PARALLEL LEXICAL OPTIMALITY THEORY

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Parallel Lexical Optimality Theory (PLOT) is a model I propose to account for opacity and related phenomena in Optimality Theory. PLOT recognizes three input interfaces and three output interfaces to the grammar. Interfaces are related to each other by constituency and by correspondence (McCarthy & Prince 1995). PLOT's architecture provides sufficient power to account for opacity, but is not overly powerful, I argue. Additionally, PLOT interfaces neatly with Comparative Markedness (McCarthy 2002b) to explain the co-occurrence of derived environment effects and counterfeeding opacity. PLOT also makes more limited typological predictions than LPM-OT (Kiparsky 2003), on which PLOT is based, since PLOT recognizes only one markedness hierarchy for the grammar.

1. Introduction

This paper enhances Optimality Theory, so that it can account for opaque phonological and morphological alternations. Within the framework of Optimality Theory (Prince & Smolensky 1993), many have attempted to deal with opacity with varied success. Opacity effects require an abstract level of representation, which is thought to require a serial derivation. Parallel Lexical Optimality Theory (PLOT), however, conceives of an OT grammar that maps between an input and three interfaces corresponding to the Stem, Word, and Phrase levels of Kiparsky (2000, forthcoming), which are themselves interdependent. I claim that PLOT makes more limited typological predictions than the Lexical Phonology and Morphology Optimality Theory (LPM-OT) of Kiparsky (2003, forthcoming). I present Turkish opacity data and analyze it with PLOT. Then a full formal description of PLOT is provided. Next I motivate a particular aspect of PLOT, the presence of three output representations, with data from Serbo-Croatian. I then consider the role of Comparative Markedness (McCarthy 2002) in relation to PLOT, concluding that both models are necessary for descriptive adequacy. I then argue that PLOT achieves greater descriptive adequacy than either LPM-OT or Sympathy Theory (McCarthy 2003, 1998).

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2. PLOT in Action

Kenstowicz & Kisseberth provide the following example of overapplication opacity from Turkish (Altaic, Turkic; data from Kenstowicz & Kisseberth 1979, citing Zimmer 1975). Two phonological processes are of interest in Turkish. The first is the deletion of the 3rd person possessive suffix /s/ when the stem has a final consonant. This is shown in the data below.

(1) Turkish s-Deletion

‘his…’	
ɑrɯ-sɯ	‘bee’
ɑrɑbɑ-sɯ	‘car’
βɑʃ-ɯ	‘head’
jel-ɯ	‘wind’

Although it is also possible that the [s] is inserted to resolve hiatus, we do not see this insertion in the forms in (2). The second process of interest is the deletion of /k/ intervocalically:

(2) Turkish k-Deletion

Nominative	Accusative	Dative	
inek	ine-ɯ	ine-ɑ	‘foot’
kujruk	kujru-u	kujru-ɑ	‘cow’
ɑjɑk	ɑjɑ-ɯ	ɑjɑ-ɑ	‘daughter’

The stems in (2) have a final [k]; other Turkish words end in different consonants or in vowels, as seen in the nominative forms (e.g. [ɑrɑbɑ] ‘car’ or [bɑʃ] ‘head’). Opacity arises in Turkish in the 3rd person possessive form, /ɑjɑk-si/ → [ɑjɑi]. In this form both alternations occur: both [k] and [s] delete, although the [k] → ø is extraneous. That is, the form [ɑjɑsi] would have satisfied markedness in the output without the extra deletion.

Parallel Lexical Optimality Theory claims that three outputs of the grammar are selected in parallel. Correspondence constraints (McCarthy & Prince 1995) demand that the outputs be identical, but in typical OT form, higher-ranked markedness constraints can dominate faithfulness. In PLOT, opacity arises when faithfulness constraints governing the output of different outputs are ranked differentially with respect to each other and with respect to markedness.

In the case of Turkish, we say that the [s] is deleted at the Stem Output. The Stem Output is in correspondence with the Stem Input (equivalent to the Input in classic OT). I assume the following markedness and faithfulness constraints.

(3) *Cs
'No consonant-s sequences.'

MAX-C-SO^S
'Every consonant in the Stem Input has a correspondent in the Stem Output.'

The constraint MAX-C-SO^S is the familiar correspondence constraint, with the difference that it demands faithfulness between the Stem Input (S) and Stem Output (O^S). It has nothing to say, for instance, about the Word Output, which is subject to different faithfulness constraints. The constraints are ranked as follows.

(4) MAX-SO^S-Stem, *Cs » MAX-SO^S-Afx

{{ɑjɑk, sɯ}}	MAX-C-SO^S-Stem	*Cs	MAX-C-SO^S-Afx
a. ɑjɑkɑɯ		*!	
S☞ b. ɑjɑkɯ			*
c. ɑjɑɯ	*!		*

The constraint ranking is conducive to deletion of [s] in the successful Stem Output Interface, as in candidate (b). Note that the 'finger of optimality' is augmented with a 'S,' indicating the grammar's selection of the Stem Output.

We now proceed to discussion of the relation between the Stem Output Interface, the Word Input Interface, and the Word Output Interface. The Word Output is in correspondence with the Word Input. Formally the Word Input is defined as the Stem Output plus any Word affixes(full details are provided in §2). In the case of Turkish there are no Word Affixes. For expository purposes we can then consider the Word Output to be in correspondence with the Stem Output. In determining the Word Output the following constraints are necessary.

(5) *VkV (Kager 1999b)
'No intervocalic [k].'

DEP-WO^W
'Every segment in the Word Input has a correspondent in the Word Output.'

The faithfulness constraint DEP-WOW demands faithfulness between the Word Input (W) and the Word Output (O^W). As mentioned, for this introductory example we can consider the correspondence to be between the Stem Output and the Word Output. The following ranking produces the proper output.

(6) DEP-WO^W, *VkV » MAX-C-WO^W

{{ɑjɑk, sɯ}}	DEP-WO^W	*VkV	MAX-C-WO^W
a. ɑjɑkaɯ	*!		
S☞ b. ɑjɑkɯ		*!	
W☞c. ɑjɑkɯ			*

The candidate which is fully faithful to the input, (a), fails in correspondence to the Stem Output, candidate (b). This candidate is perfectly faithful to the input, but this is not rewarded, since the only dimension of faithfulness for the Word Output is to the Word Input (in this case equivalent to the Stem Input). Candidate (b) is entirely faithful to (a), although it scores a fatal violation of *VkV as a result. The Word Interface Output, candidate (d), is successful for avoiding a *VkV violation by accepting a comparatively minor MAX-C-WO^W violation.

Only the Phrase Output remains to be determined. Based on the current evidence the representations at the Word Output Interface and Phrase Output Interface are identical (as demanded by PO^P correspondence). Any violation of faithfulness produces a suboptimal form.

(7) No change at Phrase Output

{{ɑjɑk, sɯ}}	DEP-PO^P
a. ɑjɑksɯ	*!*
S☞ b. ɑjɑkɯ	*!
W☞c. ɑjɑɯ P☞	

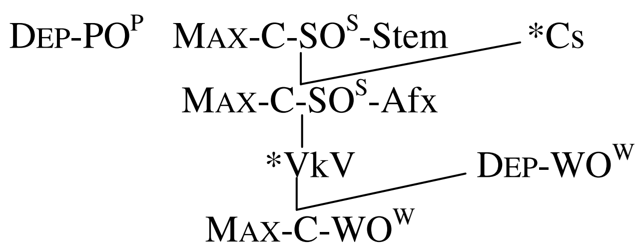
Candidates (a) and (c) attempt epenthesis, but the grammar has no preference for such candidates. The successful candidate is the candidate fully faithful to (c).

A tableau showing the full evaluation in parallel is given below. The final constraint ranking follows. As in any presentation of an OT analysis, it is often easier to examine subsets of the ranking at a time in a tableau. This is even more necessary in PLOT, since the evaluation functions only consider subsets of the entire constraint hierarchy (§2.3). Nevertheless the full tableau is presented below, to emphasize the parallel nature of the evaluation.

