Two Lectures on Optimality Theory

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The organizers of the 1998 Phonology Forum asked me to deliver two talks on Optimality Theory, addressing foundational issues in the first and current directions in the second. These are the handouts from those talks, mildly edited to remove errors and sharpen certain points.

In the first talk, I try to identify the basic issues addressed by Optimality Theory and show how the theory deals with them. These questions arise in pursuit of the basic explanatory goals of generative grammar, and they have played a continuous role, if not always an obvious one, in the development of the theory since the early 1970's. In part these arose through diagnosis of shortcomings in architecture of early generative grammar ("rule-package serialism"), and in part through exploration of conceptual and empirical problems that arose in efforts to renovate that architecture. Four main questions are distinguished: what is the span of influence within the grammar of a single constraint? how can constraints vary in their effects from language to language? how can a constraint trigger and/or block grammatical mappings? what is the source of extremal behavior — minimization and maximization effects — in grammar? The optimality theoretic assumptions of constraint universality, interaction through strict domination, output-orientation, and absence of constraints on the lexicon are shown to provide a perspective on all these problems.

The second talk does not aim to deliver a comprehensive review of the profuseness of current work, but instead points in a direction that I find particularly interesting: analysis of the basic properties of the theory, in an effort to work out its fundamental predictions. Because there is a considerable distance between the assumptions of the theory and its use in description, the utility of this tactic is fairly clear. Since any version of generative phonology is a theory of possible mappings (at least between underlying and surface forms, with further articulations possible), it is of fundamental importance to find out what mappings the theory deems possible and what *sets* of mappings it allows to co-exist within a single grammar. It is also important to see how the properties of inventories follow from assumptions about the nature of the mappings. In OT, these matters will be determined by the character of the constraints. Of particular interest is the nature of the faithfulness constraints, since these are proper to OT. In the course of the discussion, an argument is developed showing that, if implicational relations among elements and contrasts are to be preserved in the grammar, faithfulness constraints must have a certain property of symmetry with respect to the class of elements whose alteration they control. This conclusion emerges from study of the mapping structure of certain simple typologies.

Acknowledgment. I would like to thank the organizers of the Phonology Forum for inviting me to present this work and for encouraging me to provide the handouts for the proceedings volume; I hope that the argument emerges clearly from the somewhat skeletal text. Special thanks are due to Professor Haruo Kubozono for his skill and patience in dealing with the organizational details of my visit and for his helpful comments on the lectures as presented.

Foundations of Optimality Theory

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(1) Within the basic shared assumptions of generative grammar:

- What issues does OT aim to resolve?
- How does it address them?
- What further questions are raised by OT's answers and strategies?
  How can these be investigated and resolved?

▸*My aim is not so much to review the mechanisms of OT (though that will happen) as to look into their basic properties and investigate how they provide a theory of linguistic form.*

(2) Assume with Chomsky & Halle, that a *phonological grammar* maps from a lexical input representation to a surface representation, thereby representing the speaker's knowledge of both distributional structure and word-relatedness. We seek to determine the fundamental architectural properties of grammars. We wish to determine:

(a) **Span**. The span of a linguistic constraint: how much grammar does a given constraint influence? A 'rule', a bunch of 'rules', a component, a combination of components....?
(b) **Variety**. How can it be that constraints vary in their effects from language to language?
(c) **Blocking/Triggering**. How do constraints trigger a mapping? block a mapping?
(d) **Extremism**. The source of **min**imization/**max**imization effects (e.g. in epenthesis, deletion, representational change under derivation) in response to linguistic constraints.

(3) These concerns developed with and after *SPE*, and in one way or another occupied many researchers through the 70's and 80's. A few of the contributors whose work will be built upon here are, nonexclusively, Chomsky & Halle, Kisseberth, Stampe, Ross, Kiparsky, Liberman, Goldsmith, Haraguchi, Clements, Hayes, Jackendoff, McCarthy, Selkirk, Steriade, Itô, Archangeli & Pulleyblank, Mester, Myers, Paradis. Parallel developments in syntactic theory should be noted.

(4) **Rule-Package Serialism** and its demise. Under the doctrine of *Rule-Package Serialism*(RPS)

(a) A *rule* packages together a constraint *XAY and an action A → B, as A → B / X — Y.
(b) A grammar consists of a *sequence* of such rules applying serially in fixed order.

