Chapter 3

SEGMENTAL TRANSPARENCY AS AN OPACITY EFFECT

This chapter examines the analysis of transparent segments in nasal harmony, that is, segments which are produced with a raised velum within a nasal span. This realization of a truly oral segment within a nasal spreading domain is problematic because it presents a case which appears to deny the claim that feature spreading is segmentally strictly local. Chapter two maintained that a spreading nasal feature propagates only between immediately adjacent segments; skipping a segment is not a possible outcome in spreading. This result follows from the well-motivated assumption that the gapped configuration is universally ill-formed: a representational consequence of interpreting a multiply-linked feature as a continuous property or gesture. In the previous chapter, evidence was adduced from the typology of nasal harmony in support of the claim that descriptively transparent segments should be analytically grouped with undergoers of nasal spreading. Some antecedent derivational or sequential multi-level accounts of truly transparent segments have maintained the strict locality of spreading by positing a level of representation at which the transparent segment undergoes spreading (e.g. Clements 1976; Vago 1976; Walker 1996; Ní Chiosáin and Padgett 1997). A subsequent rule or constraint then applies to this representation to change the feature specification on the transparent segment to realize its surface transparency. More generally, this kind of approach analyzes true transparency as an instance of a 'derivational opacity effect' (Kiparsky 1971, 1973), in the sense of an outcome that is derived through an opaque interaction of rules or constraints. For transparent segments in nasal harmony, I follow this core idea by analyzing transparency as the outcome of an opaque interaction of optimality-theoretic constraints.

In Optimality Theory, it has recently been proposed that derivational opacity effects can be achieved by calling on a correspondence relation that enforces faith between co-candidates in the evaluation set: the output candidate and a designated 'sympathy' candidate (McCarthy 1997, with developments proposed by Itô and Mester 1997a, b). The sympathy approach to opacity effects is capable of producing transparent segments in spreading without producing gapped configurations, and it is independently motivated by other derivational opacity effects known to occur in language. This chapter develops a version of Sympathy theory in which opacity effects arise from the organization of the phonological constraint hierarchy into contiguous subgroups. Within this organizational structure, sympathetic faith is utilized to produce

opaque constraint interactions, including transparency in nasal harmony. This is the *harmonic sympathy* model of opacity in grammar.

This chapter is organized as follows. First, in section 3.1 I review the arguments that some kinds of transparent segments truly are surface-transparent to a spreading feature and I preview the sympathy-based analysis of transparency in Tuyuca. Section 3.2 then establishes the harmonic sympathy model of the grammar, with exemplification from a derivational opacity effect in Tiberian Hebrew. In section 3.3 I develop the full analysis of transparency in Tuyuca as well as the blocking effects in spreading to suffixes. Section 3.4 presents some points of comparison between the harmonic sympathy model and the 'constraint-based' model of sympathy introduced by McCarthy (1997) with modifications proposed by Itô and Mester (1997a, b). It is argued that harmonic sympathy brings a firmer understanding to what brings about opaque constraint interactions and the evaluative mechanisms involved in selection of the sympathy candidate. Section 3.5 then applies the harmonic sympathy framework to Finnish, analyzing the transparent behavior of certain vowels in vowel harmony as a (derivational) opacity effect. Section 3.6 discusses an evaluation metric for derivational opacity in a grammar. And finally, an appendix in section 3.7 presents a possible account of German truncation under harmonic sympathy, reworking a recent analysis of these facts in the constraint-based model proposed by Itô and Mester (1997a). A drawback for harmonic sympathy is discussed and a revision is proposed which better incorporates the strengths of constraint-based model.

3.1 Antagonistic transparency

A few different proposals have been made to preserve the segmentally strict locality of spreading in cases where there appears to be transparency, that is, where it appears that feature spreading has skipped a segment. These proposals fall into two main analytical directions. One line of research has argued that in certain kinds of so-called 'transparency', the relevant gesture is actually carried though a segment. I call this kind of transparency, *false transparency*. Ní Chiosáin and Padgett (1997) take this approach for 'transparent' consonants in vowel harmonies, arguing that consonants actually undergo the feature spreading but may be perceived as transparent because the consequences of the spreading property are small in terms of contrast potential for these segments. Gafos (1996) also claims that transparent segments in coronal consonant harmonies are falsely transparent. He too argues that all segments undergo the harmony, but perceived transparency arises when the spreading gesture does not produce acoustic/perceptual consequences in a given segment. Flemming (1995b) makes the same point in his analysis of the coronal harmony facts. Building on Walker (1996), Walker and Pullum (1997) take a similar line for 'transparent' glottal stops in nasal harmony (see discussion in section 2.2.3). In work with a somewhat different rhetorical focus, it has been proposed that false transparency may arise with segments which are less marked, because they better tolerate the cooccurrence of other features. McCarthy (1994) suggests this account for the transparency of coronals in vocalic pharyngeal harmony, and Padgett (1995a) makes this proposal for translaryngeal vowel harmony. All of the false transparency analyses are unified by the claim that the spreading feature is *compatible* with the 'transparent' segment.

A second kind of analysis addresses cases where the transparent segment truly appears to surface with an opposing feature specification to the spreading property. This kind of true neutrality I will refer to as *antagonistic transparency*, borrowing terminology from Archangeli and Pulleyblank (1994: 232). For these cases, it has been proposed that the transparent segments actually undergo spreading at some abstract level of phonological representation (e.g. Clements 1976; Vago 1976; Walker 1996; Ní Chiosáin and Padgett 1997). With foundation in the early generative analyses of Clements and Vago, Walker (1996) and Ní Chiosáin and Padgett (1997) construct optimality-theoretic accounts in which the output of this abstract level forms the input to a second level, at which a 'realizational' or 'phonetic' mapping takes place, and in this second level, the transparent segment is changed to bear the opposite feature specification to the spreading one in order to resolve some kind of incompatibility. Ní Chiosáin and Padgett suggest that this change takes place for transparent vowels in vowel harmony to satisfy the demands of contrast, and for nasal harmony, Walker argues that the change occurs in obstruents because of a phonetic incompatibility of feature specifications. This kind of level-based analysis differs from the false transparency proposals in two important ways. First, it assumes that the transparent segment is actually specified for the opposite specification of the spreading feature in the output, i.e. this analysis concedes transparency, and second, it makes use of an additional level of representation.

The previous proposals are not incompatible with each other, rather they have shown that apparent transparency may arise under two different sets of circumstances. Our concern lies with antagonistic transparency. I will propose a somewhat different analysis of these cases. I will argue that it is indeed correct that antagonistically transparent segments are specified for the opposite feature specification of the spreading feature in the actual output, but I will show we need not call on a second level of input-

output mapping to achieve this result — it can be captured in a one-level framework, following the core 'Sympathy' theory proposal of McCarthy (1997) and developments by Itô and Mester (1997a, b). The primary focus of this discussion will be transparency in nasal harmony, but I will also demonstrate the application of this model to antagonistic transparency in vowel harmony. On a broader scale, I will show that this model can capture a range of effects of the kind that in derivational frameworks were derived from derivationally-opaque rule interactions: so-called 'opacity effects' ('opacity' in the sense of Kiparsky 1971, 1973).

In antagonistic transparency, the spreading feature specification is incompatible with some acoustic or articulatory property of the transparent segment. Archangeli and Pulleyblank (1994) point out that in [+ATR] harmony in Kinande, the low vowel behaves transparent because the feature specification [+ATR] is antagonistic to the specification [+low]. However, in the case of vowel feature combinations, this incompatibility is not absolute; in Vata, for example, (Eastern Kru; Ivory Coast; Kaye 1982), [+low] vowels clearly undergo [+ATR] spreading. Further, even in Kinande, a low vowel that is long and low-toned exhibits a [+ATR] variant in harmonic domains (Hyman 1989; also noted by Archangeli & Pulleyblank 1994: 210). We may conclude that cross-linguistically the feature combination [+ATR, +low] is highly disfavored, where disfavoring of feature combinations arises from articulatory/aerodynamic or acoustic/perceptual factors (in the Grounded Phonology framework of Archangeli and Pulleyblank 1994, these are formalized as phonetic 'Grounding Conditions'). In optimality-theoretic terms, the dispreference for low [+ATR] vowels is captured by ranking the feature cooccurrence constraint, *[+ATR, +low], high in the hierarchy of [+ATR] cooccurrence constraints. Indeed, this constraint is often undominated.

Although a strong dispreference for a feature combination in a language can drive transparency in the case of vowel harmony, the transparency of buccal obstruent stops to nasal spreading is somewhat more extreme. This is a case of antagonistic transparency where the segment that would be derived from spreading onto the transparent segment is more than just disfavored, it is a phonetically impossible segment, that is, it cannot not be pronounced in any language. *Buccal* obstruents are those with a place of articulation forward of the place where the velic valve joins the nasal and oral cavities (Ohala and Ohala 1993). A nasalized buccal obstruent is phonetically impossible because the specification [+nasal], requiring that the segment be produced with a lowered velum (Howard 1973; Cohn 1993a, Walker and Pullum 1997), conflicts with satisfaction of the property defining the segment as an obstruent stop.

Analysts differ to some extent on the precise characterization of the property defining an obstruent stop, but all agree that at least in buccal segments it is incompatible with a velic opening. Ohala and Ohala see an obstruent stop as having the requirement that the stop accumulate a sufficient degree of air pressure behind the oral constriction to produce audible turbulence on release, i.e. a burst (1993: 227). They observe that a lowered velum will prevent the necessary build-up of air in the oral cavity by allowing air to escape through the nose. Steriade (1993a, d, 1994) makes another release-related characterization in the form of aperture-theoretic representations.

Many feature-based approaches make use of the feature [-sonorant]. The feature [±sonorant] distinguishes sounds with a cavity configuration that inhibits airflow through the glottis, thereby inhibiting spontaneous vocal cord vibration, from those having a cavity configuration that allows enough airflow to normally produce voicing (Chomsky and Halle 1968; Kenstowicz 1994: 36 provides clarifying discussion). In order for air to flow through the glottis, the supralaryngeal air pressure must be less than the sublaryngeal pressure. [-sonorant], characterizing obstruents, thus expresses the requirement that a segment have an accumulation of supralaryngeal pressure sufficient to inhibit spontaneous voicing. Oral stops and fricatives are nonsonorant because their high degree of constriction produces a build-up of pressure and restricts airflow. On the other hand, the weaker constriction of vowels, glides, and liquids is associated with that of [+sonorant] sounds. Although nasal stops have a complete oral closure, they are classified as sonorants because the airflow permitted by the open nasal passage normally induces voicing.[1] [-sonorant] precludes simultaneous implementation of [+nasal] in a buccal segment, because the nasal airflow conflicts with the increase in supralaryngeal pressure required in a nonsonorant (Chomsky and Halle 1968: 316). Since I am assuming feature-based representations, I will continue to use the feature [-sonorant] to characterize obstruents; however, distinguishing a closure and a release phase of an obstruent stop makes an important contribution to understanding certain prenasalization phenomena, and I do not rule out the possibility that such representations might be called on in the theory. The constraint *NASOBSSTOP, which prohibits the cooccurrence of the feature specifications [+nasal, -sonorant, -continuant], is the one that bans nasalized obstruent stops.

1 Chomsky and Halle observe that there are occasionally instances of contrast between voiced and voiceless nasals (1968: 316). However, voiceless nasals are still classified as sonorants, because the failure of these sounds to be voiced results not from a supralaryngeal pressure inhibiting airflow through the glottis but rather from a glottal spreading gesture (see also Mester and Itô 1989 and Lombardi 1991 who classify voiceless nasals as sonorants). Ohala and Ohala (1993: 231-233) suggest that the turbulence that occurs in the production of a voiceless nasal is sufficient to qualify it as nonsonorant; however, they assume a somewhat different characterization of obstruency.

The key generalization that emerges from each of the different approaches to characterizing obstruents is that a buccal obstruent stop cannot be produced simultaneously with nasality, and so a ‘transparent’ obstruent stop must actually be specified as [-nasal] in the output. This kind of transparency thus cannot fall under the set of false transparency cases where the spreading feature is actually implemented on the transparent segment in the output; the phonetic impossibility of a nasalized obstruent stop enforces a true transparency outcome for these segments in all cases where nasalization appears to spread through them. The position I will argue for in this chapter is that true surface transparency can be derived for antagonistically transparent segments while still respecting strict segmental locality of feature linking and spreading in all phonological representations. I follow Walker (1996) and Ní Chiosáin and Padgett (1997) in achieving this outcome by calling on a correspondence relation between an abstract representation in which all segments undergo spreading and the surface transparent output. However, rather than make use of an IDENT-IO constraint in a model with two input-output levels, I will make use of an IDENT constraint mapping between the abstract representation and the output as co-candidates in the evaluation set, thereby maintaining a model with just one input-output level. This move ensures that just one ranking of the constraints forms the grammar of a language: introducing levels allows for the possibility of reranking constraints at each level.

The idea of a faith relation from one candidate to another within a single candidate set is due to McCarthy (1997) and elaborated in the work of Itô and Mester (1997a, b) in breakthrough studies in the analysis of derivational opacity effects in OT. This co-candidate faith relation establishes a correspondence mapping from a designated candidate in the evaluation set to the actual output, and it promotes an output form which resembles the designated candidate, that is, it favors an output which is in *sympathy* with a particular candidate. In some cases the constraint hierarchy will be such that the sympathy candidate coincides with the actual output; however, when the sympathy candidate fails on the basis of some high-ranked constraint, then it may influence the selection of the optimal output through the correspondence relation between the sympathetic candidate and the output. This sympathetic faith relation is abbreviated as Faith-❁O, as expressed by Itô and Mester (1997a, b), with the ‘❁’ symbol referring to the sympathetic candidate. As McCarthy points out, the value of Faith-❁O constraints is that they are capable of producing opacity effects of the type previously obtained through derivationally-opaque rule interactions. This arises under circumstances where the sympathetic candidate loses but is resembled in the output by the force of Faith-❁O (for recent applications of this approach see Itô and Mester 1997a, b; Karvonen and Sherman 1997a, b; Merchant 1997; Davis 1997; Katayama 1998; Sanders 1997 provides a more general examination of sympathetic correspondence).

The emergence of truly transparent segments in spreading has been analyzed in derivational models with opaque rule interactions. An example of this kind of analysis for nasal harmony in an SPE-style framework is summarized in (1) (using a hypothetical form).

(1) Transparency through derivationally-opaque rule interaction:

a. Rules:

i. Nasal Spreading (iterative):
$X \rightarrow$ [+nasal] / [+nasal] __ (X is any segment)

ii. Obstruent stop denasalization:
[-sonorant, -continuant] $\rightarrow$ [-nasal]

Nasal spreading is ordered before obstruent stop denasalization.

b. Derivation:

Underlying representation	/ãrato/
Nasal spreading	ãr̃ãt̃õ
Obstruent stop denasalization	ãr̃ãtõ
Surface representation	[ãr̃ãtõ]

Examples of this basic type of approach to transparency in vowel harmony appear in Clements (1976) and Vago (1976) (cf. Lightner 1965). Analyses of this kind are also typically *abstract* in the sense that at some level of representation it calls on a segmental structure that never actually surfaces in any output form of the language. In the above example, the abstract segment is a nasalized alveolar obstruent stop. More generally, derivationally-opaque rule-based accounts which assume some abstractness (i.e. segments that never actually occur in any output of the language) appear in analyses by Kisseberth (1969), Hyman (1970), Brame (1972), and Vago (1973), among others (for a more complete list see references in Kiparsky 1971, 1973; see also this source for general discussion of the issue of abstractness). Many of these cases posit an underlying segment that undergoes *absolute neutralization* (terminology after Kiparsky 1971, 1973), i.e. its contrast with another underlying form is neutralized in all environments at the surface. In the nasal harmony example above, the abstract segmental representation occurs not underlyingly, but at an intermediate level of representation.

The abstract treatment of transparency can be reproduced in Optimality Theory under the sympathy approach to deriving opacity effects. The diagram in (2) illustrates the structure of the correspondence mappings in relation to the analysis in (1). The underlying representation matches the input and each of the representations derived at some stage of the derivation in (1) are included as members of the candidate set of outputs. Faith-IO constraints evaluate the faithfulness of each of the candidate outputs to the input. The intermediate represention with full spreading in (1) is designated as the sympathy candidate within the evaluation set; Faith-❁O constraints will enforce the resemblance of the actual output to this candidate. The actual output will be the surface representation from (1).

(2) Sympathetic correspondence and segmental transparency:

Input: /ãrato/
FAITH-IO ⇗⇙ ⇖⇘
Output candidates: [ãr̃ãt̃õ] ⇔ [ãr̃ãtõ]
Sympathy candidate FAITH-❁O Actual output

In order for the sympathy candidate not to win itself, it must lose on the basis of some high-ranked constraint. This will be the constraint banning nasal obstruent stops, which plays the role of the obstruent stop denasalization rule. The actual output is the candidate most closely resembling this candidate while still respecting *NASOBSSTOP.

It is important to note that all of the candidate representations being evaluated still respect locality, that is, a representation with gapping across a segment is never generated or called on for comparison. The representation of the actual output with a transparent obstruent is like that shown in (3a), with a separate [+nasal] feature specification on either side of the transparent segment; it is not as in (3b) with one [+nasal] feature specification bridging across the transparent segment. This kind of representation is universally ill-formed because a single feature occurrence fails to correspond to a continuous gesture; on formal grounds, the representation fails to be *convex* (after Ní Chiosain and Padgett 1997, recall discussion in 2.2.1). This form thus is never a member of the candidate set.

(3) a. The representation of the actual output

```
ã r̃ ã t õ
 \ | /    |
[+nasal] [+nasal]
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b. An ill-formed representation: never part of the candidate set

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ã r̃ ã t õ
 \ \ |   /
  [+nasal]
```

As observed in chapter 2, an outcome like that in (3a) cannot be obtained directly from spreading. Spreading requires that each occurrence of a feature specification be linked to all segments in the morpheme; it is not satisfied by candidates containing separate projected copies of that feature. (3a) is instead selected on this basis of its being the best possible match to the sympathetic candidate, with full nasal spreading, represented as in (4).

(4) The representation of the sympathetic candidate

```
ã r̃ ã t̃ õ
 \ \ | / /
  [+nasal]
```

Crucially, featural correspondence between the sympathetic fully nasal candidate and the actual output is enforced by an IDENT[Feature] constraint, which requires not that features themselves have correspondents but that the *featural properties* of correspondent segments are identical (McCarthy and Prince 1995). It is the IDENT-❁O correspondence relation for [+nasal] that produces the occurrence of separate [+nasal] features on either side of the transparent segment in the optimal output, that is, the optimality of the representation in (3a) is driven by its similarity in featural properties to the fully spread candidate in (4), even though (3a) itself fairs quite poorly with respect to spreading and involves introducing an extra occurrence of [+nasal]. This result provides support for a view of featural faith mediated through segmental identity, given by the IDENT[F] formulation; an alternative view of featural faith in which features themselves are in correspondence could not realize this outcome.[2]

[2] On some of the pros and cons of a correspondence view of features see McCarthy and Prince (1995); Lombardi (1995a, 1998); Causley (1996), Walker (1997b); Yip (to appear); (cf. also Lamontagne and Rice 1995).

A preview of the constraint ranking deriving segmental transparency through sympathy is given in the tableau in (5). The candidate with full nasal spreading, in (a), is designated here as the sympathy candidate, signalled by the flower symbol at its right. This candidate loses in the contention for the optimal output, because it incurs a fatal violation of the undominated constraint prohibiting nasalized obstruent stops. The next highest constraint is the sympathetic faith constraint requiring identity between the sympathy candidate (a) and the actual output in the [+nasal] property of segments. Candidate (c), which matches [+nasal] identity in all but [t], is the best of the candidates respecting *NASOBSSTOP on this faith constraint. The alternative in (b) loses because in addition to [t], the next segment [o] is also oral. This extra IDENT-❁O faith violation is fatal, even though (b) is much better than (c) on spreading.

(5) Preview of sympathy analysis of segmental transparency

	ãrato	*NAS OBSSTOP	IDENT-❁O [+nasal]	SPREAD [+nasal]
❁	a. [ãr̃ãt̃õ]	*!		
	b. [ãr̃ã]to		**!	**
☞	c. [ãr̃ã]t[õ]		*	******

The tableau in (5) shows how sympathy can derive the effect of an opaque rule interaction of the type used to produce segmental transparency in spreading, while still maintaining a restrictive conception of locality. Central to this account is the notion of a designated sympathy candidate. It is natural to question how this designation takes place. This will be the subject of the next section, which examines an opacity interaction in Tiberian Hebrew. This next section will complete the outline of the model for deriving opacity effects in Optimality Theory, and I will then go on to develop a full account of transparency and blocking effects in nasal harmony in Tuyuca.

3.2 Opacity in Tiberian Hebrew

A classic case of the type demanding a derivationally-opaque rule interaction occurs in the interaction of epenthesis and laryngeal coda deletion in Tiberian Hebrew. The description and generative analysis of this phenomenon are from Malone (1993) (see also Prince 1975), and they are summarized by McCarthy (1997) in his foundational study of the sympathy-based approach to opacity effects in Optimality Theory. An SPE characterization of the rules is given in (6). The first rule epenthesizes a vowel into a word-final consonant cluster (Malone 1993: 93)[3] and the second deletes glottal stop in a coda (Malone 1993: 59).[4]

(6) Tiberian Hebrew

a. Vowel epenthesis into final clusters:
Ø → V / C _ C#
e.g. /melk/ → [melEk] 'king'

b. ʔ-deletion in codas:
ʔ → Ø / _ $]_\sigma$
e.g. /qaraʔ/ → [qara] 'he called'

The rules in (6) have the potential to interact with one another. As shown in (7), they operate in a counterbleeding order, whereby epenthesis takes place before ʔ-deletion. This gives a surface form [deʃE] for /deʃʔ/ 'tender grass', which is opaque with respect to epenthesis, that is, there is an occurrence of an epenthetic vowel in a surface environment that does not meet the structural description of the epenthesis rule.

(7) Counterbleeding in Tiberian Hebrew:

Underlying representation	/deʃʔ/	
V-epenthesis	deʃEʔ	
ʔ deletion	deʃE	
Surface representation	[deʃE]	*deʃ

Following McCarthy's (1997) insightful and innovative analysis, the basic architecture of the sympathy-based account of this derivational opacity will be as illustrated in (8). Candidate (b), [deʃEʔ], is designated as the sympathy candidate, but it loses in the competition for the optimal output on the basis of a high-ranked constraint prohibiting glottal stop in a coda. The sympathetic faith constraint, MAX-❀O, then decides between the two alternative candidates in (a) and (c). Candidate (a), [deʃE],

3 The surface quality of the epenthetic vowel is partly conditioned by the environment. If the first consonant in the cluster is the palatal glide [j], then the epenthetic vowel is [i]. If the first consonant is a guttural, then the vowel is [a]. Otherwise, the epenthetic vowel is [e] (transcribed by Malone as [ɛ]).

4 The examples given here focus only on the segmental alternations relevant to the rules in (6). I abstract away from alternations brought about by rules such as vowel lengthening and post-vocalic spirantization (Prince 1975; Malone 1993).

which corresponds to the opaque rule interaction, is the winner, omitting only one segment that appears in the sympathetic candidate. Candidate (c), [deʃ], which corresponds to a transparent rule interaction, loses because it omits two segments that appear in the sympathetic candidate.

(8) Overview of the sympathy account

	Input /deʃʔ/	$*ʔ]_\sigma$	MAX-❀O
☞	a. deʃE (Optimal, opaque rule interaction)		*
❀	b. deʃEʔ (Non-optimal, sympathetic)	*!	
	c. deʃ (Non-optimal, transparent rule interaction)		**!

To develop the full sympathy account of this opacity effect in Tiberian Hebrew, we must begin by reviewing the constraints and preliminary rankings established by McCarthy (1997) that correspond to the rules outlined in the derivational analysis. First, to drive epenthesis into a consonant cluster, *COMPLEX (Prince and Smolensky 1993), which penalizes complex syllable margins, must outrank the faith constraint prohibiting addition of structure, DEP-IO (McCarthy and Prince 1995).

(9) *COMPLEX >> DEP-IO

	/melk/	*COMPLEX	DEP-IO
☞	a. melEk		*
	b. melk	*!	

In order to resolve the cluster by epenthesis rather than deletion, MAX-IO must outrank DEP-IO.

(10) MAX-IO >> DEP-IO

	/melk/	MAX-IO	DEP-IO
☞	a. melEk		*
	b. mel	*!	

Locating the site of epenthesis between the consonants rather than after them is achieved with the correspondence constraint, R-ANCHOR-IO (McCarthy and Prince 1995: 371), which requires that the rightmost element of the input have a correspondent in the rightmost element of the output. This constraint is abbreviated below as ANCHOR-R.[5]

(11) ANCHOR-R

	/melk/	ANCHOR-R
☞	a. melEk	
	b. melkE	*!