(8) DEP-PO^P, MAX-C-SO^S-Stem, *Cs » MAX-C-SO^S-Afx » *VkV, DEP-WO^W » MAX-C-WO^W

{{ɑjɑk, sɯ}}	DEP-PO^P	MAX-C-SO^S-St	*Cs	MAX-C-SO^S-Afx	*VkV	DEP-WO^W	MAX-C-WO^W
a. ɑjɑksɯ	**		*			*	
S☞ b. ɑjɑkɯ	*			*	*		
W☞ c. ɑjɑɯ P☞		*					*

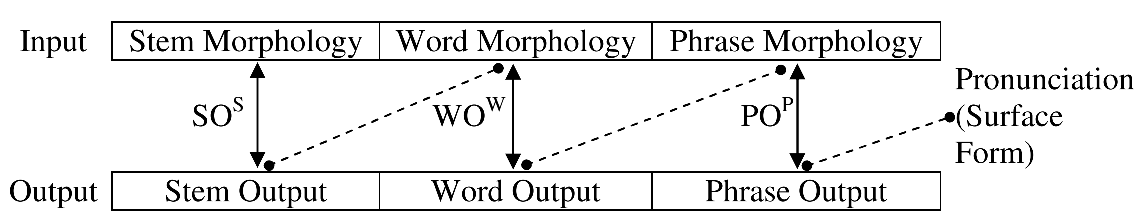
(9) Turkish Constraint Ranking



3. The Model Defined

Parallel Lexical Optimality Theory recognizes three outputs of the phonological grammar, with three concomitant inputs. The primary insight of PLOT is that this does not require a serial derivation; rather, the relations can be captured in a parallel system.[1] The PLOT model is illustrated in (10):

(10) Parallel Lexical Optimality Theory[2]



where ⟷ represents a correspondence relation, •- - - -• a constituency relation

[1] A more complete exposition on what this means is to be found in Appendix A.
[2] Thanks to Scott Jackson for suggesting this diagrammatic representation, which represents a substantial improvement over its predecessor.

In PLOT there is no serial process. Instead, the grammar describes dependencies between interfaces of the grammar. None of these dependences are serial dependencies. There are constraints on the relation of the stem morphological input to the stem output (Stem-Output^{Stem}), the relation of the stem output and the word morphological input, the relation of the word morphological output to the word output (Word-Output^{Word}), the relation of the word output to the phrase morphological input, and the phrase morphological input to the phrase output (Phrase-Output^{Phrase}). All constraints apply simultaneously in the evaluation of the outputs.

Discussion now turns to the formalization of the grammar, first of the inputs and outputs of the grammar, and then of the dependencies between the interfaces.

3.1 Inputs and Outputs

There are three input interfaces on the grammar. Like all inputs, these can be considered as constraints on the possible states of the grammar. In previous models of Optimality Theory (Prince & Smolensky 1993, McCarthy & Prince 1993, 1995), the constraints presented by the input were supplied entirely by the lexicon; now, the grammar introduces constraints on the nature of the interfaces.

3.1.1 The Stem Interface

The most easily understood interface is the Stem Interface. The input to the grammar from the syntax must consist of a set of labeled roots $\mathbf{R} = \{R_1, R_2, R_3, R_4, \ldots R_n\}$, with n the number of words in the phrase (i.e. whatever total number of lexical items is being submitted to the phonological grammar). Along with the bare stems, a set of affixes must be submitted at the level of the Stem Interface. I assume with McCarthy & Prince (1993) that affixes are submitted to the phonology as a set, with linear order being determined by various alignment constraints. The affix sets must be labeled, such that the set takes the form $\mathbf{A} = \{A_1, A_2, A_3, A_4, \ldots A_n\}$. We can then consider the Stem Interface Input to be a set of stems $\mathbf{S} = \{S_1, S_2, S_3, S_4, \ldots S_n\}$, where $S_i = R_i \cup A_i$, the union of the Root and Stem-Interface Affixes.[3]

[3] Space prevents an illustration of a phonological analysis where the presence of a word-level affix is crucial to the analysis. Such a case is to be found in Kinande (Baker in prep.)

3.1.2 The Word Interface

The Word Interface introduces further constraints about the phonological output of the grammar, by introducing further affixes to the grammar. The idea of multiple rounds of affixation comes from Lexical Phonology and LPM-OT (Kiparsky 2000), and is shown in this paper to be necessary in analyses of Kinande (§3.3) and English (§5.2.3). These affixes are also be assumed to be bundled into labeled sets, formalized as the set $\mathbf{B} = \{B_1, B_2, B_3, B_4, \ldots B_n\}$ (with **B** being one more than **A**, i.e. the next 'round' of affixation). The Word Interface Input must be defined with respect to the Stem Output (O^S). We therefore say that the Word Interface Input is the set $\mathbf{W} = \{W_1, W_2, W_3, W_4, \ldots W_n\}$, $W_i = O^S{}_i \cup B_i$, the union of the Stem Output and the Word-Interface Affixes.

3.1.3 The Phrase Interface

The Phrase Interface is the final level of affixation. It depends entirely on a linearization of each Word Output (O^W). I refer only to a general linearization function L that can produce a phrase $P = L(O^W{}_1, O^W{}_2, O^W{}_3, O^W{}_4, \ldots O^W{}_n)$. The Phrase Output O^P is then pronounced according to the phonetic implementation rules of the grammar.

3.2 Correspondence Relations

I analyze the dependencies between interfaces in terms of Correspondence Theory (McCarthy & Prince 1995), which provides an intuitive, comprehensive program for evaluating the similarity of strings. I assume the standard array of faithfulness constraints proposed in M&P 1995, and now define appropriate correspondence relations for the grammar.

McCarthy & Prince (1995) define their correspondence constraints for strings S1 and S2. The table in (11) provides a descriptions of the correspondence relations in LPM-OT, compared in (12) with the correspondences in PLOT.

(11) LPM-OT Correspondences

S1	**is in correspondence with**	**S2**
i)	Input From Stem Morphology	Output of Stem OT Grammar
ii)	Output of Word Morphology	Output of Word OT Grammar
iii)	Output of Phrase Morphology	Output of Phrase OT Grammar

(12) PLOT Correspondences

S1	**is in correspondence with**	**S2**
i) Stem Interface Input		Stem Output
ii) Word Interface Input		Word Output
iii) Phrase Interface Input		Phrase Output

The similarities between the models should be evident. PLOT achieves the same correspondence relations but without a serial process.

Formal definitions of the correspondence relations, which is to say those which should be used in counting constraint violations, are given below in (13).

(13) Formal PLOT Correspondences

i) **SO^S Correspondence**
Let S1 be $S_i \in \mathbf{S}$
Let S2 be $Sj \in \mathbf{O}^S$
$i = j \rightarrow S1\ \Re\ S2$

ii) **WO^W Correspondence**
Let S1 be $W_i \in \mathbf{W}$.
Let S2 be $Wj \in \mathbf{O}^W$
$i = j \rightarrow S1\ \Re\ S2$

iii) **PO^P Correspondence**
Let S1 be P.
Let S2 be O^P.
Then $S1\ \Re\ S2$

(13i) says that all stems in the Stem Input Interface are in correspondence with their coindexed stems in the Stem Output Interface; this is Stem/Stem-Output Correspondence (SO^S Correspondence). The definition of WO^W correspondence in (13ii) is identical. Phrase/Phrase Input Correspondence (PO^P Correspondence) simply establishes a correspondence relation between the Phrase Interface Input and the Phrase Output Interface. The phrase input and output are not sets. As previously discussed, the Phrase Interface Input is the linearization of the Word Interface Outputs.

3.3 Evaluation

In PLOT, three evaluation functions select three outputs, O^S, O^W, and O^P. There are at least two ways for these outputs to be selected, such that faithfulness violations are registered appropriately for all candidates. One solution is to create three candidate sets, that is, a candidate set for each the Stem, Word, and Phrase interfaces. Each candidate set would be labeled as Stem, Word, and Phrase, which are used for registering faithfulness violations. To avoid the complications of three candidate sets, I propose three evaluation functions, $_S$H-eval, $_W$H-eval, and $_P$H-eval. The evaluation functions differ only in that they consider different subsets of Con, the constraint hierarchy. Consider a ranking of markedness constraints M, and faithfulness constraints F^S, F^W, and F^P. We then say that $_S$H-eval evaluates candidates by constraints which are the union of the markedness and stem faithfulness constraints ($M \cup F^S$). The role and function of the three evaluation functions are given below.