(5) **Q**: What is the grammatical *span* of a linguistic constraint? RPS says: *one rule-package* (which may fuse order-adjacent, similar rules). But this is wrong.(*Kisseberth 1970 et seq.*)

(6) **Span [1] — Rules**. Yawelmani Yokuts.

V→ Ø /VC—CV
Ø→ V/ C—CC

(7) *Let us interrogate* the complexity of these formulations:

Why not simply V→ Ø /VC— ? because then *v*C**V**CC*v* → v**CCC**v

Why not simply Ø→ V/ C—C ? because then *cv***CC***vc* → *cv*C**V**C*vc*

Answer: both are sensitive to *CCC = *CC at syllable margins = *COMPLEX.

• V→ Ø is *blocked* and Ø→ V is *triggered* by this constraint.

Kisseberth 1970 notes an odd further interaction between serial ordering and generalization through notational collapse: only adjacent rules may be generalized in this way. Yet the generalizations have to do with the type of rule, and the output, not the position in the ordering.

▮ The Span of *COMPLEX includes several distinct, non-fusable processes.

Note the parallel in syntax: a transformation like *Passive* repeats many things about the basic phrase structure of the language and falls under constraints that apply broadly to other 'rules'.

(8) ★ **Liberation Thesis.** Constraints must be liberated from the parochial rule-package.

(9) An advance in this direction. The prosodic theory of epenthesis and deletion. *Itô 1989*, with *Steriade 1982, Selkirk 1981, McCarthy 1979*, in the background. Principles of syllabification are armed with resources so that syllabification itself can, in essence, impose modifications on the input to meet its own requirements. No longer just bottom-up parse, then fix-up by later rules.

(10) Compare ***Prosodic Morphology*** (*McCarthy 1981, McCarthy & Prince 1986 et seq.*) Syllabic and prosodic constraints determine the extent of copying, truncation, expansion, as well as canonical forms of lexical items.

(11) ★ **Output-orientation Thesis**. These suggest a fundmental revision in perspective: what's crucial to determining a process is often not an *input configuration* but rather an *output* configuration that must be achieved (e.g. syllables shaped .CVC.). In Prosodic Morphology, it's not a matter of copying a unit like a syllable from the base, but achieving an output **target** like 'heavy syllable', as in e.g.

Ilokano: **tra**.ba.ho→ **trab**.–tra.ba.ho. nars → **naː** – nars, etc.

(12) **Span [2]**: **Lexicon + Rules**. Restrictions on Lexicon mirrored in restrictions on rules. (*Kisseberth et al.*). 'Duplication' / 'structure preservation'

• Yawelmani rounding harmony. i→u *NOT the simpler* i→ü . But the Y *lexicon* has only /i u/.

▮ The span of **ü* includes both lexicon and rule-system.

• Latin Bimoraic Trochee (*Mester 1994*) governs minimal shape of lexical items, various types of morphological combination, as well as processes of vowel-length phonology.

(13) ★ **Inventory Thesis**. There are no lexicon-specific constraints.

•The constraints of phonology *induce* structure on Lexicon.

(14) **Mapping** and 'Stampean occultation'. *Neutralizing phonology* + minimal assumptions about lexical learning will result in structure in lexicon, without separate assumptions about purely lexical restrictions (*Stampe 1973*, *Dell 1973*).

• Say a language has ü→u *everywhere*. Then, lacking special evidence of abstract patterning, the learner will not set up /ü/ where /u/ would suffice.

(15) This language's lexicon lacks /ü/ not because of a 'Morpheme Structure Condition', but because
(a) the *output* lacks ü
(b) the *grammar* enforces the lack by actively eliminating *ü* through a phonological mapping.

(16) **Interlinguistic Variation. *Parameters?*** Interlinguistic differences *in* the constraints.
• On this view, languages may *have* or *lack* various constraints & parts of constraints.
• Itô distinguishes 'strong' and 'weak' versions on Onset Principle:
[strong: absolute] onsets absolutely required
[weak: relative] onsets required if segmental material permits.

(17) ★ **Interaction Thesis.** Variation lies not in the constraints themselves ('parametrization'), but in their possibilities of **interaction**.

(18) **Universality**. If the *Interaction Thesis* is implemented vigorously, then a very strong stand can be taken with respect to the universality of linguistic constraints. They can be assumed to be *literally universal*, in the sense that they are *present in every grammar*.

