applies generally to a particular segment class (e.g., dorsals) irrespective of the feature whose faithfulness status is in question (e.g., voicing).

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