(14)

Evaluation Function	Selects	Considers
$_S$H-eval	O^S	$M \cup F^S$
$_W$H-eval	O^W	$M \cup F^W$
$_P$H-eval	O^P	$M \cup F^P$

As was illustrated in the comparison of (11) and (12), this is quite similar to LPM-OT. An important is that in PLOT, these three Eval functions operate in parallel and select from the same candidate set. The crucial difference between PLOT and LPM-OT, discussed below, is that PLOT features only one markedness hierarchy.

This discussion of evaluation provides the background needed to address an important typological prediction of Parallel Lexical Optimality Theory.

3.4 The PLOT Markedness Principle

Note that in the discussion of the PLOT H-eval functions in §2.5, the set of markedness constraints is identical. This is an important feature of the theory, as it gives rise to the PLOT Markedness Principle, stated below.

(15) Parallel Lexical Optimality Theory Markedness Principle
Every language has exactly one markedness hierarchy.

This differs dramatically from LPM-OT, in which three serially-arranged OT grammars evaluate candidates with independent constraint hierarchies. In PLOT, there is one markedness hierarchy. Differences in representation at the Stem, Word, and Phrase Output Interfaces are due only to differential ranking of faithfulness and markedness constraints.

The specific prediction that PLOT makes is that different representations at different interfaces are never the result of differently ranked markedness constraints. In derivational language, this is tantamount to saying that a representation A will never be preferred with respect to relative markedness over representation B at one stage of derivation, while B is preferred over A with respect to markedness at a different stage in the derivation.[4] The claim is that relative markedness is always the same, at all interfaces of the grammar.

This prediction gives PLOT a clear advantage over LPM-OT, which allows a variety of derivations which never occur in the world's languages (see §5.1).

3.5 Parallelism in Grammar

This section describes the advantage of maintaining a grammar that operates in parallel. This paper advocates parallel computation for two reasons. The first is that maintaining parallel evaluation produces interesting predictions and clear limitations on what human language can do (see §5.1 for a fuller exposition on this point). The second reason that that I understand Optimality Theory to be a high-level description of the actual grammar, i.e. the biological system that produces the grammar (Prince & Smolensky 1997; Stemberger & Bernhardt 1999).

The language of "satisfying multiple constraints simultaneously" and "constraint interaction" does not have its origin in Optimality Theory, but in the connectionist manifesto, *Parallel Distributed Processing* (Rumelhart & McClelland 1986, vols. 1 and 2; e.g. Ch. 1). In fact, the volume contains work by Paul Smolensky, in which he describes his connectionist mathematical theory, Harmony Theory (Ch.6). The conceptual and historical connections between Smolensky's connectionist Harmony Theory and Optimality Theory are hinted at in Prince & Smolensky (1993: 217-8), but made explicit in Prince & Smolensky (1997): "The relation we seek to identify between optimality theory and neural computation must be of the type that holds between higher level and lower level systems of analysis in the physical sciences… [O]ptimality theory is a self-contained higher level theory." Put otherwise, Optimality Theory is a symbolic

[4] This restriction on derivations in achieved in the Target Conditions of Archangeli & Pulleyblank (1994).

instantiation that approximates the results obtainable with a sub-symbolic connectionist network.[5]

I adopt this view of Optimality Theory in this paper, inasmuch as it provides a motivation for maintaining a parallel grammar. Parallel Lexical Optimality Theory provides a means to obtain the results of LPM-OT, but without recourse to the serial derivations.

4. Motivation for Three Interfaces Serbo-Croatian

Parallel Lexical Optimality Theory stipulates that there are three input and three output interfaces. I here motivate that stipulation empirically, by showing that stress assignment opacity in Serbo-Croatian requires two interfaces in the grammar beyond what is pronounced (Yawelmani Yokuts also requires three levels; see Baker in prep.).

Serbo-Croatian (Indo-European, Slavic) provides an opaque interaction having to do with stress assignment. Epenthetic vowels are not only ignored in stress assignment: they are inserted even when markedness constraints do not require their presence (overapplication).

Two general processes are of particular interest in Serbo-Croatian (Kenstowicz 1994). The first process is epenthesis, illustrated in (16a) below. Some adjectival stems end in /Cɾ/ or /Cn/ sequences, which when affixed with phonologically-empty masculine agreement affix, create violations of the Sonority Sequencing Principle. To avoid this, /ɑ/ is epenthesized before the final stem consonant, e.g. /dobɾ+Ø/ → [dobɑɾ]. Although it is possible to analyze the forms in the top of (16a) as cases of deletion, this analysis is more difficult. First, it is not clear why the vowel would be deleted in these forms. Second, an epenthesis analysis can be motivated by the Sonority Sequencing Principle.

The second alternation, illustrated in (16b), is the vocalization of underlying /l/ into surface [o]. Arising apparently out of a prohibition of a word-final [l], the consonant is realized as a vowel in the masculine.

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[5] The authors' full claim is this: "Linguistic research employing optimality theory does not, of course, involve explicit neural network modeling of language. The relation we seek to identify between optimality theory and neural computation must be of the type that holds between higher level and lower level systems of analysis in the physical sciences. For example, statistical mechanics explains significant parts of thermodynamics from the hypothesis that matter is composed of molecules, but the concepts of thermodynamic theory, like "temperature" and "entropy", involve no reference whatever to molecules. Like thermodynamics, optimality theory is a self-contained higher-level theory; like statistical mechanics, we claim, neural computation ought to explain fundamental principles of the higher level theory by deriving them as large-scale consequences of interactions at a much lower level. Just as probabilistic systems of point particles in statistical mechanics give rise to nonprobabilistic equations governing bulk continuous media in thermodynamics, so too should the numerical, continuous optimization in neural networks give rise to a qualitatively different formal system at a higher level of analysis: the nonnumerical optimization over discrete symbolic representations–the markedness calculus–of optimality theory."

(16) Serbo-Croatian Data (Kenstowicz 1994)

a. a-Epenthesis

Masculine	*Feminine*	*Neuter*	*Plural*
dóbɑɾ	dobɾɑ́	dobɾó	dobɾí
jásɑn	jɑsnɑ́	jɑsnó	jɑsní
sítɑn	sitnɑ́	sitnó	sitní

cf. stems with other final consonant sequences:

mlɑ́d	mlɑdɑ́	mlɑdó	mlɑdí
tʃést	tʃestɑ́	tʃestó	tʃestí
púst	pustɑ́	pustó	pustí

b. l-Vocalization

Masculine	*Feminine*	*Neuter*	*Plural*
debéo	debelɑ́	debeló	debelí
posustɑ́o	posustɑlɑ́	posustɑló	posustɑlí
béo	belɑ́	beló	belí

c. Interaction

óbɑo	oblɑ́	obló	oblí
nɑ́gɑo	nɑglɑ́	nɑgló	nɑglí
pódɑo	podlɑ́	podló	podlí

The forms in (16c) demonstrate the interaction of the two processes. Stems that underlyingly end in an [l] exhibit both a-Epenthesis and l-Vocalization. Further, note that the stress pattern is irregular where epenthesis and l-vocalization occur. Typically, stress is assigned to the final syllable of the word. Yet, this generalization is violated systematically in two contexts: both the epenthetic [ɑ] and the vocalized [o] are invisible to stress assignment. Now, derivationally these facts are quite easily explained. The two necessary rules are ordered such that epenthesis applies before vocalization. A derivation is given below:

(17)

UF:	/pust/	/debel/	/obl/
Stress Assignment	púst	debél	óbl
a-Epenthesis	--	--	óbɑl
l-Vocalization	--	debéo	óbɑo
SF:	[púst]	[debéo]	[óbɑo]

A Classic OT analysis cannot produce the proper surface forms of the word forms in (16c). The problem is that, in the surface form, words such as [obɑo] are equally marked, but less faithful, than forms such as [obo]. The epenthesis is superfluous, as the SSP is satisfied incidentally as a consequence of vocalizing the word-final [l]. Further, stress assignment is unpredictable in the surface forms, unless reference can be made in stress assignment to vowels that are found only in the surface form, which seems highly undesirable.