Compare the universality of 'processes' in Stampe-Donegan theory. On their view a process can be suppressed by rule-ordering — yet still be present in the grammar, and still shows its effects when a suitable test is devised. They also recognize other means of suppressing 'processes' besides the ordering interaction.

(19) **Farewell to *Perfection***. Optimality Theory (*Prince & Smolensky 1993*) brings these threads together through the addition of one further crucial ingredient: **comparative evaluation**.
A given Input-Output pair (α,β) is well-formed **not** because it *satisfies* every grammatical constraint, **but** because *no other pair* (α, γ), (α, δ),.... does *better* on the constraints.
• A map $\alpha \rightarrow \beta$ is typically imperfect: it doesn't satisfy all relevant constraints.
☞ But it is *optimal* — it does the best of all potential mappings $\alpha \rightarrow \omega_k$.

(20) **Basic theses of Optimality Theory**.
a. Grammar is defined by the interaction of constraints.
b. Constraints come in two basic kinds:
▸ 'Markedness' constraints evaluate *output* representations.
▸ 'Faithfulness' constraints demand that *input* and *output* must be the same in a certain way.
c. Constraints may *conflict* with each other over the relative value of representations.
d. Even so, all constraints are in every grammar.
e. Constraints are violable: conflicts are decided by prioritization (ranking).
f. Differences between grammars are precisely differences in their prioritization schemes.
g. Each input gives rise a set of potential outputs, a *candidate set*.
(i) This candidate set is the *same* for all grammars.
(ii) The candidate that *best satisifies* the ranked constraint set is output for the given input.

(21) **Architecture of OT**. Universal Grammar provides:
CON: the set of univeral constraints present in every grammar
Gen: the function determining the *candidate set* for each input.
Eval: the mechanism by which the candidate set is evaluated, for a given ranking R of CON.

(22) **Eval(R, Gen(*in*)) = *out***, for every ranking R of CON and every possible input *in*.

∎ A particular grammar is a total ranking R of CON.

∎∎ OT, like other versions of generative grammar, is a theory of *mappings*.

(23) **Eval**. A constraint C $\in$ CON evaluates each candidate $cand_k \in$ Gen(α), determining how much (how many times) $cand_k$ violates C.

• Each C imposes an order on the candidate set. (The order is what's crucial: other ways of imposing an order besides violation-summing are conceivable, too.)

(24) The trick is to go from these individual C-orders to CON-wide evaluation of R(α).

(a) Many, many schemes exist in the larger world, where *optimization* runs everything from economics to robots to speech perception systems.

(b) But we need something highly restrictive, so that every predicted grammar is *linguistically possible*.

(c) Some schemes are too simple. Majority rule, e.g., yields only one possible grammar!

(d) Most numerical schemes are too flexible, allow non-linguistic pathologies like counting.

(e) But unless some explicit scheme is adopted, we are left in the foggy terrain where "some principle of economy" battles obscurely with "some other principle of economy".

(25) **The four relations**. Consider two constraints C_1 and C_2 comparing two candidate mappings $\alpha \rightarrow \beta$ and $\alpha \rightarrow \gamma$. Four *relations* exist:

(a) **Neutrality**. C_1 and C_2 agree: each candidate fares as well or as poorly as the other.

(b) **Concordant Preference**. C_1 and C_2 agree: one of the mappings is better than the other: say, $\alpha \rightarrow \beta \succ \alpha \rightarrow \gamma$ by both C_1 and C_2.

(c) **One-sided Preference**. One, say C_1 , finds both candidates *the same*, but C_2 prefers one to the other.

(d) **Conflict**. One, say C_1, prefers $\alpha \rightarrow \beta$, but C_2 prefers $\alpha \rightarrow \gamma$.

(26) These relations can be shown in *constraint tableaux*.

a. Neutrality

/ampalk/	NoCoda	Dep
.am.pa.l**i**k.	**	*
.am.pal.k**i**.	**	*

b. Concordant preference

/akt/	Onset	Dep
.a.k**it**.	*	*
.a.**i**.k**i**t.	**	* *

c. One-sided Preference

/k/	NoCoda	Dep
.k***i***.		*
.ik.	*	*

d. Conflict

/akt/	NoCoda	Dep
.a.k***it***.	*	*
.a.k***i***.t***i***.		* *

(27) For two-way comparisons such as these, the relations are easier to see in **comparative tableaux** than in the familiar data tableaux just given (cf. *Prince 1998* for further discussion.)