The second rule in the derivational analysis performs glottal stop coda deletion. This kind of outcome can be realized in Optimality Theory by ranking a constraint prohibiting glottal stop in a coda over MAX-IO.[6]

(12) $*ʔ]_σ$ >> MAX-IO

	/qaraʔ/	$*ʔ]_σ$	MAX-IO
☞	a. qara		*
	b. qaraʔ	*!	

ʔ-deletion enforces a violation of right-anchoring, so $*ʔ]_σ$ must outrank ANCHOR-R.

(13) $*ʔ]_σ$ >> ANCHOR-R

	/qaraʔ/	$*ʔ]_σ$	ANCHOR-R
☞	a. qara		*
	b. qaraʔ	*!	

As McCarthy notes, the constraint hierarchy that has been established thus far cannot be the full story because it determines the wrong outcome for an input like /deʃʔ/. The outcome that would be selected here is [deʃʔE] rather than [deʃE]. This incorrect outcome is signalled by the left-pointing hand beside the predicted but incorrect winner. The right-pointing hand indicates the desired winner.

5 Rather than ANCHOR-R, McCarthy's account makes use of the constraint, ALIGN-R_{IO}(Root, σ).
6 McCarthy calls the constraint prohibiting glottal stops in codas: 'CODACOND'.

(14) Incorrect outcome is predicted for /deʃʔ/

	/deʃʔ/	1. $*ʔ]_σ$ 2. *COMPLEX	ANCHOR-R	MAX-IO	DEP-IO
☞	a. deʃE		*	*!	*
(❁)	b. deʃEʔ	*!(1)			*
☜	c. deʃʔE		*		*
	d. deʃ		*	*!	
	e. deʃʔ	*!*(1, 2)			

Because candidate (c) incurs a subset of the violations that (a) does, no reranking will serve to select candidate (a) over (c). Even if another constraint were invoked to rule out (c), a second problematic competitor is the transparent derivational candidate [deʃ], which also incurs a subset of the violations that (a) does. To realize the correct outcome, it will be necessary to call on a faith relation to a sympathy candidate. As McCarthy suggests, this sympathy candidate will be the one in (b). It is in the means of selection of the sympathy candidate that I depart from McCarthy's account. My proposal is outlined below; its goal is to develop a means of selecting the sympathy candidate by building on the basic mechanisms of optimality-theoretic evaluation and to constrain the range of opacity effects that may be produced under sympathy. I compare this with the alternative proposed by McCarthy (with modifications proposed by Itô and Mester 1997a, b) in section 3.4.

The question we are faced with is how to select the sympathy candidate. In order to answer this question, the problem presented by the tableau in (14) must be carefully considered. An important basis of Optimality Theory is the notion of *ranked* and *violable* constraints in conflict. In the normal case, when the satisfaction of two constraints conflicts, the conflict is resolved by a ranking which forces the violation of one constraint over the other. This is what occurs in (14), where ranking $*ʔ]_σ$ over ANCHOR-R causes the sympathy candidate, in (b), to lose to alternatives without a laryngeal coda. In this resolution, $*ʔ]_σ$ gains undominated status in the constraint hierarchy, along with *COMPLEX. Under this normal resolution of the conflict between $*ʔ]_σ$ and ANCHOR-R, the ANCHOR-R constraint loses absolutely; for example, here candidate (c) wins over alternatives, even though it is quite different from the one that would have been selected by ANCHOR-R. However, as (14) shows, this produces the wrong outcome for Tiberian Hebrew. The candidate that would have been chosen if ANCHOR-R had won the conflict turns out to influence selection of the optimal output.

This influencing candidate is the sympathetic one in (b). It fails because of its glottal stop coda; but setting the glottal stop coda constraint aside, we may observe that it is the most harmonic candidate with respect to the remainder of the hierarchy. If we were to split *ʔ$]_\sigma$ off from the rest of the hierarchy, candidate (b) would win. The actual surface form is (a), the candidate which most closely resembles the special failed candidate (b). This outcome does not come out of the usual resolution of constraint conflict. I suggest that in this kind of 'battle of the titans', where a high-ranked constraint is threatened by another, a second type of resolution is possible. This resolution is a bifurcation of the constraint hierarchy at the point of conflict into two ranked modular components. One of the conflicting constraints, in this case, *ʔ$]_\sigma$, is split off into the higher segment, which I will call the P1 component. The competing constraint, here ANCHOR-R, remains with the rest of the hierarchy in the P2 component. The P1 component outranks the P2 component. As the constraint that breaks into the P1 component, *ʔ$]_\sigma$ triumphs in the conflict: it will be respected in all surface forms. The conflicting constraint, ANCHOR-R, loses by virtue of its domination by the P1 component; however, it gains a consolation prize. I propose that the candidate which is most harmonic with respect to the P2 hierarchy is the sympathy candidate. The high-ranked status of ANCHOR-R within the P2 component thus enables its force to be reflected in the form of the sympathy candidate.

Let us examine the resulting organization of the grammar in (15). This shows the bifurcation of the phonological constraint hierarchy into two segments, as induced by the conflict between the undominated constraint, *ʔ$]_\sigma$, and ANCHOR-R. In this tableau I have shaded the P1 component to focus on the selection of the sympathy candidate in P2. Because *ʔ$]_\sigma$ has been elevated to P1 in the resolution of its conflict with ANCHOR-R, the coda constraint is the one that will be respected in the optimal output. However, it is ANCHOR-R, along with the rest of the constraint hierarchy that will determine the sympathy candidate. With the component-based organization of the constraints, P2 selects [deʃEʔ] as the sympathy candidate, because it best respects this hierarchy of constraints. This means of selecting the sympathy candidate as the most harmonic with respect to some component, I call *harmonic sympathy*.

(15) Selection of the sympathy candidate

	P1 component		P2 component			
/deʃʔ/	*ʔ$]_\sigma$		*COMPLEX	ANCHOR-R	MAX-IO	DEP-IO
a. deʃE				*!	*	*
b. deʃEʔ	*	❁				*
c. deʃ				*!	*	
d. deʃʔ	*		*!			
e. deʃʔE				*!		*

With the sympathy candidate identified as the one with epenthesis and no deletion, a tableau selecting the opaque optimal output can now be exhibited in (16). Since the sympathy candidate violates *ʔ$]_\sigma$ in P1, it falls out of the running for the optimal output early. Candidates (a) and (c) survive the glottal stop coda constraint and the deciding constraint is the sympathetic faith constraint, MAX-❁O. This chooses [deʃE] over [deʃ], because [deʃE] more closely resembles the sympathy candidate. (Note that candidate (e) from (15) is omitted here; I will return to this form presently.)

(16) Harmonic sympathy account of opacity in Tiberian Hebrew

		P1			P2			
	/deʃʔ/	*ʔ$]_\sigma$	MAX-❁O		*COMPLEX	ANCHOR-R	MAX-IO	DEP-IO
☞	a. deʃE		*			*	*	*
	b. deʃEʔ	*!		❁				*
	c. deʃ		**!			*	*	
	d. deʃʔ	*!	*		*			

The opaque resolution of constraint conflict means weighting the losing constraint, here ANCHOR-R, so that the actual output will resemble as closely as possible the output that would have been selected if ANCHOR-R were respected. The hierarchy bifurcation is what enables selection of the sympathy candidate and it is the placement of sympathetic faith between the two opaquely interacting constraints that produces the weighting effect of the sympathy candidate in the selection of the actual output. This positioning of sympathetic faith goes hand-in-hand with the hierarchy bifurcation. The organization that I assume locates sympathetic faith in P1. P2 then functions as an embedded optimizer for the sympathy candidate, and the P1 and P2 segments together compose the phonological grammar. It should be noted that the preliminary tableau in (15) is shown separately for expository purposes only; the tableau in (16) represents the complete evaluation. This evaluation involves two optimizations, one with respect to P2 and the other with respect to the entire hierarchy. Selection of the sympathy candidate and the optimal output is performed in parallel evaluation with a single input-output level.

In (16), the winning candidate incurs one violation with regard to MAX-❀O, since the perfectly faithful sympathy candidate cannot win. However, two other candidates incur different kinds of sympathetic faith violations. The failure of these candidates is indicative of the rankings of different sympathetic faith constraints in Tiberian Hebrew. One failed candidate, [deʃʔE], shows that MAX-❀O must be outranked by LINEARITY-❀O (McCarthy and Prince 1995: 371), which enforces consistency of precedence structure between the sympathetic candidate and the output (17). Another failed candidate, [deʃEʔE], indicates that DEP-❀O must also dominate MAX-❀O (18).

(17) LINEARITY-❀O >> MAX-❀O

		LINEARITY-❀O	MAX-❀O
☞	a. deʃE		*
	b. deʃʔE	*!	

(18) DEP-❀O >> MAX-❀O

		DEP-❀O	MAX-❀O
☞	a. deʃE		*
	b. deʃEʔE	*!	

The complete tableau with the additional Faith-❀O constraints is given in (19):

(19) Expanded Faith-❀O

	P1					P2			
	/deʃʔ/	$*ʔ]_\sigma$	1.DEP-❀O 2.LIN-❀O	MAX-❀O		*COMPLEX	ANCHOR-RIGHT	MAX-IO	DEP-IO
☞	a. deʃE			*			*	*	*
	b. deʃEʔ	*!			❀				*
	c. deʃ			**!			*	*	
	d. deʃʔ	*!		*		*			
	e. deʃʔE		*!(2)				*		*
	f. deʃEʔE		*!(1)				*		**

For verification of the harmonic sympathy analysis, tableaux are exhibited in (20-21), showing that the constraint hierarchy correctly produces /melk/ → [melEk] and /qaraʔ/ → [qara]. (20) provides an example where the sympathetic candidate coincides with the optimal output.

(20) /melk/

	P1					P2			
	/melk/	$*ʔ]_\sigma$	1.DEP-❀O 2.LIN-❀O	MAX-❀O		*COMPLEX	ANCHOR-RIGHT	MAX-IO	DEP-IO
☞	a. melEk				❀				*
	b. melE			*!			*	*	*
	c. melk			*!		*			
	d. mel			*!*			*	*	

(21) /qaraʔ/

	P1					P2			
	/qaraʔ/	$*ʔ]_\sigma$	1.DEP-❀O 2.LIN-❀O	MAX-❀O		*COMPLEX	ANCHOR-RIGHT	MAX-IO	DEP-IO
☞	a. qara			*			*	*	
	b. qaraʔ	*!			❀				
	c. qar			**!			*	**	
	d. qaraʔA		*!(1)				*		*

A summary of the constraint hierarchy needed for Tiberian Hebrew is given in (22):

(22) Bifurcation trigered by opaque resolution of conflict between $*ʔ]_σ$ and ANCHOR-R.

a. P1: $*ʔ]_σ$
Sympathy. DEP-❀O, LINEARITY-❀O >> MAX-❀O

b. P2: ANCHOR-R
Epenthesis. *COMPLEX, MAX-IO >> DEP-IO

To summarize, we have seen that the harmonic sympathy model is capable of capturing the opacity effect in Tiberian Hebrew epenthesis. This model admits a second kind of resolution of conflict between constraints. Rather than the usual domination resolution within a single module, the hierarchy may be bifurcated into two ranked components with sympathetic faith mediating between them. As a result of this split, the losing (i.e. dominated) constraint may play a special role in selecting the optimal output: it contributes to the selection of the sympathy candidate through its high-ranked status within the dominated P2 component. The sympathy candidate is the most harmonic one with respect to P2. This model thus posits opacity as induced by sensitivity to the candidate that would be optimal with respect to some component: a contiguous segment of Eval for a language. Most commonly the hierarchy split takes place between two high-ranking constraints in the grammar. An explanation for this tendency is discussed in section 3.6.

From a broader perspective, this means for obtaining derivational opacity effects draws on an independently supported mechanism, namely ranking separate modular components of the grammar. Golston (1995) proposes that syntactic constraints outrank all phonological ones (see also Tranel 1997). This design has foundation in the proposal of standard generative theory that syntax feeds phonology (Chomsky and Halle 1968; also Chomsky 1986; but cf. the syntax-phonology interface models outlined by Nespor and Vogel 1986; Selkirk 1986; Zec and Inkelas 1990; a different organization is posited in the Lexical Phonology model, Kiparsky 1982). Structuring the grammar in this way makes the prediction that the range of word order sequences attested in language will be given by the interaction of syntactic constraints and will not be determined by phonological conditions. Phonology is expected only to play a role in word order in deciding between syntactic structures that tie with respect to syntactic constraints, a prediction that generally seems to be borne out. The proposal here is that the

phonology itself can be organized into ranked components.[7] The overall structure of the grammatical components is given in (23).

(23) Syntax >> Phonology 1 >> Phonology 2

I suggest that the default status for a grammar is for no bifurcation to exist in the phonological constraint hierarchy (this is discussed further in section 3.6); however, evidence of opacity induces a split into two ranked components mediated by sympathetic faith. The notion of harmonic sympathy then allows the most harmonic element with respect to some component to influence the decision between candidates respecting the constraints of higher-ranked components.

3.3 Tuyuca

I turn now to the analysis of antagonistic transparency in nasal harmony. This analysis calls on a phonological representation that may never surface because it cannot be physically implemented. I begin this section by outlining my assumptions about phonetic versus phonological possibility, and then I go on to apply the harmonic sympathy model of derivational opacity effects to transparent segments in Tuyuca. In this account, I explore the implications of the blocking behavior of stops in suffixes for their underlying representation and the understanding of the contrasts which hold in Tuyuca.

3.3.1 Phonetic versus phonological possibility

First it is necessary to make clear my assumptions about the phonetic versus phonological admissibility of segments. Let us consider again the representation of the sympathetic candidate for this account. This representation from (4) for a hypothetical form is repeated below in (24).

(24) The representation of the sympathetic candidate

```
ã r̃ ã t̃ õ
 \ \ | / /
 [+nasal]
```

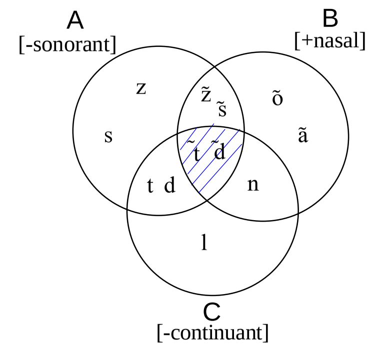
7 A different kind of split is proposed in Lexical Phonology, e.g. Kiparsky (1982, 1985), also related work cited in Mohanan (1995).

In (24) [+nasal] has spread to every segment in the word; this is necessary to produce nasalization of the final vowel since segments cannot be skipped in spreading. The fully-spread representation posits a nasalized voiceless alveolar obstruent stop, transcribed as [t̃]. This segment combines the feature specification [+nasal] with those defining an obstruent stop, [-sonorant] and [-continuant]. As observed in section 3.1, a segment of this kind cannot be physically produced because the demands that a segment be a buccal obstruent stop and nasal cannot both be satisfied at the same time. The specific problem is that realizing the segment with a lowered velum, as required by [+nasal], prevents the build-up of pressure behind the oral closure needed to inhibit spontaneous voicing, a property required for an obstruent stop. A segment like [t̃] is thus *phonetically impossible* — understanding phonetically possible segments as those that can be *pronounced*, i.e. those that can realize the implementational requirements of all of their phonological features (after Walker and Pullum 1997). It is important to note that the phonetic impossibility of a nasalized obstruent stop does not stem from a contradiction in its *description* — it is not at once specified both [+nasal] and [-nasal] (i.e. *P & ~P)* — the phonetic impossibility is instead a consequence of the *interpretations* of the features yielding a logical falsehood for realizable segments (following a line proposed by Walker and Pullum 1997: 3). By this, I mean that the segments described by the feature specifications *[+nasal], [-sonorant], [-continuant]* correspond to disjoint sets of phonetically produceable segments; no segment can be realized as nasal and at the same time be produced as an obstruent stop. These opposing realizational requirements prevent any candidate containing [t̃] from ever being selected as the optimal output.

I propose, however, that the unpronounceability of a nasalized obstruent stop does not exclude forms containing nasalized obstruents from being generated (by the function Gen, Prince and Smolensky 1993: 4) and evaluated as part of the candidate set. That is, the set of phonologically possible segments — those that are available for evaluation in the grammar — includes some segments which are not phonetically produceable. A segment like [t̃] signifies a well-formed representation; it simply is one that cannot be pronounced. In this understanding of the dichotomy between admissible phonetic and phonological representations I follow Walker and Pullum (1997) (cf. also Walker 1996). Walker and Pullum propose that a group of phonetically impossible segments are contained in the set of phonologically well-formed segments. They suggest that the set of phonologically well-formed segments are 'derived by closing the set of phonetically describable segments under feature-value pairing' (for some set of phonological features) (1997: 32), while the phonetically possible segments are the

subset which are realizationally possible. The set of segments produceable by Gen is thus not an infinite one, but it contains some well-formed 'abstract' segments that cannot be physically realized. The situation with respect to the phonetic and phonological possibility of segments described by the feature specifications [-sonorant], [+nasal], and [-continuant] is represented diagrammatically in (25). Circles A, B and C represent the sets of segments described by each of the feature specifications (a few representative segments are given for each set).

(25) Phonetic versus phonological possibility of a nasalized obstruent stop.



Entire group:
Phonologically possible segments.

Shaded area:
Phonologically possible segments that are phonetically impossible.

Nonshaded area:
Phonetically possible segments.

The hypothesis is that the set of phonologically possible segments describable with these features represents the union of the three sets of segments (A, B, and C) in (25). On the other hand, some of these phonologically possible segments are not phonetically possible: they do not describe segments that can be realized with the human vocal apparatus. These are the segments in the shaded portion: nasalized obstruent stops.[8] These must be filtered out from selection by undominated feature cooccurrence constraints which rule out unpronounceable outputs.

Any analysis of a language in Optimality Theory assumes a number of undominated constraints. Some of these constraints seem to be undominated in almost every language, or perhaps even all of them (for example, FOOT-BINARITY; Prince and Smolensky 1993: 47). For constraints of this type we may question whether they belong in Gen or in the constraint hierarchy. The answer to this question has important

8 As was noted in section 2.4, the phonetic possibility of nasalized fricatives has been called into question, but there appears to be evidence for occurrences of these segments in some languages (with gradient reduction of nasalization or frication).

implications for analysis. If a constraint is part of Gen, no candidates in the evaluation set can violate it. On the other hand, if a constraint is simply undominated, a candidate violating it can be compared with others, and through a sympathy correspondence relation this candidate can influence the selection of the optimal output. I will not attempt to define every constraint that must belong to Gen versus the evaluative hierarchy, but some distinctions can be made clear. First, following Prince and Smolensky (1993: 4) I assume that Gen contains information about the universal basis for phonological representations — it encodes the built-in wiring of phonological possibility. Gen includes the primitives of phonological structure, such as the set of phonological features and the levels of prosodic hierarchy, and it contains information about the elements of their organization, for example, feet are composed of syllables, not vice versa, prosodic constituents have heads, etc.. The set of candidates that Gen produces is then derived by performing combinative operations on these primitives of structure and organization. In addition to faith constraints, the kinds of constraints that appear in the hierarchy evaluating these candidates are those that ban specific occurrences or configurations within the limits of organizational possibility. Examples include markedness constraints (e.g. *[+low]), cooccurrence constraints (e.g. *[+ATR, +low]), constraints on sequencing (e.g. *COMPLEX, phonotactic constraints), constraints on structural coincidence (e.g. alignment), and constraints on strict layering (e.g. PARSE-σ).

Of course any constraint that is violated in the output of *some* language must belong to the evaluative hierarchy and not to Gen, but this need not be the only criterion by which the status of a constraint be determined. I suggest that a constraint can also belong to the evaluative hierarchy even if it is unviolated in the optimal output set of *every* language. This does not in principle undermine the optimality-theoretic claim that constraints are ranked and violable. Forms violating undominated constraints will still be part of the candidate set and are evaluated along with the others. In any language, the learner discovers that certain constraints are unviolated in every optimal output: these define the undominated constraint set for that language. What I propose is that for some constraints there can never be evidence for the learner that they are violated in the optimal output. Examples of this kind will be constraints against phonetically impossible representations, such as *NASOBSSTOP. Because this combination of features describes an unpronounceable segment, there can never be a surface form violating this constraint, although in principle this constraint could be dominated by the nasal spreading constraint. Thus nasalized obstruents are not excluded in actual surface forms because they are not possible phonological

representations — these feature combinations can still be produced by Gen — rather it is a consequence of physical limitations of the vocal apparatus. This is not to say that the phonological hard wiring for segment structure is not informed by phonetic principles. The set of phonological features itself has a phonetic basis and the unpronounceability of a nasalized obstruent stop is reflected in the phonology in being least favored in the fixed hierarchy of nasalized segments. Where phonology is distinct from phonetics is in making available all feature combinations, even those that do not correspond to the set of pronounceable segments. Other conceivable examples of phonetically impossible segments derived under exhaustive combination of feature specifications are voiced glottal stops and voiceless toned segments. Some possible cases of phonological instances of such segments that are neutralized to phonetically possible articulations in production are cited and discussed by Walker & Pullum (1997).

3.3.2 Harmonic Sympathy in Tuyuca

Because constraints against phonetically impossible feature combinations will never be violated in an optimal output, they will be posited as undominated in every learned grammar. However, given sympathy theory, there still can be evidence that these constraints are part of the evaluative hierarchy rather than Gen. This evidence comes from surface forms that could not be optimal except by a correspondence relation to a co-candidate which violates an undominated constraint in the grammar.[9] The transparency of nasal obstruents to nasal harmony is precisely the kind of evidence needed to indicate that *NASOBSSTOP is violable in generation of the candidate set. Let us recall the result from chapter 2 for languages with obstruent transparency. For these cases it was hypothesized that SPREAD[+nasal] outranks all nasalized segment constraints, a grammar predicted by factorial constraint ranking. When this ranking holds, the best candidate with respect to the hierarchy of phonological constraints will be the one in which [+nasal] has spread to every segment, including obstruent stops. This result from section 2.2.2 for spreading within a morpheme in Tuyuca is repeated in (26) below.

9 It should be noted that using the form of a sympathetic candidate as evidence for whether a constraint occurs in Eval or Gen requires the assumption that any constraints have the potential to enter into an opaque interaction — an extension of the theory proposed by Ito and Mester (1997b). The original proposal by McCarthy limited sympathy candidates to ones satisfying some designated faithfulness constraint.

(26) Tuyuca

	w̃ãti	SPREAD ([+nas], M)	*NAS OBSSTOP	*NAS FRIC	*NAS LIQUID	*NAS GLIDE	*NAS VOWEL	*NAS SONSTOP
☞	a. [w̃ãt̃ĩ]		*			*	**	
	b. [w̃ã]ti	*!*				*	*	
	c. w[ã]ti	*!**					*	
	d. [w̃ã]t[ĩ]	*!****				*	**	

Although this constraint hierarchy selects candidate (a), containing a nasalized obstruent stop, this grammar could never be learned, because this output cannot be pronounced. Yet the notion of a sympathetic correspondence relation allows for a grammar which realizes an outcome as close to candidate (a) as possible. This would be an outcome like that in (d): one that is identical in all segmental properties to (a), except for the phonetically impossible nasalization on the obstruent stop. Without a sympathetic correspondence relation, candidate (d) cannot be derived. Comparing its constraint violations with those of the other phonetically-possible candidates in (26) (in (b) and (c)), we see that it incurs a superset of the constraint violations of its competitors; no reranking of these constraints can make (d) come out as optimal. Since (d) can only be selected by calling on a sympathetic candidate with full spreading, like (a), the attestation of (d) in a language provides evidence for the abstract representation in (a) as a member of the candidate set. This is assuming that there is reason to believe that an alternative full spreading co-candidate, such as [w̃ãnĩ], where /t/ becomes a sonorant, is not the sympathetic one. Evidence to this effect is discussed in section 3.3.5.

In the harmonic sympathy model, a phonetically-impossible candidate like [w̃ãt̃ĩ] will be selected as the sympathetic candidate only if it is the most harmonic candidate with respect to the P2 component. This comes about as a consequence of the resolution of two constraints vying for undominated status in Tuyuca, namely SPREAD[+nasal] and *NASOBSSTOP. The segmental markedness constraint is the one that is surface-true in the language, so it must be the winner. If this constraint conflict were resolved by ranking within the P2 component, then the resulting pattern would be one in which obstruent stops blocked spreading (see, for example, the constraint ranking needed for Applecross Gaelic in section 2.2.2). However, obstruent stops actually behave transparent in Tuyuca, so the conflict is instead resolved by promoting *NASOBSSTOP to the P1 component. Fricatives also behave transparent, indicating that a conflict between *NASFRIC and the nasal spreading constraint has also forced the fricative nasalization constraint up to P1.