I propose the following PLOT analysis. The agreement affix is part of the Stem Interface Input, along with the root. The Stem Output is identical to the Stem Input, except that stress has been assigned. The mapping between the Word Input and the Word Output is such that epenthesis occurs, but not l-vocalization. Finally, in the mapping between the Phrase Input and Phrase Output, l-vocalization occurs.

From the data in (16) it is clear that stress is assigned to the rightmost syllable. Following McCarthy & Prince (1993), I analyze Serbo-Croatian stress assignment as follows. A single iambic foot is aligned at the right edge of the prosodic word; other syllables are left unparsed. This can be accomplished with the ranking ALL-FT-RIGHT, FT-FORM: IAMBIC » PARSE-σ (Prince & Smolensky 1993, McCarthy & Prince 1993, Kager 1999b). This ranking ensures that exactly one foot is permitted in the output, and that the foot is aligned to the right edge of the prosodic word. Further parsing would result in a misaligned foot, therefore PARSE-σ must be dominated by ALL-FT-RIGHT.

(18) ALL-FT-RIGHT, FT-FORM: IAMBIC » PARSE-σ

/posustɑl-ɑ/	ALL-FT-RIGHT	FT-FORM: IAMBIC	PARSE-σ
a. (posú)(stɑlɑ́)	*!*		
b. (pósu)(stɑ́lɑ)	*!*	**	
c. posu(stɑ́lɑ)		*!	**
S☞ d. posu(stɑlɑ́)			**

Candidates (a) and (b) fail because they have feet that are misaligned by two syllables. Candidate (c) fails for an incorrect foot-form. Candidate (d) is successful, as it both satisfies the foot-form requirement, and wisely leaves two syllables unparsed, to achieve perfect alignment with the right edge of the prosodic word. Thus the ranking places stress on the final syllable.

I propose the following constraint ranking to account for the epenthesis of [ɑ], which follows Kenstowicz (1994)'s proposal that Serbo-Croatian is motivated by the Sonority Sequencing Principle (SSP; Sievers 1876). R-ANCHOR crucially dominates O-CONTIG, since the epenthetic vowel disrupts the contiguity of the output, instead of changing the identity of the right boundary segment.

(19) SSP, R-ANCHOR-WO^{W} » O-CONTIG-WO^{W}

This constraint ranking guarantees that epenthesis occurs to avoid an SSP violation, and further that the epenthesis is word-internal. The ranking argument is as follows:

(20) SSP, ANCHOR-WO^{W} » O-CONTIG-WO^{W}

/dóbɾ + Ø/	SSP	ANCHOR-WO^{W}	O-CONTIG-WO^{W}
a. dób		*	
b. dóbɾ	*!		
c. dóbɾɑ		*!	
W☞d. dóbɑɾ			*

Unwilling to tolerate an SSP violation in the faithful candidate (b), the language resorts to a violation of faithfulness. Both deletion (a) and edge-epenthesis (c) are disfavored; stem-internal epenthesis is preferred, which is the strategy of the faithful candidate (d).[6]

The proper analysis of l-Vocalization is more difficult. Although it is simple to create a markedness constraint $*l]_{W}$, it is unclear why changing /l/ to [o] incurs the fewest violations. Nevertheless, the alternation is very well attested in a variety of unrelated languages, e.g. Portuguese (Indo-European; from a native speaker), and Xavánte (Macro-Ge; Merrifield et al. 1987). Not having access to a featural

[6] Here I have ignored the assignment of stress at the word level. In fact, the PLOT Markedness Principle claims that assignment of stress should be uniform across all interfaces of the grammar (since stress assignment is determined typically only by markedness constraints, and PLOT has only one ranking of markedness constraints). The only way to ensure that the foot-parsing of the Stem Output is identical to that of the (pronounced) Phrase Output is to call on stress faithfulness constraints, which have been discussed in (Ito et al 1996, McCarthy & Prince 1999, Graf 2000, Graf & Ussishkin 2002). I assume that appropriately-ranked faithfulness constraints secure full faithfulness of stress assignment from the Stem Output to the Phrase Output.

system that makes the connection between [l] and [o] intuitive, I use the bland IDENT-PO^P to at least acknowledge faithfulness in the grammar.

(21) IDENT-PO^P
‘Corresponding segments in the Phrase Input and Phrase Output are identical.’

(22) *l]$_W$ » IDENT-PO^P

/debel+Ø/	*l]$_W$	IDENT-PO^P
a. debél	*!	
P☞ b. debéo		*

The benchmark of the analysis, of course, is its ability to handle the forms in (16c), eg. /obl/ → [obao]. An illustration with the masculine-affixed root /obl/ is given below. As in previous demonstrations, the large number of constraints involved prohibits a single tableau, although it is emphasized that the tableau all belong to a single, parallel evaluation. For /obl/ in particular, a tableau showing stress assignment to the only vowel in the string would be quite tedious. I therefore proceed to illustrate the Word Input/Output Mapping, with the optimal Stem Output candidate [óbl] already selected.

(23) Word Input/Output Mapping

/óbl + Ø/	SSP	ANCHOR-WO^W	IDENT-WO^W	O-CONTIG-WO^W	*l]$_W$
S☞ a. óbl	*!				*
b. ób		*!			
c. óblɑ		*!			
W☞ d. óbɑl				*	*
e. óbɑo			*!		

The tableau is shown for $_W$H-eval, although the optimal stem candidate (a) is included for clarity. This candidate is unsuccessful as a Word Output candidate, due to its violation of SSP. Candidates (b) and (c) both fail because of a violation of ANCHOR, though for different reasons; their satisfaction of SSP is of no value to the grammar at that cost. Candidate (d) succeeds, for violating the relatively unimportant O-CONTIG-WO^W in order to satisfy the higher-ranked SSP. Anticipating the Phrase Output, the surface form (e) is included in this tableau. It is not successful as a Word Output candidate, however, because its satisfaction of

$*l]_W$ is not important to $_W$H-eval, which discounts it due to an IDENT-WO^W violation.

Next we examine the optimal phrase output, given the ranking developed in (22).

(24) Phrase Input/Output Mapping

/óbl+Ø/	$*l]_W$	IDENT-PO^P
S☞ a. óbl	*!	
W☞ b. óbɑl	*!	
P☞ c. óbɑo		*

Here we see the preference at the Phrase Output for avoidance of a word-final [l], even at the expense of faithfulness. The outputs of the Stem and Word levels are unsuccessful at the Phrase level, since they violate the crucial markedness constraint. Candidate (c) is successful, breaking faithfulness with the Phrase Input (which in this case is only the Word Output) in order to satisfy markedness.

We have seen that PLOT can handle Serbo-Croatian opacity. It accomplishes this without a serial derivation: all candidates are evaluated by the three flavors of H-eval, in parallel.

5. PLOT and Comparative Markedness

One of the more interesting features of Parallel Lexical Optimality Theory is its descriptive adequacy is complementary to that of Comparative Markedness (henceforth CM; McCarthy 2002b). I argue that, taken together, PLOT and CM form an appropriate powerful theory of markedness/faithfulness interactions in generative phonology. I begin by illustrating the inadequacy of PLOT on its own, and then show how CM supplements the theory. Next I argue that PLOT and CM should be taken together, and demonstrate that they account for complementary sets of phonological phenomena. This is shown to be empirically necessary: both models have already been independently motivated, and data from Meskwaki motivate the synthesis of the two models.

5.1 Lomongo: Opacity for which PLOT cannot account

PLOT cannot handle all forms of opacity, some of which must be analyzed as derived environment effects. This can be illustrated with data from Lomongo (Niger-Congo, Bantoid; data from Kisseberth 1976). There are two processes of interest in Lomongo, hiatus avoidance, and the deletion of [b] intervocalically. Hiatus occurs when a stem with an underlying initial vowel is affixed with a vowel-final prefix. It is resolved in two ways. If the affixal vowel is [o], the vowel is glided and becomes [w]. As shown below, the 2nd sg. affix is a candidate for gliding, while the 3rd sg. can only be deleted.

(25) Lomongo Morphophonemics

Imperative	/o/ *2nd sg.*	/ɑ/ *3rd sg.*	*Gloss*
kɑmbɑ	okɑmbɑ	ɑkɑmbɑ	'work'
ɛnɑ	wɛnɑ	ɛnɑ	'see'
inɑ	winɑ	inɑ	'hate'

The second process of interest is the deletion of [b] intervocalically. It is this process which introduces opacity. Although the [b] is deleted, hiatus is tolerated in these forms.