■NB. The **winner** of the comparison is shown in the cell, when there is a winner.

a. Neutrality

/ampalk/	NoCoda	Dep
.am.pa.l***i***k ~ *am.pal.ki*		

b. Concordant preference

/akt/	Onset	Dep
.a.k**it**. ~ *.a.**i.**k**it**.*	.a.k**it**.	.a.k**i**t.

c. One-sided Preference

/k/	NoCoda	Dep
.k***i***. ~ ***.i****k.*	.ki.	

d. Conflict

/akt/	NoCoda	Dep
.a.k**i.**ti ~ *.a.k**it**.*	.a.k**i.**ti.	*.a.k**it**.*

(28) Of these relations, only *Conflict* (d) is challenging. Others have a clear winner, or no winner.

(24) **Strict Domination**. Let two constraints be ranked, $C_1 >> C_2$. In case of conflict the winner on C_1 is the winner on the (sub-)hierarchy. C_1 *strictly dominates* C_2.

(29) In the Conflict case (d), if NoCoda>>Dep, *a.k.i.ti* wins. The other way round, *a.kit*. wins.

() (**a**≻**b**; **R**). Let R be a total ranking of CON. A candidate ***a*** is better than candidate ***b*** on R if ***a*** is better than **b** on *the highest-ranked constraint that distinguishes them*.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
a ~ b		**a**	**b**		**b**	**a**	**b**

- Candidate **a** wins even though the majority favors b.
- And it doesn't matter how much C_3 , C_5, and C_7 hate **a** or prefer **b**. Cand. **a** could violate C_3 50 times, while **b** satisfies it completely. Candidate **a** still wins on dominant C_2 .
  This is the *strictness* of strict domination.

(31) **Optimality.** A mapping α→β is **optimal** for some ranking R of CON, if it *never loses* a pairwise competition against *any* other candidate. That is (α→β≥α→x; R) for every x.

- If α→β is optimal, then β is the output for α, given the grammar R.

(32) **Ranking Argument**. (*Domination-Cancellation Lemma*: *Prince & Smolensky 1993*) Suppose we know that **a**:α→β is empirically correct. How do we find a ranking that will produce this? From tableaux (30) we can see directly that to triumph over some competing **b,** the mapping **a** must appear in the first nonempty cell going left-to-right. Ergo, taking (30) to be as-yet unranked, we have that C_2 >> {C3, C5, C7} ***OR*** C6 >>{C3, C5, C7}.

▮ *Some* constraint favoring **a** must dominate *every* constraint favoring **b**

■ **NB**: to argue correctly, we must consider the entire set of constraints!

(33) **How does OT as constructed here meet the issues raised above?**

- Span, Variety, Extremism, Blocking/Triggering?
- The Liberation Thesis, Output Orientation Thesis, Inventory Thesis, Interaction Thesis?

(34) **Span**. The **Liberation Thesis** (8) has been satisfied. Constraints are no longer trapped in the rule-package. A constraint can interact with many other constraints in the grammar. It can force the violation of any constraint it dominates; and be forced into violation by constraints dominating it.

(35) **Variety**. Variety is obtained through variation in ranking, not through altering the constraints themselves.

- Consider Itô's absolute/relative versions of ONSET. We accept only her absolute formulation:
  ONSET: Syllables must have onsets: $*[_\sigma V$
- ONSET may conflict with faithfulness constraints:
  MAX: x↛Ø. 'No deletion of input material' (input must be MAXimally realized.)
  DEP: Ø↛x. 'No insertion of material into output' (output must DEPend on input)

(36) Suppose ONSET, MAX >> DEP . Then ONSET must be satisfied at the expense of DEP.
This is the **absolute** interpretation.

/ipa/	ONSET	MAX	DEP
(a) **.ʔ**i.pa. ~ *.i.pa.*	**ʔi.pa.**		**.***i.pa.*
(b) **.ʔ**i.pa. ~ *.pa.*		**ʔi.pa.**	*.pa.*

(37) Similarly, if ONSET, DEP >> MAX , the optimal form is ONSET-respecting *.pa.* **Absolute** again.