A preliminary representation of the resulting grammar is given in (27). The markedness constraints against nasalized obstruents are separated into the P1 component and high-ranked constraints within the P2 hierarchy include nasal spreading and the combination of faith and markedness constraints preventing an underlying /t/ from surfacing as an [n], which I refer to here as *t→n (to be explored in the next section). Because of *t→n, the phonetically possible candidate, [w̃ãnĩ], with full spreading, loses to an alternative candidate. In this tableau, constraint columns in the P1 component are shaded to focus on selection of the sympathy candidate in P2. Because the obstruent markedness constraints have been promoted to P1 and spreading is high-ranked in P2, sympathy status is assigned to the abstract candidate in (a), with full spreading. (For space reasons, the low-ranked *NASSONSTOP is omitted here.)

(27) Selecting the sympathetic candidate

	P1			P2				
w̃ãti	*NAS OBSSTOP	*NAS FRIC		SPREAD ([+nas], M)	*t→n	*NAS LIQUID	*NAS GLIDE	*NAS VOWEL
a. [w̃ãt̃ĩ]	*		❁				*	**
b. [w̃ã]ti				*!*			*	*
c. w[ã]ti				*!**				*
d. [w̃ã]t[ĩ]				*!****			*	**
e. [w̃ãnĩ]					*!		*	**

With the sympathy candidate identified as the abstract one with full spreading, the analysis of transparent obstruents in Tuyuca can now be presented in (28). This tableau incorporates the sympathy correspondence constraint, IDENT-❁O, in P1. For a nasal morpheme containing a voiceless obstruent, the harmonic sympathy candidate is the abstract one in (a), with nasalization of all segments. This candidate loses on the basis of the P1 component constraint against nasalized obstruent stops. IDENT-❁O then acts to select the candidate of those remaining that most closely matches the content of the sympathy candidate. Candidates (d) and (e) tie on this point (insofar as this is presently an undifferentiated IDENT constraint), but (e) loses on the basis of input-output faith. (d) is thus the winner, achieving segmental transparency through its similarity to the most optimal candidate with respect to the P2 component.

(28) Transparency in Tuyuca:

	wãti	P1: *NAS OBSSTOP	P1: *NAS FRIC	P1: IDENT-❀O		P2: *t→n	P2: SPREAD ([+n], M)	P2: *NAS LIQ	P2: *NAS GLIDE	P2: *NAS VOWEL
	a. [w̃ãt̃ĩ]	*!			❀				*	**
	b. [w̃ã]ti			**!			**		*	*
	c. w[ã]ti			**!*			***			*
☞	d. [w̃ã]t[ĩ]			*			*****		*	**
	e. [w̃ãnĩ]			*		*!			*	**

Within this model, it is the markedness constraints against nasalized obstruents in P1 that drive the transparent outcome for these segments (the analysis of transparency proposed by Kiparsky 1981 provides foundation for this approach, see also Archangeli and Pulleyblank 1994; Pulleyblank 1996). It should be noted that the interim result from chapter 2 in which the spreading constraint outranks constraints against nasalized obstruents has been reinterpreted here in terms of an opaque resolution of these constraints. In this resolution, constraints against nasalized obstruents actually outrank nasal spreading, but nasal spreading can still induce violations of nasalized obstruent constraints in the selection of the sympathy candidate. In section 3.7, I discuss a revised approach in which *NASOBS constraints occur in two places: undominated in P1 and dominated by spreading within P2, maintaining the result that (within P2) spreading outranks all nasalization constraints in Tuyuca.

The kind of opacity effect we are dealing with here is somewhat different from the one in Tiberian Hebrew. In derivational terms, the opacity effect in Tiberian Hebrew involves allowing some underlying structure (a glottal stop coda) to survive part-way into the derivation in order to trigger some rule (epenthesis). At the final stage of the derivation, the triggering structure is deleted. In contrast, the opacity effect in Tuyuca is of the sort realized in derivational frameworks by applying a rule to a form to derive some structure that feeds a rule (iterative nasal spreading) and then applying another rule which changes the structure back to its original form: the so-called 'Duke of York Gambit' (α→β→α) (Pullum 1976). Under harmonic sympathy, Duke of York Gambit effects are possible under conditions where the constraint changing β back to α (i.e. *β) is surface-true. Markedness constraints in the P1 component correspond to surface-true neutralization rules. Shifting a markedness constraint to this higher component, allows for an output containing the banned structure to be selected as the sympathy candidate,

but the supremacy of the constraint's position enforces its satisfaction at the surface. Note that an undominated constraint remaining in the P2 component cannot produce this kind of (derivationally) opaque outcome. Undominated constraints in the P2 segment must be respected in the sympathy candidate, since it is selected on the basis of its harmonicity with respect to the P2 hierarchy. This is the usual case, and it produces transparent rather than opaque constraint interactions. I assume that the learner will posit the most transparent grammar possible to generate the forms s/he comes in contact with. This has basis in Kiparsky's (1971, 1973) proposal that opacity effects are disfavored or 'marked' in grammars. Interpreted in relation to the harmonic sympathy model of opacity, this means that there will be no bifurcation in the phonology except where there is evidence to the contrary. All else being equal then, Faith-❀O violations and hierarchy bifurcation will be eschewed in grammar optimization.[10] Note that even in a language like Tuyuca, Faith-❀O violations will be incurred only for nasal forms containing an obstruent stop. For all other nasal morphemes, the sympathetic form will be the same as the optimal one. This is illustrated in (29) for the form [j̃õr̃ẽ] 'little chicken'.

(29) Full spreading in Tuyuca:

	jõre	P1: *NAS OBSSTOP	P1: *NAS FRIC	P1: IDENT-❀O		P2: *t→n	P2: SPREAD ([+n], M)	P2: *NAS LIQ	P2: *NAS GLIDE	P2: *NAS VOWEL
☞	a. [j̃õr̃ẽ]				❀			*	*	**
	b. [j̃õ]re			*!*			**		*	*
	c. j[õ]re			*!**			***			*
	d. [j̃õ]r[ẽ]			*!			*****		*	**

Note that it is reasonable to ask why segmental transparency is found only with obstruents in nasal harmony and not with sonorants as well, given that it would be computationally possible to produce such effects. This question is taken up in section 3.6, where it is suggested that an evaluation metric for opaque constraint interactions in grammar offers explanation.

10 An evaluation metric for opacity effects is discussed in section 3.6.

3.3.3 Underlying representations and contrast

As outlined in chapter 1, I follow Prince and Smolensky (1993) in assuming that inventories and contrast are emergent properties of the ranking of faith and markedness constraints.[11] The rankings responsible for representations and contrast in Tuyuca will make an important contribution to understanding the realization of obstruent stops under nasalization and why certain outcomes which are alternatives to transparency for voiceless obstruent stops do not occur. Recall that the consonantal inventory of Tuyuca is as follows: [p, b, t, d, k, g, m, n, ŋ, s, r, w, j, h] with nasal and voiced stops in complementary distribution as defined by nasal harmony environments (Barnes 1996).

I start with the occurrence of voiced stops and nasals in outputs of Tuyuca. It is important that we admit both of these segments as 'phonemic' in the language in the sense that both kinds of segments in the input will survive in the output in the general case (i.e. they are not ruled out simply by high-ranking markedness constraints). The surface complementary distribution of these segments will come about from their interaction with nasal spreading. The argument for 'phonemic' voiced obstruent stops in Tuyuca comes from their behavior under nasalization: voiced stops are reluctant undergoers of nasalization. This point was raised in chapter 2: in Tuyuca, voiced and voiceless stops block spreading across morpheme boundaries. This blocking pattern is a clear indication that these stops are the least compatible segments with nasalization. If the blocking voiced stops were underlyingly [+sonorant], this outcome would be unexpected, as voiced stops would then be one of the most compatible segments with nasalization and should block only when all less compatible segments do as well. I will first demonstrate how rankings of output-oriented constraints produce an inventory including both voiced obstruent stops and nasals, and then I will come back to the issue of the effect of nasal harmony on the output distribution of these segments as well as voiceless stops.

The occurrence of voiced obstruent stops in the inventory of a language is a property that emerges from ranking: the faith constraint preserving obstruency, IDENT-IO[-sonorant], must outrank the markedness constraint against voiced obstruent stops, *[+voice, -continuant, -sonorant]. The effect of this ranking for an input containing /d/ is shown in (30) ([díа] 'river').

[11] As noted in chapter 1, the assumption that contrast is an emergent property of faith and markedness constraint rankings is not crucial to the core of the analysis of nasal harmony. It may be that segmental contrast is best handled in an approach drawing on Dispersion theory (Flemming 1995a recasting and extending ideas of Lindblom 1986, 1990; see Steriade 1995b for related ideas; Padgett 1997 provides a recent application), but that is not an issue to be decided here.

(30) IDENT-IO[-sonorant] >> *[+voice, -continuant, -sonorant]

	dia	IDENT-IO[-son]	*[+voi, -cont -son]
☞	a. dia		*
	b. nia	*!	

The winner in (30) is the faithful candidate in (a), which preserves the input [-sonorant] property of the stop. The claim of obstruent status is uncontroversial for voiceless stops. The ranking, IDENT-IO[-sonorant] >> *[-voice, -continuant, -sonorant], will produce the same result for voiceless stops: a voiceless obstruent stop in the input will remain an obstruent in the output. It should be noted here that I assume that there is a markedness constraint against every feature combination. The markedness constraint against voiceless obstruents will always be ranked quite low in the hierarchy of markedness constraints.

While it is clear that there are voiced and voiceless obstruent stops in the inventory of Tuyuca, there is also reason to posit nasal stops as well. It is generally recognized that nasal stops are more harmonic than voiced obstruent stops, since an open velo-pharyngeal port facilitates voicing. This suggests that the occurrence of voiced obstruent stops in an inventory should imply the presence of nasals, an implication which is almost universally true (Maddieson 1984). In addition, Ferguson (1963) notes that the presence of nasal vowels in the inventory of a language implies the occurrence of nasal stops. The inclusion of nasals in the Tuyuca inventory is obtained by the ranking in (31), which ranks the identity demand for [+sonorant] over a markedness constraint against voiced sonorant stops (I assume that some phonetically-based constraint forces these stops to be [+nasal]). The winning candidate here is (a), which preserves the input nasal stop (nasal spreading is not shown in this output; the actual output is [mṍã] 'salt').

(31) IDENT-IO[+sonorant] >> *[+voice, -continuant, +sonorant]

	moa	IDENT-IO[+son]	*[+voi, -cont, +son]
☞	a. moa		*
	b. boa	*!	

We have achieved the three series of stops in the Tuyuca inventory: voiceless, voiced, and nasal. Let us now consider the outcomes for these segments in nasal harmony. The case of a morpheme containing a nasal stop is shown in (32). I consider here a possible input in which the only underlying nasal segment is the nasal stop. Here the nasal stop triggers nasal spreading to all segments in the morpheme. Morphemes containing a nasal segment in the input will thus come out as nasal morphemes.[12] Identity constraints for [±sonorant] features are collapsed here and are high-ranked in P2. To simplify the tableau, constraints against nasalized obstruents are collapsed, as are ones against nasalized sonorants; also, only constraints which are immediately relevant are shown.

(32) /m/ triggers nasal spreading.

	P1		P2		
moa	*NasObs	Ident-❀O	Ident-IO [±son]	Spread ([+nas], M)	*NasSon
☞ ❀ a. [mõã]					***
b. [m]oa		*!*		**	*
c. [mõ]a		*!		*	**
d. boa		*!**	*		

In (32), the sympathetic candidate is the one which fully satisfies the nasal spreading constraint, while obeying IDENT[±son]. This chooses (a), with nasalization across the morpheme, as the sympathetic form. Because (a) does not contain any nasalized obstruents, it also is selected as the optimal output, since it best satisfies ❀O-Faith.

Thus far we have not explored the content of the IDENT-❀O constraints in P1. The outcomes for obstruent stops in nasal spreading help to clarify the required ranking. First I consider the case of voiced stops. Although in isolation the ranking of IDENT[-sonorant] over *[+voice, -continuant, -sonorant] forces voiced obstruent stops in the input to be maintained as obstruents in the output, this preservation of sonorant identity can be violated in nasal morphemes, i.e. /b, d, ɡ/ → [m, n, ŋ]. Because this outcome involves changing the [sonorant] property of the stop, it has a cost not found in the nasalization of other segments. To achieve this change in sonorancy, I suggest that sympathetic faith is capable of mapping an obstruent to a sonorant through IDENT-❀O[+nasal] outranking IDENT-❀O[-sonorant]. The outcome for a nasal morpheme containing a voiced obstruent stop is shown in (33).

12 As noted in chapter 2, I assume that it is nasal segments in the first syllable that trigger nasal spreading. This will discussed further in section 3.3.4.

(33) Realization of /d/ in a nasal morpheme.

	P1			P2			
wĩdo	*Nas Obs	Ident-❀O [+nas]	Ident-❀O [-son]	Ident-IO [±son]	*[+voi, -cont, -son]	Spread ([+n], M)	*Nas Son
☞ a. [w̃ĩnõ]			*	*			****
b. [w̃ĩ]do		*!*			*	**	**
c. w[ĩ]do		*!**			*	***	*
d. [w̃ĩ]d[õ]		*!			*	*****	***
❀ e. [w̃ĩd̃õ]	*!				*		***

Note that I assume here that /d/ → [n] takes place in the sympathy mapping, and is not achieved by nasal spreading itself, that is, for the purposes of nasal spreading, nasalization of /d/ produces a very marked segment [d̃] rather than a very harmonic one [n]. This is to explain the fact that obstruents are reluctant undergoers of nasalization. An alternative in which nasal spreading outranks IDENT-IO[-son], giving a candidate like (a) as the sympathy candidate, is discussed (and rejected) in section 3.3.5. The tableau in (33) shows that ❀O-Faith causes an input voiced obstruent stop to come out as a nasal stop in the output of a nasal morpheme. In an oral morpheme, the sympathy candidate will be the same as the output, and so a voiced stop will surface faithfully as an oral obstruent.

Finally, I consider the case of voiceless obstruent stops. For these segments in a nasal morpheme, the high-ranking status of IDENT[-son] in P2 will select a sympathy candidate with a nasalized voiceless obstruent stop, not one changing the voiceless stop into a nasal sonorant stop, such as [n]. IDENT[-son] thus eliminates the /t/→[n] candidate from the running for sympathy status. In the analysis of transparency for [t] in Tuyuca from (28), IDENT[-son] may be substituted for *t→n. The tableau in (34) illustrates the selection of the sympathy candidate.

(34) Selection of the sympathy candidate for /w̃ãti/.

	w̃ãti	P1: *NasObs	P1: Ident-❁O [+nas]	P1: Ident-❁O [-son]		P2: Ident-IO [±son]	P2: Spread ([+n], M)	P2: *NasSon
	a. [w̃ãt̃ĩ]	*			❁			***
	b. [w̃ã]ti		**				*!*	**
	c. w[ã]ti		***				*!**	*
	d. [w̃ã]t[ĩ]		*				*!****	***
	e. [w̃ãnĩ]			*		*!		****

In contrast to the outcome for voiced stops in nasal morphemes, voiceless stops do not become full nasals in the optimal output. We have established that sympathetic faith can change an obstruent into a sonorant in order to preserve a [+nasal] specification; this gives [d̃] → [n]. However, a nasalized voiceless stop does not map to a voiced nasal (i.e. *[t̃] → [n]), indicating that IDENT-❁O[±voice] outranks IDENT-❁O[+nasal]:

(35) Voice specifications in sympathy candidates are preserved.

	w̃ãti	P1: *Nas Obs	P1: Ident-❁O [±voi]	P1: Ident-❁O [+nas]	P1: Ident-❁O [-son]		P2: Ident-IO [±son]	P2: Spread ([+n], M)	P2: *Nas Son
	a. [w̃ãt̃ĩ]	*!				❁			***
	b. [w̃ã]ti			**!				**	**
	c. w[ã]ti			**!*				***	*
☞	d. [w̃ã]t[ĩ]			*				*****	***
	e. [w̃ãnĩ]		*!		*		*		****

We have seen now that sympathetic faith must preserve voicing contrasts but it may change a voiced obstruent stop into a sonorant nasal. I turn now to the question of voiceless nasal outcomes for voiceless stops. Although voiced stops change to voiced nasal sonorant stops, voiceless stops do not make a parallel shift to voiceless nasals, instead they come out as voiceless oral obstruents. To understand these different resolutions, it is important to recognize that voiced nasal stops are extremely common

across languages, but voiceless nasals are very marked cross-linguistically, that is, they occur only rarely in the languages of the world (Maddieson 1984, Ladefoged and Maddieson 1996). The markedness of voiceless nasals may be understood both in terms of disfavored perceptual/acoustic properties and articulatory properties of these segments. First, voicelessness in a nasal segment tends to obscure perceptual cues for place of articulation. In acoustic studies of voiceless nasals in two South-East Asian languages, Burmese (Tibeto-Burman; Myanmar) and the Hmar dialect of Mizo (Tibeto-Burman, India), Ladefoged and Maddieson (1996: 112-3) find that voiceless nasals are actually partially voiced, with the onset of voicing beginning well before the release of oral closure. This kind of voiced period has been interpreted by various researchers as providing formant transitions to help distinguish place of articulation (Ladefoged 1971; J. Ohala 1975; Dantsuji 1986). Second, producing voicelessness in a nasal stop involves a wide-open glottis, a gesture requiring a relatively high degree of effort. In general, the airflow through the nasal cavity that occurs during a nasal stop induces spontaneous voicing; this is why nasal stops are characterized as [+sonorant]. Becase the supralaryngeal cavity configuration for sonorants produces voicing in the general case, the usual vocal cord opening for voiceless segments is insufficient to inhibit voicing in the production of voiceless sonorants, and so the vocal cords must be spread to a greater degree. Consistent with these observations, many analysts have characterized voiceless nasals (and other voiceless sonorants) as aspirated, that is, as involving a wide glottal spreading gesture (on this characterization of aspiration see Lombardi 1991 and references therein). Phonological arguments for this analysis of voiceless nasals have been made by Mester and Itô (1989, drawing partly on the phonetic description of Burmese voiceless nasals by Okell 1969), Cho (1990), Lombardi (1991, 1995c), and Steriade (1993b) (cf. Clements 1985 on voiceless laterals in Klamath). This result is also suggested by nasal airflow measurements taken in the production of Burmese voiceless nasals (Bhaskararao and Ladefoged 1991; Ladefoged and Maddieson 1996: 69, 112-113). The implication for realizing a voiceless stop as a voiceless nasal in nasal contexts is that the resulting nasal must not only be voiceless but also involve a wide glottal aperture. This kind of gesture is not common in sonorants cross-linguistically, and it does not occur in nasals in Tuyuca. I will encode the cross-linguistic markedness of voiceless nasals with the constraint, *N̥, which prohibits voiceless nasal sonorants. In most languages, this constraint will be ranked quite high. In Tuyuca it is undominated.[13]

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13 Aspiration occurs in voiceless *obstruent* stops in Tuyuca in the environment of high vowels (Barnes and Takagi de Silzer 1976: 125-6); however, across languages aspiration of obstruent stops is a great deal more common than aspiration of nasals. Ladefoged and Maddieson (1996) note that in

In Tuyuca, *N̥ actually belongs to P1 along with the nasalized obstruent constraints, because it must dominate sympathetic faith, specifically IDENT-❀O[+nasal]. This ranking is needed to ensure that a [t̃] in a sympathy candidate comes out as an oral [t] rather than a nasal [n̥].[14] This is illustrated in (36) (showing only immediately relevant constraints). Importantly, *N̥ rules out candidate (f), with a voiceless nasal, giving (d), with a transparent voiceless stop as the optimal output.

(36) Ruling out voiceless nasals.

	wãti	P1: 1.*NASOBS 2.*N̥	ID-❀O [±voi]	ID-❀O [+nas]	ID-❀O [-son]		P2: IDENT-IO [±son]	SPREAD ([+n], M)	*NASSON
	a. [w̃ãt̃ĩ]	*!(1)				❀			***
	b. [w̃ã]ti			**!				**	**
	c. w[ã]ti			**!*				***	*
☞	d. [w̃ã]t[ĩ]			*				*****	***
	e. [w̃ãnĩ]		*!		*		*		****
	f. [w̃ãn̥ĩ]	*!(2)			*		*		****

I conclude this section with a summary of the sympathetic faith hierarchy and contrast rankings for Tuyuca stops in (37). The stop inventory rankings admit three series of stops in Tuyuca: voiceless, voiced, and nasal. The complementary distribution of voiced obstruent stops and nasals is not attributed to any restriction on inputs or underlying representations, rather it is achieved by the ranking of constraints on outputs. These produce full [+nasal] spreading in all morphemes containing a nasal segment, and through sympathetic faith, map a nasalized voiced obstruent stop to a nasal sonorant stop. The inventory and distribution of segments in Tuyuca is thus an emergent property of the constraint hierarchy rather than based on any conditions on possible inputs.

relation to obstruent stops, 'aspiration' sometimes describes a delayed timing of voice onset rather than a specific glottal aperture. Voiceless nasals, on the other hand, always require a wide glottal aperture and may or may not induce a voice onset delay. It is not clear whether aspiration of voiceless stops in Tuyuca refers to a voice timing relation or expanded glottal width. If the former, it may be that the wide glottis gesture simply does not occur in any segment in Tuyuca aside from [h].

14 Alternatively, this could be handled by IDENT-❀O[±aspiration], assuming that the kind of aspiration involved in voiceless nasals differs somewhat from the contextual aspiration occurring in voiceless stops in Tuyuca (see n. 13).

(37) a. Stop inventory rankings:
Voiced & voiceless obstruent stops: IDENT-IO[-son] >> *[±voi, -cont, -son]
Voiced nasal stops: IDENT-IO[+son] >> *[+voi, -cont, +son]

b. Tuyuca sympathetic faith:
IDENT-❀O[±voice] >> IDENT-❀O[+nasal] >> IDENT-❀O[-sonorant][15]

3.3.4 Cross-morphemic spreading and fixed affixes

Next I consider the pattern of cross-morphemic spreading in Tuyuca. As outlined in 2.1, nasality spreads from the root to a set of alternating suffixes (there are no prefixes in Tuyuca). Examples of alternations with the suffix /-ri/ 'imperative of warning' are repeated below.

(38) a. Oral suffix alternant with oral stem
/tutí - ri/ → [tutíri] 'watch out or you will get scolded!'
scold - imp. of warning

b. Nasal suffix alternant with nasal stem
/h̃ĩĩ́ - ri/ → [h̃ĩĩ́r̃ĩ] 'watch out or you will get burned!'
burn - imp. of warning

As discussed in chapter 2, Barnes (1996) notes that alternating suffixes share a common phonological property: their initial segment is a sonorant continuant; stop- and fricative-initial suffixes always belong to the class of suffixes which are fixed in their

15 It should be noted that the reverse ranking of IDENT-❀O[+nasal] and IDENT-❀O[±voice] would yield a language in which both /t/ and /d/ were realized as [n] under nasalization. This pattern is expected under factorial ranking in OT, but it is unattested. I suggest that this can be understood as a consequence of the highly neutralizing effect of such an outcome, that is, neutralization of the contrast between the series of stops in nasal morphemes in a language like Tuyuca would produce too great a reduction of their contrast potential. The notion of a threshold of neutralization of contrast potential could be understood in quantificational terms, and I leave pursuit of this matter for further research. A second prediction under sympathetic faith reranking is that /d/ could be realized as transparent [d] in the output of nasal harmony (by IDENT-❀O[-sonorant] >> IDENT-❀O[+nasal]). This outcome does in fact occur in the nasal harmony of Coatzospan Mixtec (Pike and Small 1974; Gerfen 1996). Interestingly, voiceless stops block nasal spreading in this language. The generalization seems to be that languages do not admit transparent outcomes for voiced and voiceless stops in the same language. As Walker (1996) notes, this may be best understood in terms of contrast: it is difficult to maintain a perceptible voicing contrast in oral stops between nasal vowels (see also Hayes 1995). I will not pursue this further here, but note that an account may require a more elaborated theory of contrast, such as that of Flemming (1995a; see Steriade 1995b for related ideas; also Padgett 1997).

oral/nasal quality. Voiced oral stops pattern with the obstruents in never appearing in the alternating affix category, i.e. in affixes a voiced stop/nasal stop alternation never occurs.[16] Examples of obstruent-initial fixed oral suffixes are given in (39).