(26) Lomongo Morphophonemics – further data

Imperative	/o/ *2nd sg.*	/ɑ/ *3rd sg.*	*Gloss*
binɑ	oinɑ	ɑinɑ	'dance'
bɑtɑ	oɑtɑ	ɑɑtɑ	'get'
botɑ	ootɑ	ɑotɑ	'beget'

The affix vowel is neither deleted (*inɑ) nor turned to [w] (*winɑ). I will attempt a PLOT analysis of these facts, and then show why Lomongo must be explained as a derived environment effect.

PLOT claims that the grammar of a language contains a single markedness hierarchy. Interactions between different interfaces of the grammar are attributable to the differential ranking of interface-specific faithfulness constraints relative to a single markedness hierarchy. This limits the predictive power of the theory (see §5.1), but does not on its own achieve descriptive adequacy.

A PLOT analysis of the Lomongo facts might be described as follows. At the Stem Output Interface, hiatus is resolved by gliding or deleting an affix vowel; intervocalic [b] remains unmolested. At the Word Output Interface, intervocalic [b] is deleted, but gliding is tolerated. For purposes of illustration I assume the following markedness constraints:

(27) *VbV
'No intervocalic [b].'
*HIATUS
'No VV sequences.'

Determining the appropriate rankings seems straightforward. At the Stem Level, hiatus is resolved, preferably by gliding, but also with deletion. Also at this interface, VbV sequences are low-ranking. These are interactions of the typical OT sort:

(28) *HIATUS » MAX-V-SO^S » IDENT-SO^S-[syllabicity]

		*HIATUS	MAX-V-SO^S	IDENT-SO^S-[syllabicity]	*VbV
/o-inɑ/	a. oinɑ	*!			
	b. inɑ		*!		
	S☞ c. winɑ			*	
/ɑ-inɑ/	a. ɑinɑ	*!			
	S☞ b. inɑ		*!		
/o-binɑ/	a. oinɑ	*!			
	b. winɑ			*!	
	S☞ c. obinɑ				*

At the Word Output Interface, VbV sequences are eliminated, but hiatus is ignored:

(29) *VbV » MAX-C-WO^{W}, MAX-V-WO^{W}, IDENT-WO^{W} » *HIATUS

	*VbV	MAX-C-WO^{W}	MAX-V-WO^{W}	IDENT-WO^{W}	*HIATUS
/o-inɑ/ a. oinɑ					*!
b. inɑ		*!			
S☞ W☞ c. winɑ					
/ɑ-inɑ/ a. ɑinɑ					*
S☞ W☞ b. inɑ					
/o-binɑ/ W☞ a. oinɑ		*			*
b. winɑ		*		*!	
S☞ c. obinɑ	*!				

Although the tableaux work, a ranking paradox is introduced into the hierarchy. Two rankings seem to be required:

(30) *HIATUS » FAITH-SO^{S} » *VbV
*VbV » FAITH-SO^{S} » *HIATUS

In fact there is no ranking of the PLOT faithfulness constraints with standard markedness constraints that produce the correct output.

Instead, I analyze the Lomongo opaque alternations as an effect of a derived environment. Lomongo hiatus violations are eliminated if they are present in the underlying representations, but tolerated if they are created as a result of a b-deletion. This sort of insight can be captured formally with Comparative Markedness (McCarthy 2002b, wherein full detail to formalism can be found[7]). CM is, as the name suggests, a theory of markedness. Specifically, McCarthy claims that markedness constraints distinguish between old violations (situations where the violation was present in the underlying form) and new violations (where a new marked configuration is created). Every constraint has an "old" version and a "new" version. In Lomongo we see evidence for a old and a new version of *HIATUS, given as $_{O}$*HIATUS and $_{N}$*HIATUS, respectively. The grammar tolerates new violations of *HIATUS, but not those that are new to the output candidates.

[7] As an additional simplification, I will ignore in my tableaux the selection of the fully faithful candidate (FFC). Comparison with a FFC is necessary in CM to ensure that prosodic information is present and reliable. Since I do not address prosodic issues here, I have omitted it for clarity.

This is one of the attested rankings that McCarthy presents. In the case of Lomongo, the following ranking of constraints is sufficient to produce the appropriate forms. The ranking that ensures deletion of [b] is omitted for clarity. Note that PLOT is unnecessary.

(31) $_{O}$*HIATUS » MAX-V » IDENT[syll] » $_{N}$*HIATUS

		$_{O}$*HIATUS	MAX-V	IDENT[syll]	$_{N}$*HIATUS
/o-inɑ/	a. oinɑ	*!			
	b. inɑ		*!		
	☞ c. winɑ			*	
/o-binɑ/	a. winɑ			*!	
	☞ b. oinɑ				*

The distinction between the forms is in the evaluation of the markedness constraints. In the top tableau, the hiatus violation is old, being present in the input, so it violates $_{O}$*HIATUS. Since this constraint is higher-ranking than faithfulness, it compels a change. In the lower tableau, the only hiatus violation is new: it was not present in the underlying form, but is present as a result of the deletion of [b]. Since $_{N}$*HIATUS is low-ranking relative to faithfulness, it cannot command satisfaction. Thus new violation of *HIATUS are tolerated, while violations that are present underlyingly are eliminated.

5.2 CM and PLOT Complementary[8]

Here I show that PLOT and CM address different phonological phenomena. This entails that embracing both models does not create redundancy in the grammar.

There are two ranking of Comparative Markedness constraints that produce a situation distinct from the standard OT markedness/faithfulness scheme. The two situations are:

(32) a. $_{O}$M » F » $_{N}$M
b. $_{N}$M » F » $_{O}$M
(where M is a markedness constraint, and F is a faithfulness constraint)

[8] For further discussion of Comparative Markedness as it relates to opacity, particularly compensator lengthening, see Yun (2004).

The situation in (32a) is the sort encountered in Lomongo. Old violations are eliminated, but new violations are tolerated. PLOT cannot address these phenomena because it has only one markedness hierarchy.[9] CM distinguishes between new and old marked configurations. New marked configurations are only encountered when a high-ranking markedness constraint M_1 modifies the phonological form such that it violates a constraint M_2. If the output is one which creates an M_2 violation in order to satisfy M_1, then we know that M_2 dominates M_1. If at any interface of the grammar M_1 is able to compel a faithfulness violation, arising from the ranking M_1 » F, then by transitivity M_2 » M_1 » F. Therefore M_1 can never be satisfied except that M_2 is also satisfied. Counterfeeding opacity such as is described by the ranking in (32a) does not work if all markedness constraints are satisfied at one interface. What is required is for M_1 to be satisfied without satisfying M_2 (e.g. for instance satisfying *VbV but not *HIATUS) but this is never possible.

The situation in (7b) is one in which old violations are "grandfathered in" (McCarthy's term), while new violations are eliminated. This is not a form of opacity, and so how a PLOT analysis might even approach the problem is not clear to me.

The limitations of CM on its own are discussed by McCarthy in his §5.4. Space limitations prevent a full discussion of how PLOT solves the problems that CM cannot on its own.[10]

5.3 Both PLOT and CM Necessary: Meskwaki

By claiming that derived environment effects and opacity effects should be handled separately in the formal system, I make the implicit claim that derived environment effects and opacity are different phenomena. This is in contrast, for instance, to McCarthy (2002), who notes that CM makes the claim that derived environment effects should not co-occur with counterfeeding opacity (pg. 44; he credits Paul Kiparsky with the observation). For my claim to be born out, however, it is necessary to show an interaction of opacity and derived environment effects: this would prove that they cannot be accounted for with a single model.

[9] A clarification: in maintaining that PLOT has one markedness hierarchy, I am not making a claim as to the nature of the markedness constraints. That is, I am not excluding Comparative Markedness, which in a vague, informal sense can be said to have two markedness hierarchies. I intend that one markedness hierarchy exists for the language, which holds at all levels.