/ipa/	ONSET	DEP	MAX
(a) .pa. ~ *.i.pa.*	**.pa.**		*i.pa.*
(b) .pa. ~ .**ʔ***i.pa.*		**.pa.**	*ʔi.pa.*

(38) But if MAX, DEP >> ONSET, full faithfulness is required:

/ipa/	MAX	DEP	ONSET
(a) .i.pa. ~ *.pa.*	**.i.pa.**		*.pa.*
(b) .i.pa. ~ .**ʔ***i.pa.*		**.i.pa.**	**ʔ***i.pa.*

(39) This last provides the 'relative' interpretation. ONSET may be violable, but it cannot be ignored, even when subordinated. Note *.i.pa.* not **.ip.a* even here, and in innumerable further examples:

(40) ONSET emerges as critical when higher-ranked constraints do not decide:

/pato/	MAX	DEP	ONSET
.pa.to ~ **_.pat._**_o_			.pa.to.

(41) The Onset universal. In *every* grammar, whatever the ranking, syllabification as onset (rather than coda) is entailed by syllable theory *whenever the segmental material is available in the input.*

(Other steps — epenthesis, deletion — may or may not be taken, depending on the constraint ranking, and other subtheories, like that of stress, may potentially impose further condtions.)

• In this way, we relate universal constraints on structure to how individual items are parsed.

(42) **Variety and Universality**. The sources of universality are

(a) **Gen**, which defines the absolute rules of combination of linguistic primitives

(b) **Interaction**: **Any ranking R of CON is a grammar**. The full set of possible rankings of some subset of CON is the *factorial typology* of that set. This in itself will exclude many possible outcomes. (As just seen, CVC.V. is excluded in basic syll. theory — no interaction gives it.)

• No language can *prohibit* onsets or *require* codas, no matter what the ranking.

▮ A point of strategy. A better theory will depend more on *interaction* to obtain typological results than on increasing the stipulations in Gen or in the definition of the constraints.

(43) **Extremism**. Many linguistic phenomena run to extremes, or include an extremal component.

(a) Stress may fall at the *edge* of a word.

Or it may fall *as near to the edge as it can*, given other conditions:

Heavy syllables should be stressed.

Stress may not fall on final syllable

(b) Epenthesis when allowed is *minimal* (*Selkirk 1981*) and used only to resolve banned configurations.

(c) An affix lies at an edge,

Or it may fall *as near to the edge as it can*, respecting other conditions such as:

Syllables have codas (NOCODA)

Syllables have onsets (ONSET)

(44) Such generalizations follow in OT because violations even when forced must still be avoided to the greatest degree possible.

(45) Consider epenthesis under the compulsion of ONSET: $*[_\sigma V$.

Epenthesis is banned by DEP: Ø $\not\rightarrow$x , which declares each epenthetic element to be a violation.

• For illustration, let us examine Arabic /al-qalamu/ → ʔal.qa.la.mu. ‘the pen’

(46) Data Tableau

/al-qalamu/	ONSET	DEP
al.qa.la.mu.	* !	
☞ ʔal.qa.la.mu.		*
ʔal.qaʔ.la.mu.		**!
ʔal.qaʔ.laʔ.mu.		**! *
ʔal.qaʔ.laʔ.muʔ.		**! **

(47) Comparative Tableau

al-qalamu → *ʔal.qa.la.mu.*	ONSET	DEP
ʔal.qa.la.mu. ~ *al.qa.la.mu.*	ʔal.qa.la.mu.	*al.qa.la.mu.*
ʔal.qa.la.mu. ~ *ʔal.qaʔ.la.mu.*		ʔal.qa.la.mu.
ʔal.qa.la.mu. ~ *ʔal.qaʔ.laʔ.mu.*		ʔal.qa.la.mu.
ʔal.qa.la.mu. ~ *ʔal.qaʔ.laʔ.muʔ.*		ʔal.qa.la.mu.

Note: we simplify by not showing MAX, which must be in a dominant position to rule out deletion.

(48) This exemplifies a very general scheme in which, by C_1>>C_2 , C_1 forces violation of C_2 , but Eval still favors minimal violation. Thus, the very architecture of the theory predicts that violation of C_2 is "possible only when necessary", a fundamental and widely encountered pattern of interaction.

• And distinct from "parametrization" which by itself predicts only presence *vs.* absence of constraint.

(49) **Blocking/ Triggering**. Here ONSET *triggers* epenthesis, which DEP exists to *block*. In essence, ONSET blocks the blocking due to DEP — which continues to block as much as it can. Further depth in the hierarchy can create more blocking — by blocking the blocking of blocking.