(39) a. [h̃õố - pɨ] 'at that place (over there)'
there - locative

b. [j̃ũkã - da] no gloss[17]

The phonological generalization concerning obstruents in fixed affixes is explained if obstruents block nasal spreading across morphemes. Otherwise the exclusion of obstruent-initial forms in the set of alternating affixes would be an unexplained gap. In this section I will first present an analysis of the alternating affixes, deriving the blocking effect of obstruents, and I will then go on to analyze the fixed affixes. Interestingly, we will see that the blocking outcome for obstruents in alternating affixes arises under a straightforward ranking resolution of the cross-morpheme spreading constraint and the nasal markedness constraints banning nasalized obstruents, that is, it arises when the constraint conflict is resolved with a transparent interaction by ranking without hierarchy bifurcation. In contrast, for spreading within the morpheme, the constraint conflict is resolved with an opaque interaction, producing 'skipped' or transparent nasalized obstruents. This makes apparent a mismatch in the common terminology: (derivationally) *opaque* constraint interactions yield *transparent* behavior of segments and (derivationally) *transparent* constraint interactions yield blocking or *opaque* behavior of segments.

The straightforward interaction of nasalized obstruent constraints with cross-morpheme spreading versus the opaque interaction with intra-morpheme spreading raises a kind of complexity in spreading and nasalized segment markedness that we have not yet considered. In order to examine its implications for the analysis, we must first determine what causes the cross-morpheme spreading. I propose that cross-morpheme spreading is driven by the word-spreading constraint in (40).

16 Voiced velar stops are an exception; see discussion in n. 5 of chapter 2.

17 Barnes and Malone (1988) give the gloss for this word in Spanish as 'hilo de cumare'. 'Hilo de' means 'thread of', but I have been unable to find a translation for 'cumare'.

(40) SPREAD([+nasal], W)
Let n be a variable ranging over occurrences of the feature specification [+nasal], and S consist of the ordered set of segments $s_1 ... s_k$ in a word W. Let Assoc(n, s_i) mean that n is associated to s_i, where $s_i \in S$.
Then SPREAD([+nasal], W) holds iff
i. $(\forall s_i \in S)\ [[\exists n\ (Assoc(n, s_i)] \rightarrow [(\forall s_j \in S)\ [Assoc(n, s_j)]]]$.
ii. For each feature occurrence, n, associated to some segment in W, a violation is incurred for every $s_j \in S$ for which (i) is false.

The constraint in (40) analyzes spreading across morphemes as a demand on spreading any occurrence of a [+nasal] feature to all segments within the word. In Tuyuca, the set of segments propagating nasal spreading in the morpheme (all segments) is a superset of those propagating word spreading (sonorants). For this difference in blocking effects to arise, it must be the case that the intra-morpheme spreading constraint, SPREAD([+nasal], M), outranks the cross-morpheme one, SPREAD-R ([+nasal], W):

(41) SPREAD([+nasal], M) >> SPREAD([+nasal], W)

The occurrence of blocking effects in spreading across morphemes but not within morphemes would be handled by interleaving a nasal markedness constraint between the morpheme and word spreading constraints. For example, blocking by obstruents across morphemes can be obtained with the ranking in (42). (Constraints against nasalized obstruents are collapsed as *NASOBS.)

(42) SPREAD([+nasal], M) >> *NASOBS >> SPREAD([+nasal], W)

Our reasoning has led us to the ranking in (42); however, we now face a dilemma: it was established earlier that the transparency outcome for nasalized obstruents in morphemes involves the reverse ranking of SPREAD([+nasal], M) and *NASOBS:

(43) Transparency of nasalized obstruents:

P1		P2
*NASOBS	>>	SPREAD([+nasal], M)

If *NASOBS outranks both SPREAD([+nasal], M) and SPREAD([+nasal], W) by moving to P1, then we cannot realize the different behavior of nasalized obstruents with respect to the two spreading constraints. We predict instead that nasalized obstruents will behave transparent in spreading within *and* across morphemes. This undesirable outcome is illustrated in (44) with a hypothetical form. Here *NASOBS outranks both spreading constraints by appearing in P1. Candidate (e), with a transparent suffix obstruent, is chosen over (d), where the obstruent blocks spreading. (Constraints against nasalized sonorants are collapsed in the last column.)

(44) Incorrect outcome: obstruents are transparent in cross-morpheme spreading

		P1			P2		
	ãta-ta	*NASOBS	IDENT-❁O [+nasal]		SPREAD ([+nas], M)	SPREAD ([+nas], W)	*NASSON
	a. [ãtã]-ta	*!	**			**	**
	b. [ã]ta-ta		***!*		**	****	*
	c. [ãtã-tã]	*!*		❁			***
☞	d. [ã]t[ã]-ta		***!		****	********	**
☜	e. [ã]t[ã]-t[ã]		**		*****	********* ***	***

The problem comes about because P2 selects candidate (c), with full word spreading, as the sympathy candidate. Candidate (a), where [t] blocks in spreading across morphemes, is the one that we instead want to be selected as sympathetic.

The issue is summarized in (45). For each of the spreading constraints, the ban on nasalized obstruents wins over perfect satisfaction of spreading. One of these constraint conflicts is resolved with a (derivationally) opaque interaction, yielding transparent or skipped obstruents, and the other is resolved with a (derivationally) transparent interaction, yielding blocking obstruents.

(45) a. *NASOBS >> SPREAD([+nasal], M)
Opaque constraint interaction: nasalized obstruents behave transparent.

b. *NASOBS >> SPREAD([+nasal], W)
Transparent constraint interaction: nasalized obstruents block (in affixes).

We may note that opaque constraint interactions come about when constraints belong to separate components (i.e. segments of the constraint hierarchy) and transparent interactions occur between constraints within the same component. This means that for obstruents to block in spreading to suffixes, some constraint prohibiting the nasalization of these segments must dominate SPREAD([+nasal], W) within the same component. As shown in (44), this cannot be the general *NASOBS constraint, because we have already established that it must occur in P1. The nasalized obstruent markedness constraint in P2 must be something more specific, namely a constraint prohibiting the nasalization of obstruents in affixes.

This solution is grounded in the notion of positional markedness. The idea underlying positional markedness is that marked phonological structure may be dispreferred or excluded in prosodically or morphologically weak positions. It gives basis to work on positional licensing, which has been proposed to have applications to a wide range of phonological phenomena, spanning features, segments, syllables, and metrical structure (e.g. Itô 1986; Goldsmith 1990; Lombardi 1991; Itô and Mester 1993; Steriade 1995b, 1997; Itô, Mester, and Padgett 1995; Padgett 1995b; Zoll 1996, 1997, in press; Walker 1997b; among others; for references to the broader range of work on the role of positional prominence in phonology, see citations in Zoll 1997). The marked phonological structures we are concerned with here are nasalized obstruents. In the sympathy candidate, word spreading can drive this kind of structure in roots but not in suffixes. This is an example of exclusion of marked segments in morphologically weak positions; affixes, which are dependent morphemes, are weaker than roots, which have the status of morphological heads. Within current optimality-theoretic work, effects of positional prominence have been implemented in two different ways: through positional markedness constraints, which enforce the coincidence of marked structure with prominent positions (Zoll 1996, 1997, in press and precursors cited above), and through positional faith, which enforce faith requirements specific to prominent positions (e.g. McCarthy and Prince 1995; Beckman 1995, 1997, 1998; Padgett 1995a; Urbanczyk 1996b; Alderete 1995, 1996, 1997a; Smith 1997; Walker 1997b; Katayama 1998).

In a careful examination of a range of positional licensing effects, Zoll presents evidence demonstrating a need for positional markedness constraints (1996, 1997, in press). Zoll (1997) focuses on two kinds of phenomena which necessitate positional markedness constraints. These are (i) the blocking of derived marked structure in weak positions, and (ii) the guiding of marked structure to strong positions. Zoll discusses the first point in relation to a licensing effect in the prosodic structure of Guugu Yimidhirr. This language is remarkable for limiting the occurrence of heavy syllables to the first two syllables, a domain which may be defined as the head (or innermost) prosodic word (Pwd) (Kager 1995). Positional markedness can explain this restriction by requiring that a heavy syllable belong to the head Pwd (or alternatively banning heavy syllables in non-head positions). Importantly, the positional markedness constraint also blocks the derivation of heavy syllables in weak positions. Guugu Yimidhirr has a suffix [-nda], which induces lengthening of the preceding vowel when it occurs in the head Pwd. When the vowel preceding [-nda] is outside of the head Pwd, it does not lengthen. The lengthening in these cases is blocked by the constraint requiring that a heavy syllable belong to the head Pwd. Zoll points out that this outcome is not one that can be achieved with positional faith constraints. The positional faith approach to a licensing effect in the head Pwd would make use of faith constraints specific to this structural position. Ranking the position-specific faith constraint higher than non-positional faith is capable of producing various positional licensing effects; however, it cannot block the derivation of marked structure outside of the licensing position. Applied to Guugu Yimidhirr, positional faith constraints would predict that strong positions (e.g. head positions) should be more resistant to change than weak positions (e.g. non-head positions), and if strong positions can be altered to admit vowel lengthening, then weaker positions must also admit this change. However, the positional licensing effect in Guugu Yimidhirr is not of this kind, and is one that must be handled by positional markedness.

Zoll's second argument comes from the relocation of marked structure from a weak position to a strong position. She observes that a positional markedness constraint requiring that marked structure coincide with a strong position can cause marked structure to migrate from a weak position in which it originates to a strong position. This outcome retains the marked structure in the output rather than losing it all together, better satisfying MAX. Zoll shows that a phenomenon of this kind occurs in the mimetic palatalization of Japanese, described by Mester and Itô (1989). Positional faith, on the other hand, cannot explain this kind of event, because the migrating structure did not originate in a prominent position. Positional faith constraints enforce faithfulness to strong positions, and they thus resist change in these locations. It should be noted that although positional faith does not apply to these positional markedness phenomena, positional faith constraints offer explanation for other kinds of positional licensing effects. For example, positional faith has been utilized to derive effects of triggering of spreading from strong positions and targetting of weak positions (Beckman 1995, 1997, 1998). Arguments for positional faith will be discussed later in this section.

Zoll makes a convincing case for positional markedness constraints. Her finding that only positional markedness constraints can block the derivation of marked structure in weak positions is directly relevant to the matter of obstruents blocking nasal spreading in affixes in Tuyuca. The blocking of marked structure is the kind of phenomenon we are dealing with here, i.e. we are dealing with an instance of positional markedness. To reflect the dispreference for marked material in affixes, I suggest that markedness constraints may be specific to this morphological position (Padgett 1995b makes a similar proposal for blocking formation of complex segments in affixes in Gã). The constraint against nasalized obstruents in affixes is given in (46) (cf. Zoll 1996, 1997, in press for a somewhat different formulation of positional markedness constraints).

(46) $*\text{NASOBS}_{\text{affix}}$

Affix-specific markedness constraints occur in addition to the more general non-positional markedness constraints prohibiting nasalized segments. It is when these constraints are ranked separately in the grammar that asymmetries between the status of nasalized segments in roots and affixes becomes apparent.

We have seen that the non-positional markedness constraint has an opaque interaction with morpheme-domain nasal spreading: this yields transparent obstruent stops in the general case; however, in affixes there is a transparent interaction of word-domain spreading with markedness yielding obstruent blocking of nasal spread. This is achieved by placing the affix-specific markedness constraint against nasalized obstruents between morpheme and word-spreading in P2 to block nasalization of obstruents in cross-morpheme spreading in the sympathy candidate. The non-positional markedness constraint against nasalized obstruents is placed in P1 to obtain full nasal spreading in all other positions in the sympathy candidate, i.e. within morphemes. The structure of the ranking is illustrated in (47-48).

The tableau in (47) illustrates selection of the sympathy candidate. Within P2, $*\text{NASOBS}_{\text{affix}}$ outranks the cross-morpheme nasal spreading constraint, which in turn outranks constraints against nasalized sonorants. This ranking selects candidate (a) as sympathetic, where /t/ blocks spreading in the suffix. On the other hand, a root-based /t/ is nasalized in the sympathy candidate. Alternatives for the sympathy candidate lose either on the affixal markedness constraint (c) or on spreading (b, d, e).

(47) Selection of the sympathy candidate in cross-morpheme spreading

	ãta-ta	P1: *NASOBS	P1: IDENT-❀O [+nasal]		P2: SPREAD ([+n], M)	P2: *NASOBS$_{af}$	P2: SPREAD ([+n], W)	P2: *NASSON
	a.[ãt̃ã]-ta	*		❀			**	**
	b. [ã]ta-ta		**		*!*		****	*
	c.[ãt̃ã-t̃ã]	**				*!		***
	d.[ã]t[ã]-ta		*		*!***		********	**
	e.[ã]t[ã]-t[ã]		*		*!****		******** ****	***

The tableau in (48) shows selection of the actual output. This is the candidate which most closely resembles the sympathy candidate, while respecting the non-positional *NASOBS.[18] Since the sympathy candidate is the one with full spreading in the root and blocking by obstruents across morphemes, the actual output is the one in (d) with an oral suffix and nasalization of all segments in the root except for [t]. Candidate (e), with nasalization of the suffix vowel, introduces nasalization in the output that is not present in the sympathetic candidate. This could be ruled out by IDENT-❀O[-nasal] or simply by the spreading constraint, as shown here.

(48) Selection of the actual output in cross-morpheme spreading

	ãta-ta	P1: *NASOBS	P1: IDENT-❀O [+nasal]		P2: SPREAD ([+n], M)	P2: *NASOBS$_{af}$	P2: SPREAD ([+n], W)	P2: *NASSON
	a. [ãt̃ã]-ta	*!		❀			**	**
	b. [ã]ta-ta		*!*		**		****	*
	c. [ãt̃ã-t̃ã]	*!*				*		***
☞	d. [ã]t[ã]-ta		*		****		********	**
	e. [ã]t[ã]-t[ã]		*		*****!		******** ****	***

18 The occurrence of the non-positional *NASOBS in P1 ranked over *NASOBS$_{affix}$ in P2 is somewhat unexpected given the positional markedness context. However, this ranking of the markedness constraints gives a positional markedness effect through the transparent interaction of *NASOBS$_{affix}$ with spreading constraints in contrast to the opaque interaction of *NASOBS. An alternative without a positional markedness constraint and placing *NASOBS in both P1 and P2 is outlined in section 3.7.

To verify the analysis, I exhibit three tableaux below illustrating the analysis of cross-morpheme spreading in Tuyuca with actual forms from the language. The first example shows the blocking effect of a voiceless obstruent in spreading from a root to a suffix. In this case, with no obstruent in the root, the sympathy candidate coincides with the actual output.

(49) /hõo - pɨ/ 'at that place (over there)'

	hõo - pɨ	P1: *NASOBS	P1: IDENT-❀O [+nasal]		P2: SPREAD ([+n], M)	P2: *NASOBS$_{af}$	P2: SPREAD ([+n], W)	P2: *NASSON
☞	a. [h̃õõ]-pɨ			❀			**	***
	b. h[õ]o-pɨ		*!*		**		****	*
	c. [h̃õõ-p̃ɨ̃]	*!				*		****
	d. [h̃õõ]-p[ɨ̃]				*!		******	****

Next, we see an example of a voiced obstruent blocking across morphemes.

(50) /jũka - da/ no gloss

	jũka - da	P1: *NASOBS	P1: IDENT-❀O [+nasal]		P2: SPREAD ([+n], M)	P2: *NASOBS$_{af}$	P2: SPREAD ([+n], W)	P2: *NAS SON
	a. [j̃ũk̃ã]-da	*!		❀			**	***
	b. j[ũ]ka-da		**!*		***		*****	*
	c. [j̃ũk̃ã-d̃ã]	*!*				*		****
	d. [j̃ũk̃ã]-d[ã]	*!			*		*******	****
☞	e. [j̃ũ]k[ã]-da		*		*****		*********	***

Finally, (51) shows nasalization across a morpheme boundary to a liquid-initial suffix.

(51) /hɨ̃ɨ̃ - ri/ 'watch out or you will get burned!'

	hɨ̃ɨ̃ - ri	P1: *NASOBS	P1: IDENT-❁O [+nasal]		P2: SPREAD ([+n], M)	P2: *NASOBS$_{af}$	P2: SPREAD ([+n], W)	P2: *NASSON
	a. [h̃ɨ̃ɨ̃]-ri		*!*				**	***
	b. h[ɨ̃]ɨ-ri		*!***		**		****	*
☞	c. [h̃ɨ̃ɨ̃-r̃ĩ]			❁				*****
	d. [h̃ɨ̃ɨ̃]-r[ĩ]		*!		*		******	****

We have not yet seen a case crucially calling on a distinction between morpheme-domain versus word-domain spreading. An example of this kind will be addressed in the upcoming discussion of suffixes which are fixed in their oral/nasal property.

In Tuyuca, we have seen that the interaction between *NASOBS$_{affix}$ and nasal spreading is a transparent one, coming about from *NASOBS$_{affix}$ dominating the nasal word spreading constraint within the P2 component. Interestingly, another Tucanoan language chooses the alternative outcome for cross-morpheme spreading. The southern dialect of Barasano, a Tucanoan language spoken in Colombia, has a similar pattern of nasalization to Tuyuca (Smith and Smith 1971; Jones and Jones 1991). Like Tuyuca, Southern Barasano has nasal morphemes in which all segments are nasalized except voiceless obstruents, and nasalization spreads across morphemes to alternating affixes. There is also a set of affixes which remain fixed in their nasal quality: affixes in this set are either always oral or always nasal. Importantly, Southern Barasano differs from Tuyuca in including some obstruent-initial suffixes in its set of alternating affixes. This indicates that obstruents behave transparent in all positions. Examples of alternating affixes beginning with obstruent stops are given in (52) (data from Jones and Jones 1991).

(52) Obstruent-initial alternating affixes in Southern Barasano

a. /-ti/ 'question'

Oral alternant: /ahi - a - ti mʉ̃/ → [ahiati mʉ̃] 'do you understand?'
hear-pres.-question you

Nasal alternant: /ɲã - gʉ - ti jʉ/ → [ɲãŋʉ̃t̃ĩ jʉ] 'will I be there?'
be-masc. sg.-question 1 sg.

b. /-bʉ/ 'past nonthird person animate'

Oral alternant: /ahi - bʉ jʉ/ → [ahibʉ jʉ] 'I heard'
hear-nonthird person past 1 sg.

Nasal alternant: /ɲãŋõ - bʉ jʉ/ → [ɲãŋõmʉ̃ jʉ] 'I spoke'
talk-nonthird person past 1 sg.

In analytical terms, the difference between Tuyuca and Southern Barasano comes out as a difference in where *NASOBS$_{affix}$ occurs in P2, as shown in (53). In Southern Barasano, *NASOBS$_{affix}$ is dominated by the nasal word-domain spreading constraint in P2, yielding a sympathy candidate with full spreading, even across affixes. In Tuyuca, *NASOBS$_{affix}$ outranks word spreading to give blocking by obstruents in affixes. Tuyuca thus shows an affixal positional markedness effect with respect to nasalized segments, but Southern Barasano does not.[19]

(53) a. *Southern Barasano:* No positional markedness effect in affixes
P1: *NASOBS >> **P2:** SPREAD([+nasal], W) >> *NASOBS$_{affix}$

b. *Tuyuca:* Positional markedness effect in affixes for nasalized obstruents.
P1: *NASOBS >> **P2:** *NASOBS$_{affix}$ >> SPREAD([+nasal], W)

Nasalization in other Tucanoan languages also falls into one of these two patterns. Tatuyo (Colombia; Gomez-Imbert 1980) is of the Southern Barasano type, where obstruents can propagate nasal spreading in all positions. Tucano (Colombia; West and Welch 1967, 1972; Bivin 1986; Trigo 1988; Noske 1995) follows the Tuyuca pattern with obstruent blocking in affixes.

The next point in the analysis of cross-morpheme nasal spreading in Tuyuca concerns fixed affixes. As noted in section 2.1 (and repeated above), Tuyuca has a set of alternating suffixes and a set of suffixes which are fixed in their oral/nasal property. The alternating suffixes share the phonological property of never beginning with an obstruent (or nasal stop), as discussed above, so stop- or fricative-initial suffixes always fall in the fixed nasality category (sonorant continuant-initial suffixes may occur in

19 The same result for Southern Barasano could be obtained by promoting *NASOBS$_{affix}$ to P1; however, I assume that promotion of a markedness constraint to P1 is only posited by the learner when a transparent constraint interaction will not produce the correct resolution. The implications of (derivational) opacity effects for the learner are discussed in section 3.6.

either group). A partial list of Tuyuca suffixes grouped according to their alternating versus fixed nasality behavior is given in (54-55) (repeated from chapter 2).

(54) <u>Alternating suffixes:</u>

a.	-a	animate plural
b.	-ha	contrast
c.	-ja	imperative
d.	-wɨ	evidential
e.	-wo	evidential
f.	-ri	imperative of warning
g.	-re	specifier
h.	-ro	adverbializer
i.	-ra	pl. nominative

(55)

Fixed oral suffixes:			Fixed nasal suffixes:		
a.	-a	recent past	o.	-h̃ã	emphatic
b.	-ja	evidential	p.	-j̃ã	try
c.	-wɨ	classifier	q.	-w̃ɨ̃	singularizer
d.	-wo	classifier	r.	-w̃õ	classifier
e.	-ri	inanimate sg. nominative	s.	-r̃ĩ	time(s)
f.	-re	inanimate pl. nominative			
g.	-sa	classifier	t.	-sã	continue action
h.	-ba	classifier	u.	-mã	classifier
i.	-da	classifier	v.	-nã	at that instant
j.	-ga	evidential	w.	-ŋã	diminutive
k.	-go	evidential			
l.	-pi	too much	x.	-pĩ	classifier
m.	-to	evidential	y.	-tõ	classifier
n.	-ka	large inanimate sg.	z.	-kã	also

With the distribution of obstruents in this grouping explained, we might consider the possibility that fixed affixes fall into an identifiable grammatical class or later 'level' of affixation, where nasal spreading does not apply. However, this kind of approach is not tenable for the data. Barnes (1996: 34-5) notes that grammatical grounds are insufficient to predict whether a suffix will fall into the alternating or fixed nasality category. There

does not appear to be a correlation between the derivational versus inflectional status of a suffix and nasalization category; also fixed suffixes can occur before or after alternating suffixes in the linear sequence of affixes. Barnes notes that in addition to roots, aspectual and mood suffixes are always fixed in their nasality, but it is not clear whether there is any significance to the fixed nasality of aspectual and mood suffixes, and this remains an issue for further research.[20, 21]

The occurrence of different linear orderings of fixed and alternating suffixes is illustrated in (56-57) below (data from Barnes and Malone 1988). (56a) shows an example where a nasal root is followed by a fixed oral suffix and then an alternating suffix. Here the alternating suffix comes out as oral following the fixed oral suffix. (56b) gives an oral root followed by a fixed nasal suffix and then an alternating suffix. Here the alternating suffix is nasal in the output. (I follow the descriptive notation of Barnes and Malone, using "N" for nasal morphemes, "O" for oral ones, and "[ ]" for morphemes that alternate in nasality. I have marked nasality on the first vowel in the input here for nasal morphemes.)

```
(56) a.   N    O  [ ]
          |    |   |
         wãkú - ri - wa      →   [w̃ãkṹriwa]  'they did not think'
         think - neg. - evidential

     b.   O   N   [ ]
          |   |    |
         asio- hã - wɨ       →   [asioh̃ãw̃ɨ̃]   'I heated it'
         heat - emphatic - evidential
```

20 Barnes (personal communication 1997) notes that there does not appear to be any correlation between more 'external' suffixes and their probability of being fixed in nasality, and she reports a similar apparent lack of correlation in Tatuyo (Tucanoan). But she points out that there is still more work to be done in the investigation of this subject.

21 The absence of a clear grammatical category basis for the fixed nasality versus alternating status of a morpheme is consistent with the Kaye's (1971) findings concerning Desano (Tucanoan). Like Barnes, Kaye finds that major grammatical category morphemes (e.g. noun and verbs) are always fixed in their oral/nasal specification (with one exception), but suffixes are more variable. Kaye notes that one of the four participial endings is fixed and two of the three case endings are fixed. However, suffixes in other minor grammatical categories pattern together, either all being fixed in their oral/nasal property or all alternating. For example, personal endings, noun finals, and directionals all are fixed in their nasal specification, but mood markers, evidentials, and classifiers are all alternating. For those that are consistent across a minor grammatical category it is not clear whether there is a common basis distinguishing the set of categories which are fixed in nasality versus those that are alternating.