[10] For the interested reader: In Bedouin Arabic the ranking is as McCarthy envisions. [a] raises to [i] in a closed syllable at the Stem Output. At the Word Output Interface the syllable is opened through epenthesis or lengthening, vowel quality from the Stem Output being protected by WO^W faithfulness. The resolution to Sea Dayak is to disallow nasal vowels altogether at the Stem Output: $*V_{nas}$ » IDENT(nas)-SO^S. At the Word Output vowels nasalize in response to a nasal consonant: *NVoral » $*V_{nas}$, IDENT(nas)-WO^W. At the Phrase Output the oral consonant can be deleted optionally, with all faithfulness pertaining to nasals undominated.

Such an interaction is to be found in Meskwaki (also called Fox, Central Algonquin; data from Goddard 1994, compiled in Wier 2004).

The data below in (33) show the palatalization of [t] across morpheme boundaries.[11] (34) shows that this same process is not operant morpheme-internally: /ti/ sequences are preserved. The data then show a typical derived environment effect, as is explainable with CM: old violations are tolerated, but new violations are not.

(33) /t/ palatalizes to [č] before [i] across morpheme boundaries

a.	/ni·mi-t-i/	ni·mi**či**	'he dances'
	cf. /ni·mi-t-a/	ni·mi**ta**	'(he) who dances'
b.	/e·h-in-et-i/	e·hine**či**	'one addressed him thus'
c.	/pye·t-ike·-w-a/	pye·**či**ke·wa	'he is bringing (something)'
d.	/a·t-im-o-w-a/	a·**či**mowa	'he is telling a story'
	cf. /a·t-ot-am-w-a/	a·**to**tamwa	'he tells of it'
e.	/k-i·pit-i/	ki·pi**či**	'your tooth'
	cf. /k-i·pit-ani/	ki·pi**ta**ni	'your teeth'

(34) No t-palatalization word-internally

a.	/e·h-ma·wačim-ti·-wa·-t-i/	e·hma·wačiti·wa·či	'they called each other together'
b.	/pašito·h-etike/	pašito·he**ti**ke	'old men!' (voc. pl.)
c.	/wača·h-etiso-w-a/	wača·he**ti**sowa	'he is cooking for himself'
d.	/ti·kwe·-w-i/	**ti·**kwe·wi	'it patters'
e.	/kišk-itiy-e·-w-a/	kiški**ti**ye·wa	'his tail falls off'
f.	/taneti·-w-aki/	tane**ti·**waki	'they gamble, make bets'
g.	-eti·-		reciprocal suffix
h.	–etiso-		middle voice suffix
i.	–etike-		vocative plural suffix

The data in (35) illustrate counterfeeding opacity. There is a general process of glide deletion in Meskwaki: glides are deleted after consonants. As seen below, deletion of a glide can result in a /ti/ sequence, which, notably in the example below, occurs across a morpheme boundary. Nevertheless the [t] is not palatalized, leading to a coronal-glide sequence in a derived environment.

---

[11] An analysis where [t] is underlying is preferred, since coronal palatalization can be understood as an articulatory effect, but it is not clear why, if [či] were underlying, why it would become [t] everywhere but before [i]. Also, underlying [či] would not prevent the necessity of a DEE analysis.

(35) /t/-palatalization does not occur when /ti/ sequence created by deletion

a.	/nekotw-ičiše/	nekotičiše	'one inch'
	cf. /nekotw-ayaki/	nekotwayaki	'one group'
b.	/na·-nekotw-i/	na·neko**ti**	'one apiece, one by one'
c.	/očity-i/	oči**ti**	'bird's rump or tail'
	cf. /očity-ani/	očity-e·ni	'bird's tails'
d.	/pe·škity-i/1	pe·ški**ti**	'basket'
	cf. /pe·ški**ty-**ani/	pe·ški**ty**e·ni	'baskets'

As Wier (2004) points out (and McCarthy 2002b predicts), there is no ranking in CM that can produce counterfeeding opacity for a process that applies only in derived environments.

If one combines PLOT and CM, however, the proper forms can be generated. The necessary markedness and faithfulness constraints are:

(36) PAL (based on Wier 2004)
'No [ti] sequences.'
*T-GL (based on Wier 2004)
'No coronal-glide sequences.'
IDENT-[ant]-SO^S
'Corresponding segments in the Stem Output and Stem Input have identical values of [anterior].'
MAX-C-SO^S
'Every consonants in the Stem Input has a correspondent in the Stem Output.'
the corresponding WO^W faithfulness constraints

I assume that the palatalization of /t/ in derived environments occurs at the Stem Output. The CM schema for palatalizing in a derived environment effect is:

(37) $_N$PAL » IDENT-[ant]-SO^S » $_O$PAL

Under this ranking new violations of Pal are eliminated, while old violations are tolerated. We also need to prevent the deletion of t-glide sequences, which is accomplished by the following ranking, which is omitted from the tableau in (39) for clarity.

(38) MAX-C-SO^S » *T-GL

(39) Selection of the Stem Output[12]

		$_N$PAL	IDENT-[ant]-SO^S	$_O$PAL
/ni·mi-t-i/	a. ni·miti	*!		
S☞	b. ni·miči		*	
/ti·kwe·-w-i/ S☞	a. ti·kwe·wi			*
	b. či·kwe·wi		*!	

Note the typical derived environment effect. In the top tableau there is a new violation of PAL. Since $_N$PAL dominates faithfulness, the situation is repaired at the expense of an IDENT violation. In the lower tableau, the is no new violation of PAL in either of the outputs, the only violation being morpheme-internal and therefore present in the input.

Two important features of the Word Output are: illicit t-glide sequences are eliminated, and no further palatalization occurs. We then have the following two rankings:

(40) IDENT-[ant]-WO^W » $_N$PAL » $_O$PAL ($_N$PAL » $_O$PAL is from (37))
*T-GL » MAX-C-WO^W

Given this ranking, we produce the appropriate opaque forms, shown below.

(41) IDENT-[ant]-WO^W, *T-GL » MAX-C-WO^W, $_N$PAL » $_O$PAL[13]

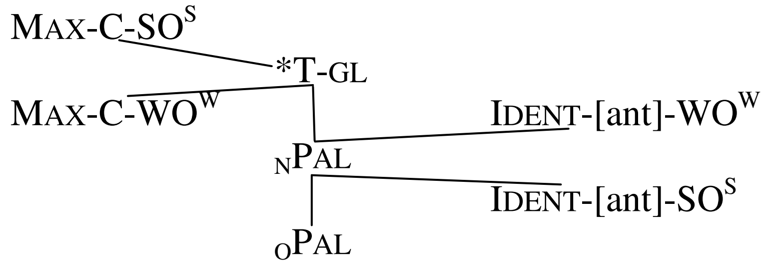
/ očity-i /	IDENT-[ant]-WO^W	*T-GL	MAX-C-WO^W	$_N$PAL	$_O$PAL
S☞ a. očityi		*!			
b. očiči	*!		*		
W☞ c. očiti			*	*	

In this tableau we see that the ranking of *T-GL above MAX guarantees deletion of the glide. The high-ranking faithfulness protecting the feature [anterior], however, dominates the demands of $_N$PAL, which results in (41c) being the optimal Word Output. There is no evidence of activity at the Phrase Level, so the Word Output is in effect the pronounced output.

[12] I have represented the inputs as concatenations of the relevant morphemes, but in §2.2.2.1 I claim that the result of morphology is a set of morphemes, which is consistent with P&S 1993 and M&P 1993, but not with M&P 1995. I believe that this language shows us that the former are more appropriate. If the Stem Input is a concatenation of the morphemes, then both of the [ti] sequences in these tableaux are 'old.' However if they are part of a set and thus unordered, they are 'new' as a result of concatenation in the output candidates, which is needed for CM to work.
[13] *T-GL dominates $_N$PAL because a glide is deleted even though that results in a new PAL violation.

The final ranking of constraints for Meskwaki is given below.

(42)



Since *T-GL is higher-ranking than $_{N}$PAL, we might expect to see the same issue in Lomongo, where *T-GL is satisfied at the Stem Output. This is not the case, however, because although *T-GL does dominate the faithfulness constraint IDENT-[ant]-SO^{S}, there is no violation of IDENT-[ant]-SO^{S} that can satisfy *T-GL.

I have demonstrated with the Meskwaki data that derived environment effects and counterfeeding opacity must be handled in the grammar independently; otherwise there would be no way to integrate the two phenomena, which is necessary in Meskwaki. PLOT and CM provide the necessary synthesis.

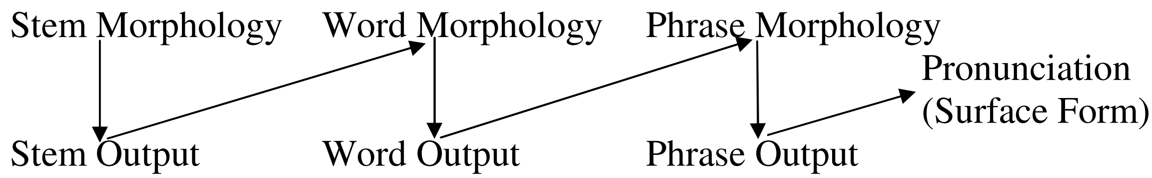
6. Other attempts at explaining opacity

Van Oostendorp & Hermans, on the topic of capturing 'derivational' effects in Optimality Theory, ask, "...how many theoretical add-ons do we allow ourselves in order to preserve our minimalist view of derivations? How natural are these extra devices? And are they not in the end mere notational variants of the original derivational ideas?" (1999: 7). This paper suggests the opposite, that in fact the "original derivational ideas" are misunderstandings of an inherently parallel system, albeit one slightly more complex than Optimality Theory has typically allowed.

6.1 LPM-OT

Among the more controversial proposals for explaining opacity within Optimality Theory is the proposal by Paul Kiparsky (2000, forthcoming) that has been called Stratal Optimality Theory and Lexical Phonology and Morphology in Optimality Theory (LPM-OT). In this approach, phonological mappings involve three mappings (instead of the one mapping provided by classic OT), one from the stem input to the stem level, one from the stem level to the word level, and one from the word level to the phrase level. LPM-OT is Lexical Phonology with optimality-theoretic grammars in place of rounds of derivational rules.

(43) Lexical Phonology and Morphology in Optimality Theory



PLOT draws heavily from Kiparsky's LPM-OT, so it is necessary to ask: why is PLOT better than LPM-OT? I argued in §2.1 that parallelism is superior to serialism on computational grounds, and is more faithful to the original conception of Optimality Theory. I argue here that PLOT is superior to LPM-OT because it makes more limited typological predictions, primarily due to the fact that PLOT has a single markedness hierarchy.

In LPM-OT, three OT grammars evaluate phonological forms in serial. Aside from the possibility of stipulative restrictions, nothing requires the ranking of the constraints in one grammar to look anything like the ranking of the constraints in another. Such freedom predicts numerous grammars, some of which are not attested in human language, and we may suppose will never be attested. I create such a non-grammar here for demonstrative purposes, drawing from metrical phonology to make the point.

Suppose that the Stem Grammar has constraint ranking such that feet are parsed into iambs, and vowels are lengthened when necessary to create uneven iambs. This situation in found for example in Hixkaryana (Hayes 1995), and is analyzed by Kager (1999a) with the following constraint ranking.

(44) UNEVEN-IAMB » DEP-μ-IO, implicit in Kager (1999a) is the ranking:
FT-FORM: IAMBIC » FT-FORM: TROCHAIC

If the Stem Grammar has as an input four light syllables (L = light), then it parses the syllables into iambs, and creates heavy syllables (H = heavy) to satisfy UNEVEN-IAMB:

(45) Stem Level: Rhythmic Lengthening

/L L L L/	UNEVEN-IAMB	DEP-μ-IO
a. (L Ĺ) (L Ĺ)	*!*	
☞ b. (L H́) (L H́)		**

Let us then suppose that at the Word Level, the constraints drive the opposite effect: syllables are parsed into trochees, but length is preserved.

(46) FT-FORM: TROCHAIC » FT-FORM: IAMBIC
MAX-μ-IO » EVEN-TROCHEE

There is nothing in LPM-OT that would prevent this occurrence, since the three grammars have autonomous markedness hierarchies. When we provide the output of the tableau in (45) to this Word Level grammar, the following results:

(47) Word Level: trochaic parsing

/(L H́) (L H́)/	MAX –μ-IO	EVEN-TROCHEE
a. (Ĺ L) (Ĺ L)	*!*	
☞ b. (Ĺ H) (Ĺ H)		**

The overall mapping of this grammar, then, is /L L L L/ → [(Ĺ H) (Ĺ H)]. That is, the grammar aggressively lengthens short syllables to create a (L H) trochee. This grammar is unattested to my knowledge.

PLOT avoids such non-grammars by hypothesizing a single markedness hierarchy for the entire grammar, and attributing opacity to the relative ranking of faithfulness at multiple interfaces to that markedness hierarchy. This predicts, for instance, that footing and syllabification follow the same set of markedness constraints at every interface of the grammar. To my knowledge this generalization is correct; two languages that illustrate this are Serbo-Croatian (§3.2) and Palestinian Arabic.

6.2 Sympathy Theory

Sympathy Theory (McCarthy 1999) is another attempt to deal with opacity in a parallel system. Aspects of PLOT resemble sympathy, namely with regard to intercandidate correspondence[14]. I argue first that the models are distinct. Next the claims of Ito & Mester (2002, 2003) are reviewed in relation to English data, and a PLOT solution is offered to the problem that they present for sympathy.

[14] In fact intercandidate correspondence is only apparent in PLOT, since the true correspondence relation is between the morphological inputs and phonological outputs. Nevertheless frequently there is no morphological change, and so the correspondence relation is equivalent to intercandidate correspondence.

6.2.1 Overview of Sympathy

Sympathy Theory is a model of intercandidate correspondence whereby the output is demanded to be identical not only to the input, but to a *sympathy candidate*. The sympathy candidate is the most harmonic candidate that satisfies a faithfulness constraint, the so-called *selector constraint*. Faithfulness between the output and the sympathy constraint is determined independently.

As an example, let us consider English flapping opacity, illustrated in (48). English vowels lengthen before voiced obstruents, hence the underlying vowel in /ɹʌʲd/ 'ride' lengthens to surface [ɹʌʲd] under the influence of the [d]. Coronal obstruents become flaps when in a non-initial unstressed syllable. Thus underlying /ɹʌʲtɹ̩/ 'writer' surfaces as [ɹʌʲɾɹ̩]. Opacity arises in the case of [ɹʌʲɾɹ̩] 'rider.' The vowel is lengthened on the surface even though there is no coronal obstruent on the surface.

(48) ride [ɹʌʲd] ~ rider [ɹʌʲɾɹ̩]
write [ɹʌʲt] ~ writer [ɹʌʲɾɹ̩]

A sympathy theory account of these facts is as follows, given the following constraints and rankings.

(49) *VcV
'No intervocalic coronal obstruents.'
*V́d
'No short vowels before voiced obstruents.'
DEP -µ
'Don't insert moras.'
IDENT-[sonorant]
'Corresponding segments have the same value of [sonorant].'
Ranking: *VcV » IDENT-[son]; *V́d » MAX-µ

The optimal candidate under this ranking is the one which preserves its vowel length, since it avoids a DEP violation. This fails to create the appropriate output form when a coronal is flapped, however, yielding a short value:

(50) *VcV » Ident-[son]; *V́d » Dep-μ

/ ɹʌʲd-ɹ̩/	*VcV	*V́d	Ident-[son]	Dep-μ
a. ɹʌʲdɹ̩	*	*		
❀ b. ɹʌʲɾɹ̩			*	
c. ɹɑʲdɹ̩	*			*
d. ɹɑʲɾɹ̩			*	*

The sympathy solution is to suggest that the vowel is long in the surface form because of a correspondence relation between it and a candidate that does not violate Ident-[son]. The selector constraint then is Ident and the appropriate ❀O dimension of faithfulness is Max-μ.

(51) Max-μ-❀O, *VcV » Ident-[son]; *V́d » Dep-μ

/ ɹʌʲd-ɹ̩/	Max-μ-❀O	*VcV	*V́d	Ident-[son]	Dep-μ
a. ɹʌʲdɹ̩	*!	*	*		
b. ɹʌʲɾɹ̩	*!			*	
c. ɹɑʲdɹ̩		*!			*
☞ d. ɹɑʲɾɹ̩				*	*

The sympathy candidate is the most harmonic of the candidates that satisfy Ident-[son], in this case the better of (51a) and (51c), which is (51c). The sympathy candidate is held in correspondence to the optimal candidate through Max-μ-❀O. With ❀O correspondence taken into account, (51d) is the optimal candidate, which is also the correct output.