The data in (57) give examples of an alternating suffix occurring between a root and a fixed suffix. In this configuration, the alternating suffix takes on the oral/nasal quality of the preceding morpheme. This indicates that word spreading is in fact directional, from left-to-right. This property of cross-morpheme spreading will be built into the analysis below.

```
(57)  a.   O  [ ]  N
           |   |   |
          atí - a - wĩ̃        →    [atiáw̃ĩ]      'he recently came'
          come - recent past - evidential

      b.   N     [ ]  O
           |      |   |
          bãka - ri - pɨ   →   [mãkãr̃ĩpɨ]  'to the towns'
          town - inan. pl. - clitic
```

In (58) we see a word consisting of six morphemes each fixed in their oral/nasal property. This form clearly shows that fixed morphemes do not affect each other and multiple switches between oral and nasal morphemes is possible.

```
(58)  N     O     N     O     N    O
      |     |     |     |     |    |
     sĩdí - peti - hõa - dɨga - bĩ - jigɨ        →    [sĩnĩpetíh̃õãdɨgamĩjigɨ]
     drink-all-completive-desid.-contraexpect.-evid.   'he wanted to drink it all
                                                        up but...'
```

I propose to attribute the alternating versus fixed status of morphemes to differences in demands on input-output faith for the different sets of morphemes (following proposals of Itô and Mester 1995a; Pater 1995; Beckman 1995, 1997, 1998 with foundation from McCarthy and Prince 1994a, 1995). One persistent and unsurprising generalization in Tuyuca and across many of the Tucanoan languages is that roots or lexical morphemes (i.e. nouns and verbs) are fixed in their oral/nasal specification. However, the notion of 'richness of the base' (Prince and Smolensky 1993: 191), which posits that all inputs are possible, gives us the possibility that all morphemes in an input come with a specification for [±nasal]; it falls to the constraint hierarchy to select an outcome whereby the root specification will be preserved and spread to the suffix (restricting attention for the moment to alternating suffixes). I assume that the nasal specification for a root originates in the first syllable (see

discussion in chapter 2). This outcome can be obtained by calling on positional faith constraint specific to the initial syllable of the root (after Beckman 1995, 1997, 1998; see also McCarthy and Prince 1994a, 1995 on privileged root-faith).

Beckman's (1998) study of positional privilege stands alongside Zoll's work as an important survey and analysis in the area of positional licensing effects. The focus of Beckman's work is on the role of position-sensitive faithfulness constraints in explaining a variety of positional asymmetries in phonological phenomena. A central point of her study is that root-initial syllables exhibit privilege effects and that these effects may be explained by calling on faithfulness constraints specific to this position. To establish the special status of root-initial sylables, Beckman presents evidence from both psycholinguistic and phonological domains. The psycholinguistic evidence comes from initiality effects in processing. These include the finding that utterance-initial portions make the best cues for word recognition and lexical retrieval, the special relevance of initial material for word recall in tip-of-tongue states, and the salience of mispronunciations in initial positions (see Beckman 1998: 53 for citations of the relevant studies). Phonological evidence for a special status for the root-initial syllable comes from languages exhibiting positional neutralization of contrasts in non-initial syllables. Beckman points out that many languages with vowel harmony neutralize certain vowel contrasts outside of the root-initial syllable; this occurs frequently, for example, in languages within the Turkic, Tungusic, Mongolian, Finno-Ugric, and Bantu families (see references cited in Beckman 1998). Further, in languages that exhibit neutralization of vowel contrasts in non-initial syllables, the set of vowels occurring in non-initial positions is often a subset of the full inventory of vowels occurring in the root-initial syllable; also non-initial vowels tend to be less marked in character than root-initial ones. Beckman observes that positional neutralization effects in non-initial syllables are not limited to vowel contrasts. She documents a number of languages in which the inventory of consonants is greater in the root-initial syllable than in non-initial positions.

Beckman presents an elegant account of these positional asymmetries by making use of positional faith constraints specific to the root-initial position, where the availability of this position comes from its enhanced salience in contrast to non-initial positions. The following ranking schema plays a central role in her analysis: IDENT-σ_1[F] >> Markedness Constraint >> IDENT[F]. This ranking places faith for the root-initial position over some markedness constraint, which in turn dominates non-positional faith. As a consequence, the root-initial syllable will have a privileged status not seen in non-initial syllables, whereby root-initial faith alone can enforce violations of the markedness constraint. Beckman shows that this ranking has two important consequences: (i) it yields triggering of phonological processes by the root-initial syllable, and (ii) it produces blocking of neutralizing phenomena in this position. These consequences of the ranking are exemplified by Beckman (1995, 1997, 1998) in a detailed study of positional neutralization and harmony in the Bantu language, Shona, as well as in an analysis of the South Dravidian language, Tamil (Beckman 1998).

As noted above in the discussion of Zoll's work, positional markedness constraints are needed to explain some positional licensing effects. However, for the kinds of positional neutralization effects examined in Beckman's work, a strong case is presented for positional faith constraints for root-initial syllables. These positional faith constraints also have application to the distribution of nasalization in Tuyuca. Ranking root-initial faith constraints for [nasal] over non-positional faith constraints can produce an emergent contrast effect whereby nasality is contrastive in the initial root syllable but not elsewhere. In addition, it will derive preservation of (initial syllable) root features over affix features and will thus force nasal spreading to be triggered by a root segment.

The tableau in (59) presents a hypothetical input where a suffix belonging to the alternating class of affixes comes with a [+nasal] specification and is affixed to an underlyingly oral root. The word spreading constraint is now shown to be a rightward spreading constraint. The role of the word-spreading constraint in the analysis is to achieve spreading across morphemes, and this is always left-to-right.[22, 23] To focus on the issue at hand, the tableau here is somewhat simplified. Only candidates containing sonorants in the relevant contexts will be considered; this means that matters of segmental transparency will not arise, so sympathy and the P1/P2 split are not shown. Sonorant nasalization constraints are collapsed (*NASSON). The constraint IDENTσ1-IO$_{root}$[±nasal] demands identity of [nasal] feature specifications for correspondent segments in the first syllable of the root, and IDENT-IO[±nasal] expresses the same requirement for correspondent segments in any position. Since nasality is a phonemic contrast in the first syllable but not elsewhere, IDENTσ1-IO$_{root}$[±nasal] will outrank *NASSON (and spreading for cases in which word-spreading is incomplete), and

22 Note that when an alternating affix is flanked by two fixed morphemes, the left of which is the root, the agreement of the alternating affix with the root rather than the following affix cannot be derived from a Faith Root >> Faith Affix ranking (McCarthy and Prince 1994a, 1995), since either outcome respects Root Faith.

23 Kaye (1971: 41) notes a few forms in Desano where spreading is leftward to an alternating suffix from a following fixed suffix. In these cases, he proposes that the alternating and fixed affix form a constituent in the word structure independent from one containing the root. It is not apparent whether the same phenomenon occurs in Tuyuca, but if it does, it could be analyzed structurally along similar lines. It is conceivable that further analysis of the word constituency structure in Tucanoan may prove to obviate the need for stipulating directionality in cross-morpheme spreading.

*NASSON will in turn dominate the non-positional IDENT-IO[+nasal]. In (59) this ranking causes a suffix specified as [+nasal] in the input to lose this specification in the output and surface as oral.

(59) Emergent neutralization of nasal contrast in alternating affixes

	wia - rĩ	IDENTσ1-IO$_{rt}$ [±nasal]	SPREAD-R ([+nas], W)	*NASSON	IDENT-IO [+nasal]
☞	a. wia-ri				*
	b. wia-[r̃ĩ]			*!*	
	c. [w̃ĩã-r̃ĩ]	*!*		*****	

Note that suffixes beginning in a nasal stop never exhibit nasality alternations. In these cases, the failure of the suffix to become oral after an oral root may be explained by IDENT-IO[+sonorant] dominating the spreading constraint. This prevents a nasal stop from changing to an oral voiced obstruent, as shown in (60) for a possible input for [hoá-mãs̃ĩ-ri-ga] 'I can't (do not know the way) to leave the clearing' (Barnes 1996: 42). This form contains an oral root followed by a nasal suffix followed by two fixed oral suffixs. In this tableau I only consider candidates with nasal spreading within fixed morphemes; the blocking of spreading across fixed suffixes is discussed below. I also abstract away from transparency, showing [s] as nasalized in the output.

(60) Nasal-stop initial affixes remain nasal

	hoa - masi - ri - ga	IDENTσ1-IO$_{rt}$ [±nasal]	IDENT-IO [±son]	SPREAD-R ([+n], W)	*NASSON	IDENT-IO [+nasal]
☞	a. hoa-mãs̃ĩ-ri-ga			****	***	
	b. hoa-basi-ri-ga		*!			*

The tableau in (61) shows a hypothetical case where the first syllable of the root is [+nasal] in the input and the suffix is [-nasal]. The ranking of IDENTσ1-IO$_{root}$[±nasal] over *NASSON will preserve this input [+nasal] property and spreading will cause it to spread to other root segments and the suffix in the output. Note that because nasal spreading can produce nasalization of input oral segments in weak positions, non-positional faith for [-nasal] must be dominated by the spreading constraint.

(61) Sustained nasal contrast in initial syllable

ĩja - ri	IDENTσ1-IO$_{rt}$ [+nasal]	SPREAD-R ([+nas], W)	IDENT-IO [-nasal]	*NASSON	IDENT-IO [+nasal]
☞ a. [ĩj̃ã-r̃ĩ]			****	*****	
b. [ĩj̃ã]-ri		*!*	**	***	
c. [ĩ]ja-ri		*!***		*	
d. ija-ri	*!				*

Thus far we have seen that the following ranking calling on faith for the initial syllable of the root versus non-positional faith can produce the fixed property of roots versus the alternating property of affixes (with further exemplification to follow).

(62) IDENTσ1-IO$_{rt}$[±nasal] >> SPREAD-R([+nasal], W) >> IDENT-IO[-nasal], *NASSON >> IDENT-IO[+nasal]

There is a third set of morphemes that we still must consider. These are the fixed suffixes. Since it will be necessary to distinguish alternating from fixed suffixes, I will call fixed suffixes 'Class 1' and alternating ones 'Class 2'. With respect to IO-faith, fixed suffixes pattern with the roots. An input [+nasal] specification will be preserved in the output and will spread (rightward) to alternating suffixes. The distinction between Class 1 and Class 2 suffixes simply refers to the separate lists of alternating versus fixed suffixes. As discussed above, some minor grammatical categories of suffixes (e.g. aspect, mood) fall completely into one class or the other in Tucanoan, but this is not always the case. In making a distinction between faith for separate groups of affixes, I follow Itô and Mester (1995a, cf. also 1995b), who propose that faith demands are different for each of four lexical strata in the Japanese lexicon; also Pater (1995), who obtains apparent exceptionality in English stress with lexically-specific faith (see also Karvonen 1998 for an application to Finnish loanword phonology; cf. Inkelas, Orgun and Zoll 1996 for a different kind of proposal). Since the Class 1 or fixed suffixes pattern with roots with respect to their fixed nasal properties, I posit a ranking in which the nasal identity constraint for the first syllable of the Class 1 suffixes is situated in the same place as root faith. This gives the ranking in (63).[24]

[24] The faith constraint for Class 1 suffixes must be formulated as specific to the initial syllable of the morpheme, because there are a few fixed affixes/clitics with two syllables and there is always full nasal spreading within these dependent morphemes (Barnes 1996).

(63) IDENTσ1-IO$_{rt}$[±nas], IDENTσ1-IO$_{C1\text{-}af}$[±nas] >> SPREAD-R([+nas], W) >> IDENT-IO[-nas], *NASSON >> IDENT-IO[+nas]

This ranking reflects the fact that in Tuyuca there is a split in root versus affix faith, as seen in many languages (McCarthy and Prince 1994a, 1995; Beckman 1995, 1997, 1998; Selkirk 1995; Urbanczyk 1996b; Alderete 1996, 1997a; Walker 1997b), but also within affix faith there is a split: some of the affixes have been promoted with respect to faith so that they pattern with the roots.

The application of this ranking to forms containing both alternating and fixed affixes is shown in (64-66) (data from (57)). In each of these instances, it is the second morpheme which is alternating and the final one which is fixed. Here I again set aside the matter of segmental transparency, simply showing transparent obstruents as nasalized in the output, as is the case within P2. To simplify the presentation, IDENT-IO[-nasal] is not included in this or subsequent tableaux. In (64), we see evidence for the ranking of IDENTσ1 over the spreading constraint.

(64) [mãkã - ri - pɨ] 'to the towns'

mãka-ri-pɨ root C2 C1	1. IDENTσ1-IO$_{rt}$[±nas] 2. IDENTσ1-IO$_{C1\text{-}af}$[±nas]	SPREAD-R ([+nas], W)	*NASSON	IDENT-IO [+nasal]
☞ a. [mãk̃ã-r̃ĩ]-pɨ		**	*****	
b. [mãk̃ã]-ri-pɨ		***!*	***	
c. [mãk̃ã-r̃ĩ-p̃ĩ]	*!*(2)		******	
d. [mã]ka-ri-pɨ		***!***	**	
e. baka-ri-pɨ	*!*(1)			**

The tableau in (65) shows a case with an alternating suffix flanked by an oral root and fixed nasal suffix. In this case, the alternating suffix agrees with the oral quality of the preceding root, not the following nasal suffix. Note that with the directional formulation of the word spreading constraint, nasal markedness constraints will prevent regressive nasal spreading from the final nasal suffix:

(65) [ati - a - w̃ĩ] 'he recently came'

	atí - a - w̃ĩ root C2 C1	1. IDENTσ1-IO$_{rt}$[±nas] 2. IDENTσ1-IO$_{C1\text{-}af}$[±nas]	SPREAD-R ([+nas], W)	*NASSON	IDENT-IO [+nasal]
☞	a. ati-a-[w̃ĩ]			**	
	b. ati-[ã-w̃ĩ]			***!	
	c. [ãt̃ĩ-ã-w̃ĩ]	*!(1)		*****	

In (66) we see that even with nasalization posited on the alternating morpheme in the input, this affix will still come out as oral in the output following an oral root.

(66) [atí - a - w̃ĩ] 'he recently came'
(Hypothetical input with nasalization on alternating second morpheme)

	ati - ã - w̃ĩ root C2 C1	1. IDENTσ1-IO$_{rt}$[±nas] 2. IDENTσ1-IO$_{C1\text{-}af}$[±nas]	SPREAD-R ([+nas], W)	*NASSON	IDENT-IO [+nasal]
☞	a. ati-a-[w̃ĩ]			**	
	b. ati-[ã-w̃ĩ]			***!	*
	c. [ãt̃ĩ-ã-w̃ĩ]	*!(1)		*****	

At this point the analysis has addressed the blocking behavior of obstruents in cross-morpheme nasal spreading and the distinction between alternating suffixes versus those that are fixed in their oral/nasal property. The separate behavior of fixed or Class 1 suffixes is obtained by ranking a morpheme-class-specific faith constraint higher in the constraint hierarchy than the general faith constraint (after Pater 1995; Itô and Mester 1995a). The separate occurrences of Class 1 faith and general faith in a single constraint hierarchy is able to produce the correct output for words containing Class 1 and Class 2 affixes in any order. An interesting consequence of this ranking is that it is able to achieve the occurrence of fixed oral, fixed nasal, and alternating affixes without calling on ternary use of distinctive features. This kind of approach, specifying affixes as [+nasal], [-nasal] or [0nasal] in the input, was proposed by Noske (1995) for Tucano suffixes in a derivational framework. Positing a Class 1-specific faith constraint in OT eliminates the need for making any crucial use of ternary [nasal] specification.

The last issue I will address in this section is the full nasal spreading within fixed suffixes. Earlier in this section, it was established that voiced obstruent stops block the spreading of nasalization across morphemes, because spreading is dominated in P2 by a positional markedness constraint prohibiting the occurrence of nasalized obstruent stops

in affixes. Given this and the assumption that nasalization originates in a segment in the first syllable of a morpheme we may expect that voiced obstruent stops would not undergo nasal spreading within suffixes, either fixed or alternating, that is, they could occur in the output of an affix containing a nasal vowel. However, they do undergo nasalization in fixed nasal suffixes. Voiced oral and nasal stops in suffixes always agree with the nasality of the suffix vowel. Some examples of oral and nasal fixed suffixes with voiced stops are given in (67).

(67) Oral / Nasal

a.	-ba	classifier	d.	-mã	continue action
b.	-da	classifier	e.	-nã	at that instant
c.	-ga	evidential	f.	-ŋã	diminutive

If a nasal stop occurs in the input of a suffix, it will trigger nasal spreading, giving a fixed nasal suffix. For voiced obstruent stops, the descriptive generalization is that they block nasalization in spreading across morphemes, but they undergo nasal spreading originating from a tauto-morphemic nasal segment. This result actually falls out of the separate ranking of the constraints on nasal spreading within the morpheme and within the word illustrated in (47): SPREAD([+nas], M) >> *NASOBS$_{affix}$ >> SPREAD([+nas], W). As shown in (68), the domination of *NASOBS$_{affix}$ by morpheme spreading predicts full spreading within morphemes, producing nasal alternants of voiced obstruent stops and transparent voiceless obstruents. Because an input [+nasal] feature specification in the first syllable can spread to a [-nasal] segment in the same syllable, including obstruents, it must be the case that IDENTσ1-IO$_{Class1\text{-}af}$[+nasal] outranks faith for [-nasal]. The same will hold for initial-syllable root faith. (68) shows selection of the sympathy candidate with a nasalized obstruent. The input here is a hypothetical one with a nasal vowel and voiced obstruent stop in the first syllable of the fixed nasal suffix.

(68) [koa - mã́] ‘allow me to dig’ (selection of the sympathetic candidate)

	koa - bã	1. IDENTσ1-IO$_{rt}$[+nas] 2. IDENTσ1-IO$_{C1\text{-}af}$[+nas]	SPREAD ([+n], M)	1. *NASOBS$_{affix}$ 2. IDENTσ1-IO$_{rt}$[-nas] 3. IDENTσ1-IO$_{C1\text{-}af}$[-nas]	SPREAD-R ([+n], W)
❁	a. koa-[b̃ã]			**(1, 3)	
	b. [k̃õã-b̃ã]			***!*(1, 2, 3)	
	c. koa-b[ã]		*!		
	d. koa-ba	*!(2)			

The tableau in (69) shows selection of the actual output. IDENT-IO[-sonorant] is added in P2 here to select the sympathy candidate with a nasalized obstruent rather than the sonorant nasal stop, as established in 3.3.3. Reasons for rejecting an analysis with (e) as the sympathy candidate are discussed in section 3.3.5.

(69) [koa - mã́] ‘allow me to dig’

		P1			P2		
	koa - bã́	*NAS OBS	ID-❁O [+nas]		1.IDENTσ1-IO$_{rt}$[+n] 2.IDENTσ1-IO$_{C1\text{-}af}$[+n] 3.IDENT-IO[-son]	SPREAD ([+n], M)	1.*NASOBS$_{affix}$ 2.IDENTσ1-IO$_{rt}$[-n] 3.IDENTσ1-IO$_{C1\text{-}af}$[-n]
	a. koa-[b̃ã]	*!		❁			**(1, 3)
	b. [k̃õã-b̃ã]	*!					****(1, 2, 3)
	c. koa-b[ã]		*!			*	
	d. koa-ba		*!*		*(2)		
☞	e. koa-[mã]				*(3)		*(3)
	f. [k̃õã-mã]				*(3)		**!*(2, 3)

A final summary of the rankings established for cross-morpheme spreading and blocking in P2 is given in (70).

(70)

```
IDENTσ1-IOrt[+nas], IDENTσ1-IOClass1-af[+nas], SPREAD([+nas], M),
                                        |
IDENT-IO[+son]     *NASOBSaf, IDENTσ1-IOrt[-nas], IDENTσ1-IOClass1-af[-nas]
        \               /
    SPREAD-R([+nas], W)
        /          \
  *NASSON        IDENT-IO[-nas]
     |
IDENT-IO[+nas]
```

To review, the undominated ranking of initial syllable identity for [+nasal] in roots and Class 1 affixes produces the triggering of nasal spread from the first syllable of these morphemes. In combination with positional IDENT for [-nasal], these constraints also achieve the fixed oral/nasal property of roots and Class 1 affixes. Interleaving the positional markedness constraint, *NASOBS$_{affix}$ between morpheme and word spreading realizes the blocking effect of obstruents in cross-morpheme spreading and the targetting of obstruents in spreading within morphemes. Both spreading constraints produce nasalization of sonorants, so *NASSON is ranked below spreading. Alternating (Class 2) affixes agree with the nasality of the preceding morpheme, regardless of any [nasal] feature specification they come with in the input. This is achieved by ranking the word spreading constraint over nonpositional faith, yielding the absence of a surface nasal contrast in Class 2 affixes, as well as in noninitial syllables of roots and Class 1 affixes.[25]

3.3.5 Another abstract alternative

In this section, I return to the issue of the abstract representation called on in the sympathy candidate for obstruent stops undergoing nasal spreading. The analysis that has been developed here of transparent nasal obstruent stops in Tuyuca posits a phonetically-impossible but phonologically-accessible segment combining the feature [+nasal] with an obstruent stop [-sonorant, -continuant] (the distinction between phonological and phonetic possibility was discussed in 3.3.1). The assumption of representations with phononologically possible but highly marked nasalized obstruents has a strong motivation: *obstruents are reluctant undergoers of nasal spreading.* This

25 Since initial-syllable faith for [+nasal] outranks nasal markedness constraints for all classes of segments in P2, it will in fact be the case that any segment in the initial syllable specified as [+nasal] in the input will trigger nasal spreading; the triggers will not be limited strictly to nasal stops and vowels. In the output-centered framework of OT, this is not a problem, since the correct distribution of nasality is still achieved in the set of optimal outputs. Lexicon Optimization (Prince and Smolensky 1993; Itô, Mester, and Padgett 1995) would in any case select underlying representations of nasal morphemes with segments nasalized in the output also nasalized in the input.

reluctance is evidenced in two ways, one concerning implications when obstruents undergo nasal spreading and the other concerning implications when obstruents block. First, when obstruents become nasalized in the output (e.g. /d/ → [n]) or behave transparent, all other segments in the system also undergo nasalization; thus there are no cases of nasal harmony where nasalization spreads to vowels and voiced stops, voiceless stops behave transparent, and the remaining segments block spreading. Second, if any segments block nasal spreading, obstruent stops will be included in this group; even in a language like Tuyuca where obstruents undergo nasalization (or behave transparent) within a morpheme, they still are the only segments to block nasal spread across morphemes. These points make clear that there are stops in Tuyuca which are obstruents in their underlying character (an emergent outcome derived by the rankings established in 3.3.3). Further, they support positing a sympathy candidate containing nasalized obstruent stops rather than nasal sonorant stops, because this representation reflects the markedness of nasalizing these segments.

It is possible, however, to construct an account of nasal spreading if we assume that nasalized obstruents are not well-formed representations and are never accessible. The sympathy candidate for a nasal morpheme with an obstruent stop would then contain a nasal sonorant rather than a nasal obstruent. In 3.3.3, a high-ranked constraint in P2, IDENT-IO[-sonorant], forced the sympathy candidate to choose an obstruent over a sonorant stop. If this constraint were dominated by the morpheme spreading constraint, then we could produce the effect of /t/ → [n̥] and /d/ → [n] in the sympathy candidate. This is illustrated in (71) for a nasal morpheme with a medial voiceless stop.

(71) /t/ → [n̥] in the sympathy candidate

	wãti	P1: *N̥	P1: IDENT-❀O [±voi]	P1: IDENT-❀O [+nas]		P2: SPREAD ([+nas], M)	P2: 1. IDENT-IO[-son] 2. IDENT-IO[±voi]	P2: *NASSON
	a. [w̃ãn̥ĩ]	*!			❀		*(1)	****
	b. [w̃ã]ti			**!		**		**
	c. w[ã]ti			**!*		***		*
☞	d. [w̃ã]t[ĩ]			*		*****		***
	e. [w̃ãnĩ]		*!				**(1, 2)	****

It should be noted that like the nasalized obstruent analysis, this account makes use of an abstract representation, that is, it calls on a sympathy candidate which contains a segment [n̥] that never occurs as an output correspondent for /t/ in the language.

The tableau in (72) shows the case of a nasal morpheme with a medial voiced stop. Here the sympathy candidate coincides with the actual output.

(72) /d/ → [n] in the sympathy candidate

	wĩdo	P1: *N̥	P1: IDENT-❀O [±voi]	P1: IDENT-❀O [+nas]		P2: SPREAD ([+nas], M)	P2: 1. IDENT-IO[-son] 2. IDENT-IO[±voi]	P2: *NASSON
☞	a.[w̃ĩnõ]				❀		*(1)	****
	b.[w̃ĩ]do			*!*		**		**
	c.w[ĩ]do			*!**		***		*
	d.[w̃ĩ]d[õ]			*!		*****		***

The above tableaux show that there is a ranking which is capable of analyzing nasal harmony without calling on phonetically-impossible representations. The question is should we call on this ranking? The answer seems to be no. If we call on rankings like the above, an overgeneration problem arises: we predict the possibility of a language where voiceless stops behave transparent and voiced stops become nasalized when other segments block spreading — an unattested pattern. This is produced under a ranking where some nasalization constraints dominate spreading, as shown below with a hypothetical form where [d] undergoes nasal spreading and [l] blocks.