6.2.2 Comparison of Sympathy and PLOT

Two points should be made about the relationship between sympathy and PLOT. To begin with, it is notable that, while PLOT allows for multiple rounds of affixation, sympathy does not. This would eliminate the possibility of analyzing languages such as Kinande, which are easily analyzed when multiple rounds of affixation are allowed. It also does not allow for an easy recognition of which processes operate within words and which operate across word boundaries. Additionally, Sympathy Theory allows in practice for any number of sympathy candidates, with their selector constraints and ❀O faithfulness. This could lead sympathy to predict more numerous layers of opacity than are attested in the languages of the world. PLOT allows only two abstract representations of a word and one pronounced, which allows for so-called "doubly opaque" (McCarthy 1998's term) phenomena, but not more than that.

An interesting difference between PLOT and sympathy is the distribution of markedness and faithfulness constraints in a language's full ranking. In classic OT, all or most faithfulness constraints are undominated;[15] it is only the occasional markedness constraint that dominates a certain specific markedness constraint to compel a change to the representation. Likewise in PLOT, the three dimensions of faithfulness enjoy high status, only occasionally being ranked below markedness. In sympathy, however, almost all of the ❀O faithfulness constraints are low ranking. It is the opposite situation: occasionally a ❀O faithfulness constraint is promoted to where it dominates other markedness and faithfulness constraints. This asymmetry is odd and perhaps aesthetically displeasing, but probably not formally significant unless one were to develop a learning algorithm based, for instance, on constraint demotion (e.g. Tesar & Smolensky 2000).

6.2.3 Weakness of Sympathy

I now present the critique of sympathy theory put forth by Ito & Mester (2002, 2003; McCarthy 2002b cites their work and suggests the English data as another potential example of the class of problems they discovered), in the context of the English data I presented in (48) and analyzed in (51). Ito & Mester note that a liability of sympathy theory is that the sympathy candidate is always one which is more faithful to the input, therefore the optimal candidate is, by transitivity, more faithful to the input. Reliance on input faithfulness is a tricky thing, because Richness of the Base (P&S 1993) dictates that there are no limits on what the input is. Most importantly for Ito & Mester's demonstration, in a situations where segments are allophones, any allophone of the phoneme is a permissible input representation. In English [d] and [ɾ] are phonemes. Consider the result of changing the underlying form of 'ride' to /ɹɑʲɾ/:

15 As an informal proof of this, consider English flapping. *VcV is dominated by every faithfulness constraint in the hierarchy except IDENT-[son].

(52) MAX-μ-❀O, *VcV » IDENT-[son]; *V́d » DEP-μ

/ ɹʌʲd-ɹ̩/	MAX-μ-❀O	*VcV	*V́d	IDENT-[son]	DEP-μ
a. ɹʌʲdɹ̩		*!	*	*	
☞ b. ɹʌʲɾɹ̩					
c. ɹɑʲdɹ̩	*!	*		*	*
☞ d. ɹɑʲɾɹ̩	*!				*

Underlying /ɾ/ should map to [d] when context requires, not to [t], i.e. /ɹʌʲɾ/ to [ɹɑʲd], not [ɹʌʲt]. The change from /d/ to [t] requires a change in [voice] as well as [sonorant], while the change from /d/ to [d] requires a change only of [sonorant]. Thus while /ɹʌʲɾ-ɹ̩/ maps to an allowable output, it does not map to the output appropriate to what the stem is. Ito & Mester analyze data from German (2002) and Japanese (2003) that illustrate this point further.

6.2.3 Sufficiency of PLOT

It is not productive to point out this weakness of sympathy theory if PLOT cannot offer a more robust analysis. I present that now.

The fact that coronal flapping occurs at all indicates a particular ranking of markedness constraints. The ban on intervocalic coronal obstruents must dominate the markedness constraint banning flaps. Otherwise flaps would never surface.

(53) *VcV » *FLAP

This ranking entails that *FLAP never eliminates an intervocalic flap. Therefore if our grammar is to map /ɹʌʲɾ/ to [ɹɑʲd], it must occur where the flap is not intervocalic, in this case when the flap is word-final. I therefore assign the agentive suffix /-ɹ̩/ to the Word Morphology, and determine the following ranking of markedness relative to SO^S faithfulness. The vowel also lengthens at the Stem Output. It must, since at the Word Output there is only a flap, which cannot compel lengthening.

(54) *VcV » *FLAP » IDENT-[son]-SO^{S}; *V́d » DEP-μ-SO^{S}

		*VcV	*V́d	*FLAP	IDENT-[son]-SO^{S}	DEP-μ-SO^{S}
/ɹʌʲd/	a. ɹʌʲd		*!			
S☞	b. ɹɑʲd					*
/ɹʌʲɾ/	a. ɹɑʲɾ			*!		*
S☞	b. ɹɑʲd				*	*

The top tableau shows the lengthening of the vowel in response to the presence of the voiced obstruent. The lower tableau shows the neutralization of /ɾ/ and /d/ word-finally.

The ranking of WO^{W} faithfulness constraints is similar, except that the ranking between *FLAP and IDENT becomes indeterminate, since flapping becomes entirely contextually-governed. The important features of the Word Output for this derivation include the presence of the agentive suffix, and the fact that there is no markedness constraint in a position to compel the shortening of the vowels lengthened at the Stem Output. Not illustrated in the tableau below is value of W, the result of the Word Morphology: /ɹɑʲdɻ̩/.

(55) MAX-μ-WO^{W}, Max-C-WO^{W}, *VcV » *FLAP, IDENT-[son]-WO^{W}

		MAX-μ-WO^{W}	MAX-C-WO^{W}	*VcV	*FLAP	IDENT-[son]-WO^{W}
/ɹʌʲd/	a. ɹʌʲd	*!	*			
S☞	b. ɹɑʲd		*!			
	c. ɹʌʲɾɻ̩	*!			*	*
W☞	d. ɹɑʲɾɻ̩				*	*
	d. ɹɑʲdɻ̩			*!		

The optimal candidate is the one which preserves faithfulness to vowel length, while also flapping the [d]. The constraint Max-C-WO^{W} shows that the optimal Stem Output is not the optimal Word Output, since it does not have the /ɹ/ affix from the Word Morphology. As far as WO^{W} faithfulness is concerned, this is a deletion.

Flapping occurs across word boundaries, as in Ladefoged (2001)'s sentence [dɛdhɛɾɪɾɛɾɛɾɪɾɪt] 'Dead-headed Ed edited it.' Therefore I subjugate IDENT-[son]-

PO^P, to the relevant flapping markedness constraints. This ensures flapping across word boundaries, although I do not illustrate this.

(56) *VcV » *FLAP, IDENT-[son]-PO^P

In conclusion, I have shown that PLOT can solve problems that sympathy cannot. I illustrated Ito & Mester (2002, 2003)'s criticism of sympathy with English data, and then showed that PLOT is sufficient to produce English opacity while still honoring Richness of the Base. I also compared PLOT with sympathy on theoretical ground, pointing out that sympathy does not allow for multiple rounds of affixation, but does allow apparently unlimited opacity. Sympathy was also shown to give rise to peculiar constraint hierarchies where ❀O faithfulness is most often among the lowest ranking constraints, in contrast to classic OT and PLOT.

7. Conclusion

I have presented a model that achieves a unified account of diverse opacity phenomena in a parallel system. Parallel Lexical Optimality Theory incorporates the insights of Kiparsky's LPM-OT without sacrificing parallelism, and while maintaining a conservative factorial typology.

PLOT demonstrates that a parallel system can achieve descriptive adequacy with respect to opacity. It accomplishes this by accepting a richer interface between phonology and morphology, and between the input and output. Opacity has been shown to result from the applications of constraints to the outputs of grammars. Further we have seen that different interfaces in the grammar are not independent of one another, but are related by correspondence constraints.

Most significantly, PLOT utilizes only one markedness hierarchy. This introduces important predictions about what a possible human language is. A human language can have only one markedness hierarchy, which has important consequences for our conception of the structure of a possible universal grammar.

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