(73) /d/ undergoes but /l/ blocks in nasal spreading: an unattested outcome

	ãdala	*N̥	ID-❁O [+nas]		*NASFR *NASLIQ	SPREAD ([+n], M)	1.IDENT-IO[-son] 2.IDENT-IO[±voi]	*NASGLIDE *NASVOWEL *NASSONSTOP
		P1			P2			
	a.[ã]dala		*!*			****		*
	b.[ã]d[ã]la		*!			********		**
	c.[ã]d[ã]l[ã]		*!			************		***
☞	d.[ãnã]la			❁		**	*(1)	***
	e.[ãnãl̃ã]				*!		*(1)	****
	f.[ã]d[ãl̃ã]		*!		*	******		***

The problem is that if obstruent stops (e.g. [t, d]) can correspond to nasal stops (e.g. [n]) in a sympathy candidate, violating only a low-ranked nasalization constraint, their reluctance to undergo (or behave transparent) is lost. This does not arise under the account making reference to nasalized obstruents. Under one scenario with nasalized obstruents, *NASOBSSTOP will be top-ranked in P2, producing blocking by obstruent stops. Under another, the sympathy candidate will contain a nasalized stop, violating *NASOBSSTOP in P1, and this configuration only comes about when spreading dominates all lower-ranked nasalization constraints occurring in P2. The reason for this is that the promotion of *NASOBSSTOP to P1 comes about as a resolution of the conflict between the nasal markedness constraint and SPREAD([+nas], M), and I assume that the promotion arises as an alternative outcome when SPREAD([+nas], M) threatens to dominate *NASOBSSTOP. In order for SPREAD([+nas], M) to be in a position to potentially outrank *NASOBSSTOP, it must dominate the lower nasalization constraints in the hierarchy within P2.

We have seen that there is good reason to call on the representation of nasalized obstruent stops. This captures the hierarchical implications for nasalization of stops in nasal harmony. In addition, under the null hypothesis, the possibility of this analysis is given to us by the theory. Optimality-theoretic constraints are posited as violable. Given that all of the other nasalized segment constraints are violable in various languages, we expect that representations violating *NASOBSSTOP should be called on in some language as well. The analysis we need is thus available to us, but now we are faced with explaining why a language with a hierarchy like that in (73) does not occur . A key element of this hierarchy is that spreading dominates IDENT-IO[-sonorant]. This

ranking enables correspondence between obstruent stops in the input and sonorant nasal stops in the sympathetic output. To rule this out, I suggest that there is an overriding ranking structure for nasal harmony:

(74) IDENT-IO[-sonorant] >> SPREAD[+nasal]

This ranking would prevent nasal spreading from changing underlying [-sonorant] specifications. The consequence would be that only sympathetic faith could induce changes in underlying obstruency. The undesirable alternative would then be ruled out, because underlying obstruents could not correspond to sonorants in the sympathy candidate; they would have to become nasalized obstruents or block. The fact that nasal spreading cannot induce violation of [-sonorant] identity presently has the status of a stipulation in the analysis required to capture the descriptive generalization. Further research must be done to better understand the motivation for this outcome.

3.4 Some points of comparison between harmonic and constraint-based sympathy

In section 3.2 I presented an account of opacity in ʔ-deletion and epenthesis in Tiberian Hebrew in the model of harmonic sympathy. This account followed that of McCarthy (1997) in most of the particulars of constraint ranking and in employing the basic mechanism of sympathy. Where the two accounts differ is primarily in the means of selection of the sympathy candidate. In this section I briefly review a version of McCarthy's 'constraint-based sympathy' method of identifying the sympathy candidate. I suggest that harmonic sympathy explicates selection of the sympathy candidate by connecting it more closely to the kinds of evaluative mechanisms that are independently-motivated in Optimality Theory. In addition, I show that harmonic sympathy brings new understanding to a set of undesirable (derivational) opacity effects which the 'constraint-based' model is capable of generating.

McCarthy's sympathy-based account of Tiberian Hebrew is a landmark in the analysis of opacity effects in OT, bringing an illuminating new perspective to these kinds of phenomena. In what follows, I summarize how selection of the sympathy candidate takes place in Tiberian Hebrew under the constraint-based sympathy approach. The problem presented by a transparent approach to the Tiberian problem is repeated below:

(75) Incorrect outcome for /deʃʔ/ under a transparent account:

	/deʃʔ/	1. *ʔ]$_\sigma$ 2. *COMPLEX	ANCHOR-R	MAX-IO	DEP-IO
	a. deʃʔ	*!*(1, 2)			
(❁)	b. deʃEʔ	*!(1)			*
☞	c. deʃE		*	*!	*
☜	d. deʃʔE		*		*
	e. deʃ		*	*!	

The winner under this ranking is candidate (d); however this does not correspond to the attested form in Hebrew. The attested form, in (c), incurs a superset of the violations that (d) does, so no reranking of the constraints will serve to select (c) over (d). The solution (following McCarthy) is to designate candidate (b) as sympathetic and then select (c) by virtue of its resemblance to (b).

Under the harmonic sympathy account, this situation is resolved by bifurcating the hierarchy so that *ʔ]$_\sigma$ belongs to the P1 component. The sympathy candidate is then selected by being the most harmonic with respect to the P2 constraint hierarchy. In McCarthy's original approach, he notes that of the candidates respecting ANCHOR-R,[26] candidate (b) is the most harmonic, and he proposes to single out the sympathy candidate on this basis. McCarthy suggests that the sympathetic candidate is identified by being the most harmonic of the set of candidates satisfying some designated 'sympathy constraint'. Opacity effects arise when the sympathetic candidate fails as the actual output by incurring a violation of some constraint dominating the sympathy constraint. Selection of the sympathy candidate with a designated sympathy constraint is illustrated in (76). The sympathy status of ANCHOR-R is signified by the raised '❁' symbol. Constraint rows for candidates violating this constraint are shaded; the most harmonic of the remaining candidates is the sympathy candidate.

26 McCarthy formulates ANCHOR-R as an IO root to syllable right-alignment faithfulness constraint. This will be discussed presently.

(76) Selection of the sympathy candidate by designated sympathy constraint:

	/deʃʔ/	1. *ʔ]$_\sigma$ 2. *COMPLEX	ANCHOR-R❁	MAX-IO	DEP-IO
	a. deʃʔ	**!(1, 2)			
❁	b. deʃEʔ	*(1)			*
	c. deʃE		*	*	*
	d. deʃʔE		*		*
	e. deʃ		*	*	

The sympathy candidate loses as the actual output because of its glottal stop coda. Placing sympathetic faith constraints below *ʔ]$_\sigma$ selects the correct output. As discussed in section 3.2, LINEARITY-❁O outranks MAX-❁O:

(77) Selection of the optimal output:

	/deʃʔ/	1.*ʔ]$_\sigma$ 2.*COMPLEX	LINEARITY-❁O	MAX-❁O	ANCHOR-RIGHT❁	MAX-IO	DEP-IO
	a. deʃʔ	*!*(1, 2)		*			
❁	b. deʃEʔ	*!(1)					*
☞	c. deʃE			*	*	*	*
	d. deʃʔE		*!		*		*
	e. deʃ			**!	*	*	

McCarthy's constraint-based sympathy account provides a truly insightful account of opacity in Tiberian Hebrew. The aim of the revised harmony sympathy account is to preserve these insights, while probing the question of what engenders derivational opacity. Let us consider more generally the range of opacity effects which are predicted by constraint-based sympathy versus harmonic sympathy. McCarthy (1997) proposes to limit opacity effects under constraint-based sympathy by restricting sympathy status to the set of faithfulness constraints. In accordance with this, he formulates the designated sympathy constraint as an IO faithfulness alignment constraint: ALIGN-R$_{IO}$(Root, σ) (rather than ANCHOR-R). He notes that this restriction rules out the Optimality Theory equivalent of what Pullum (1976) calls the 'Duke of York Gambit' (α→β→α) because the sympathetic candidate can never be less faithful to the input than the actual output. However, this limitation turns out to be too restrictive. In their analysis of opacity in German truncations, Itô and Mester (1997a:

127) note that it is necessary to allow other constraints, besides faithfulness, to serve as the sympathy constraint. They find that for German truncation, an alignment constraint must be awarded sympathy status. To this we may add that if transparent segments in spreading were to be analyzed under the constraint-based model, the spreading constraint would require sympathy status. Granting sympathy status to other constraints besides faith admits the possibility of Duke of York Gambit effects. This is a positive result in the case of transparency in spreading. In the analysis of transparency in Tuyuca nasal harmony, it was noted that it is a case of an attested opacity effect that needs to make use of a Duke of York Gambit (i.e. t → t̃ → t). Harmonic sympathy limits Duke of York Gambit effects to cases where the intermediate representation never surfaces in the language (or at least not in the relevant environment). The transparent behavior of segments thus adds support to Itô and Mester's finding that sympathy status must be extended to other constraints (in this case, a spreading constraint, or alternatively, another alignment constraint if this were used to drive spreading; see discussion in chapter 1). Itô and Mester further note that since assigning sympathetic status to a constraint amounts to inducing a separate optimization (in the sense of Wilson 1997) in which that constraint is top-ranked, and ranking variation amongst constraints is a basic element of OT, then 'the logic of OT itself compels us to expect other constraints in [the designated sympathy constraint] role as well' (1997a: 126-127, n. 12). For future work, they raise the important question whether any constraint can have designated sympathy status. The model of harmonic sympathy is developed in pursuit of this general issue: it attempts to bring a firmer understanding to what brings about opaque constraint interactions in grammar and the circumstances under which they occur.

Concerning what kinds of constraints may enter into opaque interactions, the harmonic sympathy model follows Itô and Mester in taking as the null hypothesis that any constraint has the potential to interact opaquely. As noted in the analysis of Tuyuca, this allows sympathetic correspondence to be used as a test for what constraints belong to Gen and which belong to the evaluative hierarchy. Constraints belonging to Gen can never be violated in any output candidate, including the sympathy candidate, but constraints belonging to Eval can potentially be violated in the sympathy candidate, even if they are undominated and are respected in the actual output.

Although harmonic sympathy and constraint-based sympathy (as understood here) both share the assumption that any constraint can undergo an opaque interaction and are similar in several other respects (e.g. drawing on sympathetic faith), they differ in some respects in the implemention of opacity. Constraint-based sympathy attributes a

privileged status to one particular constraint in narrowing the candidates that are eligible to be sympathetic. Once the candidates violating this constraint are eliminated, the constraint hierarchy chooses the most optimal of the remainder as sympathetic. Harmonic sympathy reinterprets this idea in terms of a hierarchy split as part of an opaque resolution of a conflict between two constraints. Opacity comes about when a constraint conflict is resolved with a hierarchy bifurcation at the point between the conflicting constraints. It is the high-ranking status of the constraint falling into P2 that reflects its privileged contribution to selection of the sympathy candidate, a candidate selected by optimization with respect to the dominated P2 segment of the hierarchy. Harmonic sympathy thus does not need to assign a 'sympathy' status to any particular constraint; instead it seeks to make a closer link between selection of the sympathy candidate and optimality-theoretic mechanisms, i.e. evaluation by a strictly ranked constraint hierarchy and resolution of constraint conflict by ranking. What is new under harmonic sympathy is that it allows the phonological constraint hierarchy to be organized into segments as an alternative way of resolving constraint conflict, yielding an opaque resolution of conflicting constraints. The separation of hierarchies into ranked components has independent motivation in the analysis of Syntax >> Phonology, which posits the syntactic segment of the constraint hierarchy as dominating the phonological segment (Golston 1995; also Tranel 1997; see discussion in section 3.2) — harmonic sympathy allows for a bifurcation within Phonology.

In addition to the differences in implementation, the two models differ in some of the derivational opacity effects that they produce. In particular, the constraint-based model is capable of generating a set of unattested opacity effects that cannot be derived under the present model of harmonic sympathy. This point concerns the preservation of universal hierarchies, where ranking is fixed by a universal harmonicity scale or Meta-Constraint (Prince and Smolensky 1993; see also McCarthy and Prince 1995 on Root Faith >> Affix Faith). An example is the universal syllable peak hierarchy proposed by Prince and Smolensky (1993: 134); this ranks constraints against specific segmental syllable peaks according to their sonority. It is partially represented below:

(78) *P/t >> *P/d >> *P/n >> *P/i >> *P/e >> *P/a

The fixed ranking of these constraints encodes the universal preference for a more sonorous segment as a syllable peak over a less sonorous one. However, by assigning sympathy status to one of the lower ranked constraints in this hierarchy, constraint-based sympathy is able to subvert the implication the hierarchy is intended to capture.

For example, assigning sympathy status to *P/i while ranking Faith-❁O over DEP-IO results in epenthesis of a vowel to make /i/ a margin rather than a peak, as shown in (79).

(79) /i/ must be a margin

	tadi	MAX-IO *P/t *P/d	Faith-❁O	DEP-IO	*P/n	*P/i❁	*P/e *P/a
	a. .ta.di.		*!			*	*
❁ ☞	b. .ta.dAj.			*			**

However, ranking DEP-IO over peak constraints dominating *P/i results in segments less sonorous than [i] as peaks:

(80) /n/ can be syllabic:

	tadn	Max-IO *P/t *P/d	Faith-❁O	DEP-IO	*P/n	*P/i❁	*P/e *P/a
❁ ☞	a. .ta.dn.				*		*
	b. .ta.dAn.		*!	*			**

This kind of use of constraint-based sympathy in relation to a markedness hierarchy singles out one constraint to behave as if it had undominated status in selection of the sympathy candidate, even though it may be low-ranked in the hierarchy. In the harmonic sympathy model this type of effect cannot be achieved, because harmonic sympathy maintains the ranking of a markedness hierarchy by employing a continuous segment within the overall constraint hierarchy to identify the sympathy candidate. The effects of universal hierarchies will thus be preserved.

A second case derivable under constraint-based sympathy is also worth considering. This example could be classified as involving a type of Duke of York Gambit. In this instance, a segmental markedness constraint, *p, is designated as sympathetic, so as to render it effectively invisible to conditions on syllable structure. In derivational terms, it is as if [p] is 'turned off' (i.e. deleted or extrasyllabic) at some stage of the derivation and then later turned back on again. A ranking producing this result is as follows. Consider a language which forbids complex syllable margins. It resolves inputs with such a structure by epenthesizing a vowel. This outcome is produced by the following ranking:

(81) Epenthesis to avoid complex syllable margins:
MAX-IO, *COMPLEX >> DEP-IO

	/tark/	MAX-IO	*COMPLEX	DEP-IO
☞	a. tarIk			*
	b. tar	*!		
	c. tark		*!	

Suppose that the markedness constraint, *p, was assigned sympathy status. Since [p] occurs freely in words of the language, MAX-IO must dominate *p. However, the sympathy status of *p will serve to select candidates without [p] as the sympathy form. Selection of the sympathetic co-candidate for a word containing /p/ is illustrated in (82). A column containing other segmental markedness constraints, *k and *r, is added here for comparison.

(82) *p as the sympathy constraint:

	/tarp/	MAX-IO	*p❁	*r, *k	*COMPLEX	DEP-IO
	a. tarIp		*	*		*
	b. tarp		*	*	*	
❁	c. tar	*		*		
	d. ta	**!				

Ranking DEP-❁O below MAX-IO will now select as optimal the candidate satisfying MAX which most closely resembles the sympathy form. For an input like /tarp/, this will be the completely faithful output, even though it violates *COMPLEX.

(83) Selecting the actual output:

	/tarp/	MAX-IO	DEP-❁O	*p❁	*r, *k	*COMPLEX	DEP-IO
	a. tarIp		**!	*	*		*
☞	b. tarp		*	*	*	*	
❁	c. tar	*!			*		
	d. ta	*!*					

In contrast, coda clusters that do not contain [p] will be unaffected by the derivational opacity effect; they will be resolved by epenthesis:

(84) Forms not containing [p] are unaffected:

	/tark/	MAX-IO	DEP-❁O	*p❁	*r, *k	*COMPLEX	DEP-IO
❁ ☞	a. tarIk				**		*
	b. tar	*!			*		
	c. tark				**	*!	

Because the constraint-based model can potentially single out any constraint for sympathy status, it is capable of producing this segment-specific exceptionality to general phonological phenomena in the language. This seems to be a power that would best be eschewed.

In this respect, the present model of harmonic sympathy is distinct from constraint-based sympathy: harmonic sympathy cannot derive the segment-specific invisibility of the sort derived above. If we attempt to reproduce this effect under harmonic sympathy, we must invoke a constraint hierarchy bifurcation between MAX-IO and *p, with MAX moving into the P1 component. As in the ranking under constraint-based sympathy, this means that MAX-IO will be respected in the actual output and *p will contribute to selection of the sympathy candidate. However, harmonic sympathy does not actually designate *p as special in determining the sympathy candidate; this role is played by the entire P2 hierarchy. With MAX-IO out of the picture in P2, all of the segmental markedness constraints will contribute to selection of the sympathy form. This results in an 'emergence of the unmarked' (McCarthy and Prince 1994b): the sympathetic candidate will be of unmarked shape, e.g. always a CV syllable.[27]

(85) /tarp/: Selection of the sympathy candidate

		P1	P2			
	/tarp/	MAX-IO	*p	*k, *r	*COMPLEX	DEP-IO
	a. tarIp		*(!)	*(!)		*
	b. tarp		*(!)	*(!)	*(!)	
	c. tar	*		*!		
❁	d. ta	**				

27 I assume here that a high-ranked REALIZEMORPH in P2 rules out the null parse alternative.

(86) /tark/: Selection of the sympathy candidate

		P1	P2			
	/tark/	MAX-IO	*p	*k, *r	*COMPLEX	DEP-IO
	a. tarIk			*!*		*
	b. tark			*(!)*	*(!)	
	c. tak	*		*!		
❁	d. ta	**				

MAX-IO and sympathetic faith will now select the completely faithful output in both cases. Epenthesis into coda clusters will simply never take place.

(87) /tarp/: Selection of the optimal output

		P1		P2			
	/tarp/	MAX-IO	DEP-❁O	*p	*k, *r	*COMPLEX	DEP-IO
	a. tarIp		**!	*	*		*
☞	b. tarp		*	*	*	*	
	c. tar	*!			*		
❁	d. ta	*!*					

(88) /tark/: Selection of the optimal output

		P1		P2			
	/tark/	MAX-IO	DEP-❁O	*p	*k, *r	*COMPLEX	DEP-IO
	a. tarIk		**!		**		*
☞	b. tark		*		**	*	
	c. tak	*!			*		
❁	d. ta	*!*					

The above has shown that opacity induced by a conflict between MAX-IO and *p cannot produce the effect of p-specific intermediate invisibility if MAX-IO is promoted to P1. The alternative resolution would be to promote *p to P1. In this case, *p would outrank MAX-IO yielding absence of [p] in all surface forms in the language. From a broader perspective, constraint-based sympathy and this model of harmonic sympathy differ in the following respect. Both models are capable of producing what may be considered Duke of York gambit effects for a specific segment, but harmonic sympathy achieves this only when that segment never surfaces in the language (or at least not in that environment); constraint-based sympathy includes these cases as well as those in which the segment behaves invisible but does in fact surface. An example of a Duke of York gambit under surface neutralization of the intermediate segment is transparency of a segment in spreading, an attested opacity phenomenon. An example of the other kind is the p-specific invisibility to complex syllable margins, a phenomenon unlikely to occur. In terms of constraint-based sympathy, it stands as an observational generalization that various constraints may be sympathetic, such as faithfulness constraints (Tiberian Hebrew, McCarthy 1997), and alignment or spreading constraints (German, Itô and Mester 1997a; Tuyuca, this chapter), but not segment-specific constraints (e.g. *p, *P/i). Harmonic sympathy rules out the segment-specific invisibility without stipulation. On the other hand, some potential drawbacks of the current model of harmonic sympathy will be considered in section 3.7. A revised version of harmonic sympathy designed to address these drawbacks is closer to the constraint-based model and has the potential to be faced with the same overgeneration problems. It will be proposed, however, that by spelling out opaque constraint interactions in terms of ranking and constraint hierarchy segmentation, the revised version of harmonic sympathy provides a framework in which the unattested nature of certain opacity effects can be better understood.

To summarize, in this section I have considered the alternative constraint-based model for identifying sympathetic candidates. While this approach has brought important insight to our understanding of derivational opacity in Tiberian Hebrew (McCarthy 1997) and German (Itô and Mester 1997a), it is also capable of producing some undesirable opacity effects. The present model of harmonic sympathy model is thus preferable on the basis of being more restrictive, particularly with respect to preserving the generalizations captured by fixed constraint hierarchies. Another attractive feature of harmonic sympathy is that it reinterprets the ‘sympathy’ status of constraints more directly in terms of the kinds of mechanisms that are already required in Optimality Theory, namely evaluation of candidates by strictly ranked constraint hierarchies and resolution of constraint conflict by ranking. Where it innovates is in permitting phonological constraint hierarchies to be organized into segments to produce opacity effects: it allows for an opaque resolution of a constraint conflict. Further investigation of opacity effects will surely continue to refine our understanding of the appropriately constrained means for designating a sympathetic candidate. Harmonic sympathy is a promising step in this direction. In section 3.7, I consider some further

issues bearing on the comparison of harmonic and constraint-based sympathy, and I suggest a possible revision of harmonic sympathy to better incorporate some strengths of the constraint-based model.

3.5 Finnish

I now turn to a consideration of harmonic sympathy in relation to another (derivational) opacity effect, namely transparent vowels in Finnish vowel harmony. As noted in 3.1, many cases of transparent vowels in vowel harmony are clearly instances of antagonistic transparency, where the spreading feature is truly incompatible with the transparent segment. A false transparency account does not apply to these cases. The example of antagonistic transparency in vowel harmony that I will examine here comes from Finnish, a language of the Ural-Altaic family. Throughout the Ural-Altaic family, there is widespread vowel harmony for backness, rounding, and [ATR], which have been much discussed in the literature. In Finnish, it is vowel backness that spreads.

The surface vowel inventory of Finnish is given in (89) (each vowel may be long or short) (Ringen 1975; Kiparsky 1981; data taken from van der Hulst & van de Weijer 1995).

(89)

	front		back
high	i	y	u
mid	e	ø	o
low	æ		a

The interesting asymmetry in the Finnish inventory is the absence of back counterparts for the high and mid unrounded vowels /i/ and /e/ (*ɯ, *ɤ). These two unpaired vowels are ‘neutral’ in the system.

Finnish exhibits a vowel harmony in which all vowels must either be front or back. This is a static generalization holding within stems. Alternations conditioned by vowel harmony are apparent in suffixes (like other Ural-Altaic languages, Finnish is a suffixing language). Finnish suffixes have two alternants, and the stem selects the one agreeing with non-neutral stem vowels.

(90) a. tyhmæ-stæ ‘stupid’ (ill.)
b. tuhma-sta ‘naughty’ (ill.)

Suffixes containing an /i/ or /e/ do not have a back alternant, because of the absence of a back counterpart for these vowels. However, these non-alternating vowels do not determine the front-back quality of the vowel in any succeeding suffixes. Vowels in succeeding suffixes will agree with the last non-neutral vowel in the stem, so back vowels will follow /i/ and /e/ if there is a back vowel in the stem. /i/ and /e/ thus behave transparent to the harmony:

(91) a. værttinæ-llæ-ni-hæn 'with spinning wheel, as you know'
b. palttina-lla-ni-han 'with linen cloth, as you know'
c. ljø-dæ-kse-ni-kø 'for me to hit'
d. ljo-da-kse-ni-ko 'for me to create'

The analysis of nasal harmony has shown that there is good reason to believe that spreading is a strictly local phenomenon taking place only between adjacent segments. Non-local outcomes cannot be driven directly by the demand of spreading; these instead come about through an opaque constraint interaction where sympathetic faith drives an output most closely resembling the fully spread candidate in featural properties while still respecting some high-ranked segmental markedness constraint. This result can be maintained for antagonistically-transparent vowels in vowel harmony by positing an opaque resolution of the conflict between the [back] spreading constraint and segmental markedness constraints prohibiting the occurrence of the back counterparts to the transparent vowels (*ɯ, *ɤ). In contrast to nasal harmony, transparency in vowel harmony does not arise with segments that are universally incompatible with the spreading feature; the transparent segments are typically those for which the counterparts that would be derived in vowel harmony are simply banned in the language for some reason (e.g. language-particular contrast demands). Thus, /i/ and /e/ behave transparent in Finnish simply because [ɯ] and [ɤ] are disallowed in this particular language, although this is not because they are phonetically impossible segments to make; these segments do actually occur in some languages.

The constraint conflict that brings about the occurrence of transparent segments in Finnish is between the spreading constraint, SPREAD[±back] and the markedness constraints, *ɯ, *ɤ (abbreviating feature cooccurrence constraints corresponding to these segments). The markedness constraints are the ones that win in the ranking; these constraints are surface-true in the language. On the other hand, SPREAD[±back] wins in the sympathy competition. The constraint conflict is thus resolved with a hierarchy bifurcation with *ɯ, *ɤ advancing to P1 and SPREAD[±back] located at the top of the

P2 hierarchy. The outcome is illustrated in (92-93). The spreading constraint dominates the markedness constraints against vowels that actually occur in Finnish. Also shown here is that high-ranked initial-syllable faith in P2 enforces preservation of the featural properties of the initial syllable, resulting in the initial syllable triggering spreading (after Beckman 1995, 1997, 1998). The tableau in (92) shows selection of the sympathy candidate, which is the one with full spreading from the initial syllable.

(92) Selection of the sympathy candidate (hypothetical input)

	P1			P2			
palttinæ-lla-ni-hæn	*ɯ *ɤ	IDENT-❀O [±back]		SPREAD [±back]	Faith-σ_1	*i, *e, *y, *u, *ø, *o, *æ, *a	Faith
a.palttina-lla-ni-han		**		*!***** *****…		******	**
b.palttɯna-lla-nɯ-han	**		❀			****	****
c. pælttinæ-llæ-ni-hæn		******			*!	******	**

The tableau in (93) illustrates selection of the actual output. This is the candidate which most closely resembles the sympathy candidate in [±back] specifications, while still respecting the markedness constraints prohibiting [ɯ] and [ɤ]. This is the output in which /i/ behaves transparent.

(93) Selection of the actual output

		P1			P2			
	palttinæ-lla-ni-hæn	*ɯ *ɤ	IDENT-❀O [±back]		SPREAD [±back]	Faith-σ_1	*i, *e, *y, *u, *ø, *o, *æ, *a	Faith
☞	a.palttina-lla-ni-han		**		******* ****…		******	**
	b.palttɯna-lla-nɯ-han	*!*		❀			****	****
	c. pælttinæ-llæ-ni-hæn		***!***			*	******	**

The above tableaux outline how the transparent vowels in vowel harmony can be analyzed as arising through an opaque constraint interaction. This simply presents an overview of the general approach; the vowel harmony of Finnish and other languages offer additional complexities which will not be examined here, although they are certainly of analytical interest. What is important about the above account is that it brings antagonistic transparency in both vowel harmony and in nasal harmony under the umbrella of the more general phonological phenomenon of derivational opacity effects. Under this approach, true transparency is not analyzed with parochial constraints specific to skipping of segments in spreading. Segmental transparency is rather one instantiation of the opacity effects that are pervasive in the phonologies of languages of the world.

3.6. An evaluation metric for opacity

I conclude this discussion by reviewing where we stand now on the subject of derivational opacity, segmental transparency and the locality of spreading. Chapter 2 presented a typological argument that feature spreading is strictly segmentally local: a unified typology with all expected hierarchical variants attested is achieved if systems with some transparent obstruents are regarded as patterns in which all segments actually undergo [nasal] spreading. This analytical step also has the important result of explaining why transparent and target segments pattern together in implying that all segments more compatible with nasalization will also be permeated by nasalization. These typological grounds offer reason to believe that the gapped configuration is not a possible phonological representation, i.e. it may not be violated in the set of outputs that Gen produces. The universal ill-formedness of the gapped configuration is also motivated on other grounds. It has basis in the conception of each feature occurrence as corresponding to an uninterrupted gesture, with foundation in the insights of Articulatory Phonology (Browman and Goldstein 1986, 1989, 1990; Gafos 1996). It also is supported by independent work arguing for the segmentally-strict locality of feature spreading (Ní Chiosáin and Padgett 1997; cf. Gafos 1996; with foundation in analyses by Ní Chiosáin and Padgett 1993; McCarthy 1994; Padgett 1995a; Flemming 1995b; Walker and Pullum 1997; among others).

Importantly, in addition to these various motivations for rejecting a violable conception of the gapped configuration, the analysis in this chapter has laid out one more: the gapped configuration is not needed to obtain transparency of segments in spreading (see Pulleyblank 1996 for a similar argument, but with a different analysis of segmental transparency). In this chapter I have shown that segmental transparency can be achieved through a much more general device that is required for a range of phonological phenomena beyond just segmental transparency, namely derivational opacity effects. Any adequate theory of phonology must be able to produce the opacity effects which are widespread in the phonologies of the languages of the world. In analyzing segmental transparency as a derivational opacity effect, transparency is

understood as one of a set of well-documented effects of this kind, not as a unique event requiring a phenomenon-specific theory.

Under the treatment of transparency as a derivational opacity effect, the notion of feature spreading as strictly local can be maintained, consistent with the findings of other work cited above. However, having achieved the effect of segmental transparency through opaque constraint interactions, we must examine how this effect of 'skipping' in spreading is to be limited. I suggest that this limitation comes in the acquisition of the skipping effect, and two different kinds of acquisition factors come into play: one is a perception issue and the other is a complexity issue. Let us consider the matter of transparency in the case of nasal harmony. The cross-linguistic generalization is that only obstruents ever behave transparent. This is analyzed as coming about when constraints against nasalized obstruents interact opaquely with the nasal spreading constraint by occurring in the separate P1 segment. It is conceivable that more nasalized segment constraints could also be promoted to P1, for example, constraints against nasalized approximants. We may then expect all consonants to behave transparent to nasal spreading, as illustrated by the tableau in (94).

(94) Transparency of all consonants

	P1						P2	
ẽwala	*NAS OBSSTOP	*NAS FRIC	*NAS LIQUID	*NAS GLIDE	IDENT-❁O [+nasal]		SPREAD ([+n], W)	*NAS VOWEL
a.[ẽw̃ãl̃ã]			*!	*		❁		***
b.[ẽ]wala					***!*		****	*
c.[ẽw̃ã]l[ã]				*!	*		******	***
☞ d.[ẽ]w[ã]l[ã]					**		************	***

Yet consider how the pronounced outputs of such a language would be perceived by the learner. An oral liquid or glide occurring between two nasal vowels would be extremely difficult to distinguish from a nasalized liquid or glide in the same context, e.g. it is difficult to perceive the difference between /ãlã/ and /ãl̃ã/. The basis for this claim is as follows. First, unlike obstruents, approximants do not have acoustic cues of burst or frication to signal the raised status of the velum. Second, there is little auditory distinction between nasalized and non-nasalized approximants (Cohn 1993a: 362; Ladefoged and Maddieson 1996: 132). In the environment of a nasal vowel, this distinction would be minimized even further, because of the tendency for the nasalization to overlap to some degree onto the neighboring consonant (Cohn 1993a). In addition, even when oral, approximants share similar acoustic properties with nasals, namely (weak) formant structures (Ladefoged 1993; Flemming 1995a). In the case of laterals, Flemming (1995a: 11) points out that the auditory similarity between [l] and [n] actually induces substitution of [n] for /l/ in fortition environments in Korean and Cuna. Given the similarity in auditory output for oral approximants and their nasal counterparts it is reasonable for the learner to posit the most derivationally-transparent alternative as the output, i.e. the one in which the approximant actually is nasalized in the output rather than oral. This yields a grammar in which sonorants come out as targets rather than surface-transparent.

The matter of derivational-transparency leads into the second issue of acquisition, concerning the relative difficulty of learning derivational opacity. In his discussion of derivational opacity, Kiparsky (1971, 1973) suggests that opaque grammars are marked in the sense that they are harder to learn and the direction of language change will be towards derivational transparency. The sympathy account of derivational opacity lends insight to Kiparsky's claims. Under this approach to opacity effects, an opaque constraint interaction is more complex than a transparent one because it involves computing an extra evaluation or optimization of the candidates, namely the optimization that selects the sympathy candidate. A derivationally-transparent grammar makes use of just one optimization, the selection of the actual output. It is reasonable to assume that the fewer optimizations required in selecting an output, the easier the grammar is to learn.

In addition to representing the increased complexity of derivational opacity in comparison to derivational transparency, sympathetic faith also gives us a means of evaluating the degree of difficulty for learning a particular opacity effect. I suggest that the greater the gap between the sympathetic output and the actual output, the harder the language will be to learn, that is, grammars with more sympathetic faith violations are more difficult to acquire than ones with fewer violations. Coming back to the question of nasal harmony, this means that grammars with fewer transparent segments will be easier to learn. A language in which all consonants behaved transparent would thus be difficult to acquire not only from the perspective of perception (as noted above), but also because of the great difference between the sympathetic output and the actual output. More generally, analyzing segmental transparency as a derivational opacity effect predicts that blocking by a segment will be a more common outcome in spreading than the segment behaving transparent, and this seems to be generally borne out. This view of acquisitional difficulty provides explanation for the observation made in 3.2 that

opaque interactions tend to occur between high-ranked constraints, for example, between two constraints that are competing for undominated status. The tendency for opacity to come about in a 'battle of the titans' rather than in a conflict between low-ranked constraints is predicted by attributing degree of dissimiliarity between the sympathy candidate and the actual output as directly correlated to the degree of difficulty for the learner. If P1 contains just one constraint, then sympathetic faith violations can be induced only by the single P1 constraint. As more constraints are added to P1 (corresponding to conflicts between lower-ranked constraints), the greater the potential for violations of sympathetic faith in the actual output, that is, the potential for difference between the sympathy form and real output form increases, for example in (94), the sympathy candidate can differ from the actual output in nasalization of all consonants, not just obstruents. In grammars with opacity effects, acquisitional factors will thus favor small P1 segments.

We may conclude that when faced with a choice between several alternative grammars (i.e. constraint rankings) that all produce the same correct output, the learner will choose the grammar that minimizes opaque constraint interactions and maximizes similarity between the sympathy candidate and actual output when opacity is required. Grammar optimization thus eschews opacity.

3.7 Appendix: German and harmonic sympathy revisited

One of the breakthroughs in analysis of derivational opacity effects in Optimality Theory is the sympathy-based account of opacity in German truncation developed by Itô and Mester (1997a). Their analysis in the constraint-based model of sympathy theory is important both in the extensive insights it brings to the understanding of German phonology and in the elaboration of sympathy theory. If harmonic sympathy is to be considered a viable approach to derivational opacity, it must be able to account for the German opacity as well. In this appendix I outline a harmonic sympathy account of German truncation, following the analysis of Itô and Mester in several respects. I begin by reviewing the relevant points of the constraint-based sympathy analysis and then focus on the modifications needed to capture the facts under harmonic sympathy. I discuss a drawback of the harmonic sympathy approach raised by this account, and propose a possible revision to harmonic sympathy which brings it closer in line with constraint-based sympathy. This revised version serves as a development of constraint-based sympathy which reworks and explicates the concept of a separate optimization selecting the sympathy candidate. The implications of this revised approach for the analysis of Tuyuca and for issues of overgeneration of derivational opacity effects are briefly outlined.

German exhibits a productive pattern of truncation, deriving various kinds of shortenings including hypocoristics. Some examples are given in (95) (from Itô and Mester 1997a, see citations therein for previous analyses). In the following data, double consonants appear as an orthographic convention signifying shortness of the preceding vowel; they do not represent geminate consonants.

(95) a. Truncata maximizing sequence C_0VC_1

Base	*Truncation*		
Gorbatschow	Gorbi	*Gorri	(name of politician)
Hans	Hansi	*Hanni	(personal name)
Alkoholiker	Alki	*Alli	'alcoholic'
Gruft	Grufti	*Gruffi	'older person'
Hirn	Hirni	*Hirri	'brain'
Imperialist	Impi	*Immi	'imperialist'
Tourist	Touri	*Toui	'tourist'
Radenković	Radi	*Rai	(well-known goalkeeper)

b. Non-maximal truncata

Base	*Truncation*		
Gabriele	Gabi	*Gabri	(personal name)
Andreas	Andi	*Andri	(personal name)
Dagmar	Daggi	*Dagmi	(personal name)
Heinrich	Heini	*Heinri	(personal name)
Ulrich	Ulli	*Ulri	(personal name)
Siegfried	Siggi	*Siegf(r)i	(personal name)
Klinsmann	Klinsi	*Klinsmi	(name of soccer player)
Littbarski	Litti	*Littbi	(name of soccer player)
Imker	Immi	*Imki	'beekeeper'
Knoblauch	Knobi	*Knobli	'garlic'

As Itô and Mester point out, the challenge presented by these data is identifying the exact shape of the truncatum (the portion copied from the base and suffixed with [-i]). The output of the truncation is always two syllables in length, and material from the base is copied from left to right to fill the first syllable and the onset to the second. The data

in (95a) suggest that the copied material is always the maximal string matching the form: C_0VC_1, i.e. *Gorbatschow* truncates to *Gorbi* not **Gorri*. However, the data in (95b) show that the medial consonant cluster is not always maximized. For example, the truncation of *Gabriele* is *Gabi* not **Gabri*. Itô and Mester make the important observation that the general form the truncations take is produced (descriptively) by suffixing [-i] to the maximum possible syllable of German derivable from the sequence of segments in the base scanned from left to right.

The German truncation facts are resistant to an account assuming only transparent constraint interaction. Itô and Mester outline a transparent approach along the following lines. First, the reduced size of the truncated form is analyzed with the ranking in (96) giving rise to an 'emergence of the unmarked' (McCarthy & Prince 1994b). This ranking places a size restricting constraint between input-output (IO) faith and truncation-specific base-truncatum (BT) faith.

(96) MAX-IO >> ALLFTL >> MAX-BT

The analytical assumption here is that output-output (OO) faith applies to truncation (following Benua 1997), such that identity is required between the output form of the base and the output form of the truncatum (TRUNC). The faith relations are illustrated diagrammatically in (97) (from Itô and Mester 1997a).

(97) Base-truncatum faith relations:

Input	/gorbat͡ʃof/	/TRUNC + i/
Faith-IO	⇳	⇳
Output	[gorbat͡ʃof]	[gorb i]
	⇦——*Faith-BT*——⇨	

The outcome selected by the ranking in (96) is illustrated in (98). MAX-IO is relevant only for [-i] in the input, because the TRUNC portion does not have underlying segmental material. MAX-IO thus rules out candidates (e-g), in which [-i] fails to surface. MAX-BT promotes a candidate that fully copies the material in the base; however, the domination of this constraint by ALLFTL (ALIGN(foot, L, Pwd, L)), results in an output with no more than two syllables. Since the rhyme of the second syllable must be [i] (by MAX-IO), the truncatum will consist of as much material from the base as will fill the first syllable and form the maximal possible onset to the second. PARSE-σ is added here to prevent segmental material outside of the foot from surviving.

(98) Transparent account of truncation

	Base: (.gor.ba).(t͡ʃof.) Input: /TRUNC - i/	MAX-IO	ALLFTL	PARSE–σ	MAX-BT
	a. (.gor.ba).(t͡ʃo.f-i.)		*!		
	b. (.gor.ba).t͡ʃ-i.			*!	of
☞	c. (.gor.b-i.)				at͡ʃof
	d. (.go.r-i.)				bat͡ʃof!
	e. (.gor.ba.)	*!			t͡ʃof
	f. (.gorb.)	*!			at͡ʃof
	g. (.gor.)	*!			bat͡ʃof

While the transparent account is successful for instances of truncation which maximize the C_0VC_1 sequence, it fails for the non-maximal cases. This is illustrated in (99) for the truncated form of *Gabriele*. Instead of selecting the desired winner (d), the maximizing effect of MAX-BT chooses (c). This undesirable outcome is signalled by the left-pointing hand.

(99) Transparent account fails

	Base: (.ga.bri).(e.le.) Input: /TRUNC - i/	MAX-IO	ALLFTL	PARSE–σ	MAX-BT
	a. (.ga.bri).(e.le).-i.		*(!)	*(!)	
	b. (.ga.bri).(e.l-i.)		*!		e
☜	c. (.ga.br-i.)				iele
☞	d. (.ga.b-i.)				riele!
	e. (.gab.)	*!			riele

The transparent account is insufficient to distinguish between the truncation of the maximizing forms in (95a) and the non-maximal ones in (95b). Itô and Mester propose instead to make use of the insight that the truncatum corresponds to the maximal possible syllable of German that can be formed by the sequence of segments in the base. To do this, they call on a sympathy candidate which consists of precisely this form. This candidate is identified by assigning sympathetic status to an alignment

constraint: ALLσL (ALIGN(σ, L, Pwd, L)). Ranking this constraint between MAX-IO and MAX-BT selects as the sympathy candidate a single syllable containing maximal material from the base. Note this does not necessarily correspond to the actual syllabification of this sequence of segments in the base. Selection of the sympathy candidate is illustrated in (100). Candidates violating ALLσL are shaded here.[28]

(100) Selection of sympathy candidate with constraint-based sympathy

	Base: .ga.bri.e.le. Input: /TRUNC - i/	MAX-IO	ALLσL❀	MAX-BT
	a. .ga.bri.e.le.-i.		σσσσσσσσσσ	
	b. .ga.bri.e.l-i.		σσσσσσ	e
	c. .ga.br-i.		σσσ	iele
	d. .ga.b-i.		σ	riele
	e. .ga.-i.		σ	briele
❀	f. .gab.	*		riele
	g. .ga.	*		briele!

The candidate in (f) is the best of the candidates respecting ALLσL, but it loses in the competition for the actual output because of its violation of MAX-IO. The actual output is the candidate which matches the segmental material in (f) with the addition of the [-i] suffix. This is achieved by ranking the sympathetic faithfulness constraint, DEP-❀O, below MAX-IO and above MAX-BT. The complete tableau is exhibited in (101).

28 Itô and Mester (1997a, n.15) note that alternative candidates [.ai.] and [.i.] are ruled out as sympathetic on the basis of other high-ranking constraints.

(101) Constraint-based sympathy constraint account of truncation

	Base: .ga.bri.e.le. Input: /TRUNC - i/	MAX-IO	DEP-❁O	ALLσL❁	MAX-BT
	a. .ga.bri.e.le.-i.		rielei!	σσσσσσσσσσ	
	b. .ga.bri.e.l-i.		rieli!	σσσσσσ	e
	c. .ga.br-i.		ri!	σσσ	iele
☞	d. .ga.b-i.		i	σ	riele
	e. .ga.-i.		i	σ	briele!
❁	f. .gab.	*!			riele
	g. .ga.	*!			briele

This sympathy account also achieves the correct results for a base like [gorbat͡ʃof]. In this case the sympathy candidate will be [gorb], because the consonant cluster can constitute a well-formed coda, and the actual output is the candidate adding just [-i] to this form, giving [gorbi].

Itô and Mester's sympathy-based analysis brings new understanding to the German truncation phenomenon. In this constraint-based sympathy account, the dominated alignment constraint, ALLσL, is assigned sympathetic status, resulting in selection of the maximal monosyllabic candidate for German as the sympathy candidate. Through sympathetic correspondence, this sympathy candidate determines the amount of base material that will be copied in the truncatum. Under the harmonic sympathy model, the means of selecting the sympathy candidate is framed in a somewhat different way. The sympathetic form is one that is most harmonic with respect to a contiguous segment of a bifurcated constraint hierarchy, the hierarchy forming the P2 segment. The sympathetic candidate fails to surface itself when it violates some high-ranked constraint belonging to P1. If Itô and Mester's account were to be translated directly into this model, the P1 constraint would be MAX-IO; this is the constraint dominating ALLσL that is violated in the sympathy candidate. However, under the faith-based conception of inventory structure proposed by Prince and Smolensky (1993), MAX-IO is dominated by all of the markedness constraints that correspond to prohibited segments in German (e.g. *ɮ, *ɓ, *ʕ, etc.). It is conceivable that MAX-IO and all of its dominating markedness constraints could belong to P1, but this move would permit potential sympathy candidates containing the prohibited segments, a consequence that may have problematic results for other phenomena in the language. To sidestep this possibility, I will pursue an analysis in which the P1 constraint in German is not a faith constraint but rather an undominated organizational parsing constraint: PARSESEGσ, which requires

that all output segments be parsed into syllables.[29] A segment violating this constraint will not be syllabified but it will still be pronounced, because it is contained in the output. Such a segment will be appended to prosodic structure at some higher level, such as the foot or prosodic word.[30] The constraint which threatens PARSESEGσ and induces the hierarchy bifurcation is an alignment constraint for the truncation suffix:

(102) ALIGN-TO-σ́: ALIGN([*i*]$_{Af}$, L, σ́, R).

This alignment constraint expresses the requirement that the left edge of the [-i] affix coincide with the right edge of the head syllable (denoted by σ́). This constraint is similar to the one proposed by McCarthy and Prince (1993b) for the [-ka-] possessive affix in Ulwa, which aligns the affix to the right edge of the main stress foot: ALIGN([*ka*]$_{Af}$, L, Ft', R) (on alignment to heads see also Pierrehumbert 1993b; Lorentz 1995).

The problem that arises under a transparent interaction of PARSESEGσ and ALIGN-TO-σ́ is illustrated in (103).

(103) PARSESEGσ >> ALIGN([*i*]$_{Af}$, L, σ́, R) >> MAX-BT

	Base: .ga.bri.e.le. Input: /TRUNC - i/	PARSESEGσ	ALIGN-TO-σ́	MAX-BT
☞	a. .ga.bi. (Optimal, opaque constraint interaction)		*	riele!
(❁)	b. .gab.<i> (Non-optimal, sympathetic)	*!		riele
☜	c. .gab.ri. (Non-optimal, transparent constraint interaction)		*	iele

The unsyllabified status of [i] in candidate (b) is signified by the angle brackets. Under a transparent constraint interaction, the candidate satisfying affix-to-head alignment loses on a PARSESEGσ violation. This turns the competition over to (a) versus (c), which both have exhaustive parsing of segments into syllables. Candidate (c) is then selected

29 I assume that coronal voiceless fricatives occuring at the periphery of a syllable next to a stop are not extra-syllabic but are parsed into the syllable, forcing a violation of the sonority-sequencing constraint.

30 A input-oriented version of this constraint was first proposed by Prince and Smolensky (1993: 85). The PARSE constraint of Prince and Smolensky functioned as a faithfulness constraint. In this respect it differs from the present PARSESEGσ constraint, which simply expresses a demand on the layering of prosodic structure in the output.

as the winner since it copies more base material than (a). However, this outcome is not the correct one for German; (a) corresponds to the actual attested form. A harmonic sympathy analysis can obtain this result by calling on a sympathetic correspondence relation between candidate (b) and the actual output. The constraint conflict here must thus not be resolved by simple ranking, but rather by a hierarchy split, so that ALIGN-TO-σ́ may condition selection of the sympathy candidate. We will see later in this section that this approach will have to be revised; however, I will first work out the details of this account in order to identify a shortcoming of the present model of harmonic sympathy.

In selecting the sympathy candidate, the function that ALIGN-TO-σ́ performs is similar to that of ALLσL in restricting the medial consonant cluster to a possible coda of German; however, the form of the sympathy candidate is somewhat different in the two accounts. The constraint-based sympathy analysis makes use of a truncatum-sized sympathy candidate which violates MAX-IO by failing to include the suffix [-i]. In procedural terms, this corresponds to the form that would be derived from the base by syllable circumscription before [-i] is suffixed (as noted by Itô and Mester 1997a: 125). On the other hand, the harmonic sympathy account calls on a sympathy relation to a form obeying MAX-IO. In this case the sympathy candidate contains the same segmental sequence as the output but with syllabification only of the truncatum. Serially, this loosely corresponds to the form after circumscription and i-suffixation but before resyllabification of the final string.

So far, we have determined that the harmonic sympathy account involves splitting off PARSESEGσ into P1 and assigning a high-ranked status to ALIGN-TO-σ́ in P2, but some further details remain. First, to obtain the minimized size in truncation, I call on an emergence of the unmarked ranking similar to that which Itô and Mester suggest for the transparent account. This sandwiches a size restrictor (here ALLσL) between IO and BT faith: MAX-IO >> ALLσL >> MAX-BT. Second, I note a high-ranked constraint in the P2 component which rules out various candidates for sympathy or optimal output status. This is a sonority sequencing constraint, SSC, which expresses the requirement that complex onsets rise in sonority and complex codas fall in sonority (the notion of sonority sequencing goes back to Sievers 1881; Jespersen 1904).[31] With these rankings in place, the tableau showing selection of the sympathy candidate is exhibited in (104).

31 As pointed out in n. 29, this constraint may be violated by a coronal voiceless fricative adjacent to a stop. However, the details of those cases do not concern us here.

(104) Selection of the sympathy candidate:

	P1		P2			
Base: .(gà.bri).(é.le). Input: /TRUNC - i/	PARSE SEGσ		ALIGN-TO-σ́	1.MAX-IO 2.SSC	ALLσL	MAX-BT
a. .gà.bri.é.le.<-i>	*		*!*		******	
b. .gá.br-i.			*!*		*	iele
c. .gáb.r-i.			*!		*	iele
d. .gá.b-i.			*!		*	riele
e. .gá.-i.					*!	briele
f. .gáb.<r-i>	**		*!			iele
g. .gá.<br-i>	***		*!*			iele
h. .gá.<b-i>	**		*!			riele
i. .gábr.<-i>	*			*!(2)		iele
j. .gáb.				*!(1)		riele
k. .gáb.<-i>	*	❁				riele
l. .gá.<-i.>	*					briele!

Candidates (a-e), which contain more than one syllable, may all be ruled out on the basis of the size minimizer, ALLσL, although many of these candidates also violate [-i] alignment. Candidates (f-h) illustrate how the [-i] alignment constraint rules out candidates failing to place unparsed [-i] flush with a syllable edge in the sympathy candidate; any additional unparsed segmental material causes [-i] to be misaligned. These candidates lose even though (f) and (g) include more base material than the winner. The decision comes down to candidates (k) and (l), which both contain a single syllable and align [-i] to the syllable edge. The maximizing function of MAX-BT then selects (k) over (l).[32]

(104) shows that this ranking identifies the sympathetic candidate as (k) [.gáb.<i>], the most harmonic candidate with respect to the P2 hierarchy. The actual

32 A conceivable alternative with full syllabification of the sympathy candidate would posit the opaque interaction as arising between ALIGN-TO-σ́ and ONSET, giving a sympathy candidate of the form: [.gab.i.], with an onsetless final syllable. The P1 demand to satisfy ONSET in the actual output would force the appropriate syllabification in the optimal form. However, while ONSET is widely respected in German, it is not undominated, which raises complications for the analysis. Wiese (1996: 58-9) notes that glottal stop insertion takes place to fill the onset of a vowel-initial syllable in foot-initial position but not foot-medially (compare: Cháos 'chaos' versus cha[ʔ]ótisch 'chaotic'). This pattern is given by the ranking: ONSET_{FT}, MAX >> DEP >> ONSET. For ONSET to have an opaque interaction with ALIGN-TO-σ́, this full hierarchy would have to belong to P1, giving rise to possible problems with free Faith violations in the sympathy candidate.

output is the candidate which matches the sympathetic form in segmentism, while satisfying PARSESEGσ. The transparent competitor, [.gáb.ri.], loses on a DEP-❀O violation, as shown in (105). (The candidates [.gáb.] and [.gá.-i.] are not included in this tableau and will be discussed below.)

(105) Selection of the actual output:

	P1			P2			
	Base: (.gà.bri).(é.le.) Input: /TRUNC - i/	PARSE SEGσ	DEP-❀O	ALIGN-TO-σ́	1.MAX-IO 2.SSC	ALLσL	MAX-BT
	a. .gà.bri.é.le.<-i>	*!	riele	**		******	
	b. .gá.br-i.		r!	**		*	iele
	c. .gáb.r-i.		r!	*		*	iele
☞	d. .gá.b-i.			*		*	riele
	e. .gáb.<r-i>	*!*	r	*			iele
	f. .gá.<br-i>	*!**	r	**			iele
	g. .gá.<b-i>	*!*		*			riele
	h. .gábr.<-i>	*!	r		*(2)		iele
❀	i. .gáb.<-i>	*!					riele
	j. .gá.<-i.>	*!					briele

Although candidate (d) wins over (c) on DEP-❀O, it fares worse on another sympathetic faith constraint: SROLE-❀O, which requires that correspondent segments have identical syllable roles (McCarthy and Prince 1993a ch. 7; Gafos 1996). A violation of SROLE-❀O is incurred for [b], which appears in a coda in the sympathy candidate but in an onset in the actual output (d). In the alternative candidate (c), [b] maintains its coda status. Since (c) loses to (d) in spite of its satisfaction of SROLE, DEP-❀O must outrank SROLE-❀O.

(106) DEP-❀O >> SROLE-❀O

		DEP-❀O	SROLE-❀O
☞	a. (.gá.bi.)		*
	b. (.gáb.ri.)	*!	

A second sympathetic faith ranking is evident when we compare [(.gá.bi.)] with the alternatives [(.gá.i.)] and [(.gáb.)]. In contrast to the winning candidate, [(.gá.i.)] and [(.gáb.)] obey SROLE-❀O for [b] but violate MAX-❀O. This indicates that MAX-❀O also outranks SROLE-❀O. These rankings of sympathetic faith constraints will presumably also be required under Itô and Mester's account, I am simply working out the details of the rankings here.

(107) MAX-❀O >> SROLE-❀O

		MAX-❀O	SROLE-❀O
☞	a. (.gá.bi.)		*
	b. (.gá.i.)	*!	
	c. (.gáb.)	*!	

The account is verified below for the cluster maximization example, [gorbat͡ʃof] → [gorbi]. (108) illustrates selection of the sympathy candidate [(.gorb.<i>)]. MAX-BT plays a maximizing role here, ensuring that the sympathy candidate has the largest possible coda cluster.

(108) Selection of the sympathy candidate:

Base:(.gór.ba).(t͡ʃòf.) Input:/TRUNC - i/	P1 PARSE SEGσ		P2 ALIGN-TO-σ́	1.MAX-IO 2.SSC	ALLσL	MAX-BT
a. .gór.ba.t͡ʃò.<f-i>	**		*!****		***	
b. .gór.ba.<t͡ʃ-i>	**		*!**		*	of
c. .gór.b-i.			*!		*	at͡ʃof
d. .gó.r-i.			*!		*	bat͡ʃof
e. .gó.-i.					*!	rbat͡ʃof
f. .gór.<b-i>	**		*!			at͡ʃof
g. .górb.<-i>	*	❁				at͡ʃof
h. .gór.<-i>	*					bat͡ʃof!
i. .gó.<r-i>	**		*!			bat͡ʃof
j. .gó.<-i>	*					rbat͡ʃo!f
k. .gór.ba.				*!(1)	*	t͡ʃof
l. .górb.				*!(1)		at͡ʃof

(109) exhibits the complete tableau, including sympathetic faith constraints.

(109) Selection of the actual output:

	B: (.gór.ba).(t͡ʃòf.) I: /TRUNC - i/	P1 PARSE SEGσ	1.MAX-❁O 2.DEP-❁O	SROLE -❁O		P2 ALIGN-TO-σ́	1.MAX-IO 2.SSC	ALL σL	MAX-BT
	a. .gór.ba.t͡ʃò.<f-i>	*!*	at͡ʃof(2)	*		*****		***	
	b. .gór.ba.<t͡ʃ-i>	*!*	at͡ʃ(2)	*		***		*	of
☞	c. .gór.b-i.			*		*		*	at͡ʃof
	d. .gó.r-i.		b!(1)	*		*		*	bat͡ʃof
	e. .gó.-i.		r!b(1)					*	rbat͡ʃof
	f. .gór.<b-i>	*!*				*			at͡ʃof
	g. .górb.<-i>	*!			❁				at͡ʃof
	h. .gór.<-i>	*!	b(1)						bat͡ʃof
	i. .gó.<r-i>	*!*	b(1)			*			bat͡ʃof
	j. .gó.<-i>	*!	rb(1)						rbat͡ʃof
	k. .gór.ba.		i!(1)a(2)	*			*(1)	*	t͡ʃof
	l. .górb.		i!(1)				*(1)		at͡ʃof

A summary of the rankings that have been established thus far for the harmonic sympathy analysis of German truncation is given in (110).

(110) Bifurcation triggered by opaque resolution of conflict between PARSESEGσ and ALIGN-TO-σ́

a. P1: PARSESEGσ
Sympathy. DEP-❁O, MAX-❁O >>SROLE-❁O

b. P2: Size restriction. MAX-IO >> ALLσL >> MAX-BT
Medial clusters. ALIGN-TO-σ́, SSC >> MAX-BT

At this stage it is necessary to point out a problem that emerges under this account. The problem arises because the constraint, PARSESEGσ, which plays a broad function in determining well-formed outputs, is removed from P2. This means that PARSESEGσ cannot play any part in the selection of the sympathy candidate. MAX-IO may thus enforce selection of a sympathy candidate with unsyllabified material. Sympathetic faith would then cause these segments to be preserved in the optimal output, producing strings that do not actually occur in German.[33] An example is given in (111) with a possible input for [gabriele] containing extraneous unsyllabifiable segments. Since truncation is not directly relevant here, I have omitted truncation-related constraints from the tableau.

(111) Predicting unattested strings in actual output:

		P1	P1		P2	P2
	Input: bdgabriele	PARSESEGσ	1. MAX-❁O 2. DEP-❁O		1. MAX-IO 2. DEP-IO	SSC
	a. .ga.bri.e.le.		*!*(1)		**(1)	
☞	b. .bdga.bri.ele.					*
	c. <bd>.ga.bri.e.le.	*!*		❁		
	d. .bəd.ga.bri.e.le.		*!(2)		*(2)	

The sympathy candidate in (111) is [<bd>.gab.ri.e.le.], which satisfies MAX-IO by preserving all input segments and circumvents syllable well-formedness by failing to parse the first two consonants. DEP-IO is shown in this tableau to illustrate that parsing the segments into a well-formed syllable by epenthesizing a vowel, as in (d), will still be less harmonic than the sympathy candidate in (c), because candidate (d) violates DEP-IO, while the constraint that (c) violates, PARSESEGσ, is not contained in P2. With candidate (c) selected as the sympathy candidate, the actual output is (b), [.bdga.bri.e.le.], with the string of initial consonants syllabified into the first syllable. This output is selected because sympathetic faith forces the actual output to be identical in segmentism to the sympathetic candidate, and PARSESEGσ requires that all segments be parsed into some syllable. The outputs that correspond to well-formed outcomes for German, in (a) and (d), lose on the basis of sympathetic faith.

It should be noted that this kind of problem does not arise under constraint-based sympathy, because in that model all of the constraints contribute to selection of the sympathy candidate; derivational opacity is not achieved by setting a constraint aside in a separate component. One way of resolving the problem for the analysis of German in harmonic sympathy is to posit a different constraint in P1 for the opacity effect, one that is specific to truncation. A truncation-specific constraint is given in (112); this constraint is an MCat-to-MCat alignment constraint (McCarthy and Prince 1993b) demanding that the right edge of any TRUNC be aligned with left edge of [-i] in the output.

33 Thanks to Armin Mester for raising this issue.

(112) TRUNC-TO-[-i]: ALIGN(TRUNC, R, $[i]_{Af}$, L)

If the alignment constraint in (112) were the constraint in P1 instead of PARSESEGσ, then full syllabification could always be enforced in the sympathy candidate. With PARSESEGσ respected in P2, it remains for us to ensure that the sympathy candidate for a truncatory form will consist of just one syllable with no additional unparsed material, matching the sympathy candidate selected under Itô and Mester's account. The alignment constraint in P1 will then require that [-i] occur following the truncatum in the actual output, producing a violation of DEP-❁O. The sympathetic faith constraints will prevent any additional material from being added. The ranking MAX-IO >> ALLσL >> MAX-BT restricts the size of TRUNC to one syllable. However, in addition to this, we must restrict the sympathy candidate to just TRUNC material (i.e. base-dependent material) excluding [-i]. This can be achieved with alignment constraints requiring that the left and right edges of the truncatum be aligned to the left and right edges of the word, respectively. These constraints are given in (113) and reflect that for the purposes of the sympathy candidate, the truncatory form behaves as if there were no suffix.

(113) TRUNC-TO-WD:

a. ALIGN(TRUNC, R, WD, R)
b. ALIGN(TRUNC, L, WD, L)

The tableaux in (114-115) illustrate the account using these constraints for the truncation of *Gabriele*. The tableau in (114) demonstrates how TRUNC-TO-WD selects a candidate containing only TRUNC material and the emergence of the unmarked ranking restricts TRUNC size to one syllable.[34] Only candidates respecting the sonority sequencing constraint are considered here.

34 I assume that high-ranked constraints in P2 rule out candidates in which [-i] forms a word on its own or occurs outside of a word boundary.

(114) Selection of the sympathy candidate:

		P1		P2			
	B:(.gà.bri).(é.le.) I:/TRUNC - i/	TRUNC-TO-[-i]	1.DEP-❀O 2.MAX-❀O	1.PARSESEGσ 2.TRUNC-TO-WD	MAX-IO	ALLσL	MAX-BT
	a. .gà.bri.é.le.-i.		rielei(1)	*!(2)		***** *****	
	b. .gá.br-i.		ri(1)	*!(2)		*	iele
	c. .gá.b-i.		i(1)	*!(2)		*	riele
❀	d. .gáb.	*			i		riele
	e .gá.	*	b(2)		i		briele!
	f. .gá.-i.		i(1)b(2)	*!(2)		*	briele

In (115) we see the selection of the actual output. This is one that adds the [-i] suffix to the truncatum.

(115) Selection of the actual output:

		P1		P2			
	B:(.gà.bri).(é.le.) I:/TRUNC - i/	TRUNC-TO-[-i]	1.DEP-❀O 2.MAX-❀O	1.PARSESEGσ 2.TRUNC-TO-WD	MAX-IO	ALLσL	MAX-BT
	a. .gà.bri.é.le.-i.		ri!elei(1)	*(2)		***** *****	
	b. .gá.br-i.		ri!(1)	*(2)		*	iele
☞	c. .gá.b-i.		i(1)	*(2)		*	riele
❀	d. .gáb.	*!			i		riele
	e .gá.	*!	b(2)		i		briele
	f. .gá.-i.		i(1)b!(2)	*(2)		*	briele

This approach resolves the problem of predicting unattested strings in German by positing the P1 constraint as one specific to truncation. Because of this specificity, the placement of this constraint in P1 will not impact non-truncatory forms.

An alternative solution involves revising the opaque resolution of constraint conflict in harmonic sympathy. Recall that the problem for the analysis of German which placed PARSESEGσ in P1 was that this constraint no longer played any role whatsoever in selection of the sympathy candidate. This problem could be overcome if the opaque interaction of two constraints was resolved by the winning constraint being

promoted to a P1 segment and also occurring dominated by the second constraint within P2, that is, hierarchy bifurcation would be induced so that a constraint which is dominated by another in selection of the sympathy candidate will still be respected in the actual output. Positing this occurrence of a constraint in both P1 and P2, enables the winning constraint (i.e. the one in P1) to still contribute (although dominated) to the P2 optimization. This allows a more general constraint to occur in P1, since it will also still perform a role within P2. In the case of the analysis outlined in (114-115), we could replace the truncation-specific P1 constraint with REALIZEMORPH, a constraint requiring that every morpheme in the input be phonologically expressed in the output (Samek-Lodovici 1992, 1993; Gnanadesikan 1996; Rose 1997). REALIZEMORPH would also occur dominated by TRUNC-TO-WD within P2. Because the morpheme realization constraint is otherwise high-ranked in P2, morpheme realization will be respected in the general case in sympathy candidates except when a violation is induced by truncatum-to-word alignment. The tableau in (116) illustrates how this revised model handles the German truncation.

(116) German truncation under revised model of harmonic sympathy:

		P1		P2			
	B:(.gà.bri).(é.le.) I:/TRUNC - i/	REALIZE MORPH	1.DEP-❀O 2.MAX-❀O	TRUNC-TO-WD	1.MAX-IO 2.REALIZEMORPH	ALLσL	MAX-BT
	a. .gà.bri.é.le.-i.		ri!elei(1)	*(2)		***** *****	
	b. .gá.br-i.		ri!(1)	*(2)		*	iele
☞	c. .gá.b-i.		i(1)	*(2)		*	riele
❀	d. .gáb.	*!			**(1, 2)		riele
	e. .gá.	*!	b(2)		**(1, 2)		briele
	f. .gá.-i.		i(1)b!(2)	*(2)		*	briele

A benefit of this revised model is that it eliminates the truncation-specific alignment constraint in P1, although the analysis must still call on the truncation-specific TRUNC-TO-WD within P2. The goal of this account is simply to exhibit a possible way of analyzing the facts in the harmonic sympathy model, while preserving the insights of Itô and Mester’s account where possible. The theoretical focus here is concerned not with the detailed particulars of analysis but rather with the overall opacity model in which the analysis is framed. In showing that it is possible to produce the opacity effect in German truncation under the harmonic sympathy model, the above account enables us to conclude that harmonic sympathy is not so restrictive that it fails to capture this kind of attested case. However, in the case of the German opacity effect, by calling on process-specific constraints to maintain the harmonic sympathy model, the analysis must attribute more complexity to Con (i.e. the set of universal constraints) than that required under constraint-based sympathy.

The revised model of harmonic sympathy, in which a constraint in P1 also occurs dominated within P2, is important not just to resolve the problem for the analysis of German but also to address the more general concern for the first model of harmonic sympathy that if a constraint occurs only in P1, it no longer plays any role at all in selection of the sympathy candidate. The revised approach also has a positive consequence in relation to the analysis of opacity in Tuyuca developed earlier in this chapter. Because the nasalized obstruent constraints would occur in both P1 and P2, the ranking structure in P2 would mirror the factorial ranking result from chapter 2, i.e. a language like Tuyuca, with transparent obstruents, would be one in which all nasalization constraints are dominated within P2. The transparent behavior of these segments in the actual output would arise as an opacity effect from the nasal obstruent markedness constraints occurring undominated in P1. The revised ranking structure is illustrated in (117). (Nasalized obstruent constraints are collapsed here as well as nasalized sonorant constraints.)

(117) Transparency in Tuyuca:

	P1			P2		
w̃ãti	*NASOBS	IDENT-❁O [+nasal]		SPREAD ([+nas], M)	*NASOBS	*NASSON
a. [w̃ãt̃ĩ]	*!		❁		*	***
b. [w̃ã]ti		**!		**		**
c. w[ã]ti		**!*		***		*
☞ d. [w̃ã]t[ĩ]		*		*****		***

In addition to preserving the factorial ranking result, this revised model would simplify the analysis of cross-morpheme spreading in Tuyuca. In particular, with the nasalized obstruent constraints appearing within P2, their domination of the word-spreading constraint can be achieved without calling on affix-specific nasal markedness constraints. Recall from section 3.3.4 that ranking the word-spreading constraint below *NASOBS within P2 produces the blocking behavior of obstruents in cross-morpheme

spreading. Earlier this P2 constraint was posited to be $*NASOBS_{affix}$, since the more general constraint was already located in P1; however, with a revised model in which *NASOBS occurs dominated by the morpheme-spreading constraint in P2, a positional markedness constraint is not required. In section 3.3.4 it was noted that it was odd for the general *NASOBS constraint to dominate $*NASOBS_{affix}$ in the positional markedness context, but making use of *NASOBS in both P1 and P2 obviates this issue. The tableau in (118) shows how the occurrence of *NASOBS in both segments of the hierarchy yields transparent obstruents within morphemes and blocking obstruents in cross-morpheme spreading.

(118) Morpheme-internal transparency and cross-morpheme blocking by obstruents:

	P1			P2			
ãta-ta	*NASOBS	IDENT-❁O [+nasal]		SPREAD ([+n], M)	*NASOBS	SPREAD ([+n], W)	*NASSON
a.[ãt̃ã]-ta	*!		❁		*	**	**
b. [ã]ta-ta		*!*		**		****	*
c.[ãt̃ã-t̃ã]	*!*				**		***
☞ d.[ã]t[ã]-ta		*		****		********	**
e.[ã]t[ã]-t[ã]		*		*****!		************	***

This revised approach to harmonic sympathy with a constraint occurring in both P1 and P2 amounts to saying that derivational opacity comes about when a constraint is dominated by another for the purposes of selecting the sympathy candidate, but wins in the selection of the actual output. In this sense, it is similar to a kind of spell-out of how a sympathetic constraint in constraint-based sympathy contributes to the selection of the sympathy candidate. Itô and Mester (1997a: 126) define selection of the sympathy candidate in constraint-based sympathy as the candidate best satisfying the constraint hierarchy of the language, except with the sympathy constraint top-ranked. Assigning a constraint sympathy status is thus equivalent to invoking a second optimization with one constraint reranked. Under the revised version of harmonic sympathy, the hierarchy for the optimization determining the sympathy candidate is the hierarchy represented by P2. The hierarchy for selection of the actual output is then P1 and P2 together, where a dominated constraint in P2 occurs again in P1 to be top-ranked in this optimization. This approach shares with constraint-based sympathy the idea that selection of the sympathy candidate involves an optimization corresponding to a different constraint ranking from that selecting the actual output. Constraint-based sympathy expresses this through assigning a constraint sympathetic status; the revised version of harmonic sympathy expresses the ranking for the sympathy optimization directly in the hierarchy by making the sympathy candidate the one that is optimal with respect to P2, a contiguous segment of Eval. As outlined earlier in this chapter, the bifurcation of the hierarchy and occurrence of a constraint in P1 (as well as in P2), can be understood in terms of an opaque resolution of constraint conflict, an alternative to simple ranking without bifurcation. In the opaque resolution of conflict between two constraints, one constraint wins in determining the actual output, by occurring in P1; the other constraint wins in selection of the sympathy candidate by dominating the other in P2. Harmonic sympathy thus seeks to explicate and develop the notion of reranking for a sympathy optimization, an idea central to sympathy theory.

Finally, I briefly return to the two kinds of unattested opacity effects discussed in section 3.4 which constraint-based sympathy was capable of generating. The earlier version of harmonic sympathy ruled out these effects; however, under the revised version of harmonic sympathy, these must be reexamined. The first case involved maintaining the implications of universal constraint hierarchies (e.g. given by universal harmonicity scales). The tableaux in (119-120), repeated from section 3.4 illustrate a problem that arises from assigning sympathy status to a low-ranked constraint in the peak hierarchy. Here assignment of sympathy status to *P/i causes /i/ to come out as a margin but the less harmonic /n/ can still be syllabic.

(119) /i/ must be a margin

	tadi	MAX-IO *P/t *P/d	Faith-❁O	DEP-IO	*P/n	*P/i❁	*P/e *P/a
	a. .ta.di.		*!			*	*
❁ ☞	b. .ta.dAj.			*			**

(120) /n/ can be syllabic:

	tadn	Max-IO *P/t *P/d	Faith-❁O	DEP-IO	*P/n	*P/i❁	*P/e *P/a
❁ ☞	a. .ta.dn.				*		*
	b. .ta.dAn.		*!	*			**

Under the revised version of harmonic sympathy, this problem still does not come about. In order for *P/i to be respected in selection of the sympathy candidate, it must be obeyed in the output best-satisfying P2; however, if *P/i must be respected, then all higher-ranked peak constraints must also be obeyed in the sympathy candidate. Thus, because harmonic sympathy spells out the ranking for the sympathy optimization, it explains why universal hierarchies are respected in opacity effects.

For completeness, universal hierarchies should also be considered in relation to the occurrence of markedness constraints within P1. In the analysis of nasal harmony, it should be the case that if any nasal markedness constraint occurs in P1, all higher-ranked constraints in the nasalization family must occur in P1 as well. For example, if *NASFRIC were to appear in P1 (as resolution of a conflict with SPREAD[+nasal]), then *NASOBSSTOP must also occur dominating *NASFRIC in P1. This can be explained if universal constraint hierarchies are interpreted as requiring that wherever a constraint is located in the hierarchy for a given grammar, it must be dominated by some occurrence of each of the constraints dominating it in a universal hierarchy. Thus, any occurrence of *NASFRIC in a constraint hierarchy must be dominated by some occurrence of *NASOBSSTOP. The appropriate implications will thus be maintained in the revised harmonic sympathy model.

The second unattested opacity effect considered in section 3.4 is one in which a segment-specific markedness constraint, *p, is assigned sympathy status. In a language with epenthesis into complex clusters, the sympathetic status of *p can render [p] invisible to epenthesis, but high-ranked MAX-IO can still force [p] to surface in outputs. The first version of harmonic sympathy was able to rule this out, because placing MAX-IO in P1 caused all syllables to revert to an unmarked CV shape (see discussion in section 3.4). However, if MAX-IO also occurs in P2 dominated only by *p, then the unattested outcome can be achieved:

(121) /tarp/: No epenthesis

		P1			P2				
	/tarp/	MAX-IO	DEP-❀O		*p	MAX-IO	*k, *r	*COMPLEX	DEP-IO
	a. tarIp		**!		*		*		*
☞	b. tarp		*		*		*	*	
	c. tar	*!		❀		*	*		
	d. ta	*!*				**			
	e. tap	*!			*	*			

(122) /tark/: Epenthesis

		P1			P2				
	/tark/	MAX-IO	DEP-❀O		*p	MAX-IO	*k, *r	*COMPLEX	DEP-IO
☞	a. tarIk			❀			**		*
	b. tark						**	*!	
	c. tak	*!				*	*		
	d. ta	*!*				**			
	e. tar	*!				*			

The above opacity effect remains an outstanding issue for constraint-based sympathy and the revised version of harmonic sympathy. In the harmonic sympathy model it may be observed that the undesirable effect comes about when a segmental markedness constraint dominates faith (MAX-IO) in P2 but the faith constraint wins out in selection of the actual output by appearing in P1. This gives a P2 hierarchy in which [p] is excluded from the segmental inventory, and a P1 + P2 hierarchy in which [p] is a member of inventory. It would seem to be the case that opacity effects in which the inventory P2 admits is a smaller subset of the inventory admitted by P1 should be ruled out. This observation points to a possible direction for understanding why this kind of opacity effect does not occur, but I will leave exploration of the connection between P2 and inventory structure for further research.