• ALIGN (Stem, PrWd, L) >> ONSET prevents *initial* epenthesis, but in the same grammar ONSET>>DEP yields epenthesis *elsewhere*. (*McCarthy & Prince 1993*)

/oa/	ALIGN (Stem, PrWd, L)	ONSET	DEP
.o.Ta. ~ *.o.a.*		**.o.Ta.**	*.o.a.*
.o.Ta. ~ .T*o*.T*a*	**.o.Ta.**	*.To.Ta*	.o.Ta.

(50) Because the *Liberation Thesis* guides the architecture, the same constraint can be implicated in blocking one map and triggering another.

(51) **Schematic illustration of dual blocking/triggering role**.

Suppose the Yawelmani-type deletion/epenthesis patterns represented in (6) above are due in part to the following markedness & faithfulness constraints from CON, given in crude form here. (For more serious & detailed consideration of the actual Yawelmani situation, see *Zoll 1996*.)

*V	"No vowels"	[The more conservative *V.σ "no internal open syllables" works here, too!]
*COMPLEX	"No CC clusters at syllable margins"	
MAX-V (V↛Ø)	"Don't delete a vowel"	

(52) Consider the following ranking:

*COMPLEX I
|
*V II
|
V↛Ø III

(53) **Triggering of Epenthesis.** The subhierarchy I-II, *COMPLEX >> *V yields epenthesis into CCC clusters. *COMPLEX can be said to "**trigger**" epenthesis.

logw+hin → lo.g**i**w.hin	***COMPLEX**	***V**	V↛Ø
lo.g**i**w.hin ~ *logw.hin*	lo.g**i**w.hin	*logw**.**hin*	
lo.g**i**w.hin ~ *log.whin*	lo.g**i**w.hin	*log**.**whin*	

(54) **Deletion of V**. The subhierarchy II-III, *V >> V↛Ø, yields *V-deletion* in open-open sequences:

-hatin+i:n → hat.nen	*COMPLEX	***V**	**V↛Ø**
hat.nen ~ *ha.ti.nen.*		hat.nen	*ha.ti.nen.*

(55) **Blocking**. But the dominance of *COMPLEX **blocks** V-deletion when it would create CCC clusters. (nb: constructed example based on made-up stem "haltin" !). Note that *COMPLEX operates here to over-rule the effects of the *V >> V↛Ø relation, which is exactly the same as it is in (54).

"haltin"+i:n → hal.ti.nen	***COMPLEX**	***V**	**V↛Ø**
hal.ti.nen ~ *halt.nen.*	hal.ti.nen	*halt.nen*	hal.ti.nen

(56) **Conclusion**. The notion of comparative evaluation through a hierarchy of ranked, strictly universal constraints allows OT to liberate the *constraint* entirely from the parochial rule-package, and thereby to propose answers to the classic problems of generative grammar: the sources of universality and variation; the formal source of extremal solutions; the span of interaction of constraints; and the nature of their mode of interaction.

References

This list only includes items referred to in the above text. For a bibliography of work in OT up to June 1996, see http://ruccs.rutgers.edu/ROA/ot-bib.html. For a collection of downloadable work in the area, visit the Rutgers Optimality Archive http://ruccs.rutgers.edu/roa.html.

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Current Directions in Optimality Theory

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(1) Theory construction & development is a kind of optimization too, facing different and conflicting dimensions of evaluation. Different strategies for advance are possible, and necessary, and it is appropriate that researchers work in different ways: sometimes aiming to expand the theory to face a broader range of phenomena, at other times working to deepen our understanding of the theory and sharpen its predictive powers.

(2) Some questions being investigated in current work in phonology:

- Issues of opacity and mechanisms for dealing with them (sympathy)
- Construction of composite constraints (local conjunction)
- Learning of OT grammars
- Integration of OT and Lexical Phonological perspectives
- Role or non-role of underspecification
- Role of phoneticism/functionalism in constraint system
- Paradigmatic relations and Output-Output Correspondence
- Positional specialization of faithfulness constraints
- Role of contrast in (re-)defining grammatical architecture
- Development of Generalized Template Theory in Prosodic Morphology
- Typological structure of phenomenal domains

Visit the Optimality Archive at http://ruccs.rutgers.edu to find much of this work. A very skeletal and preliminary list of references might include *McCarthy 1998; Smolensky 1993, 1995; Tesar 1995, Tesar & Smolensky 1998; Kiparsky 1997; Smolensky 1993, Inkelas 1994, Itô, Mester, & Padgett 1994; Kirchner 1997; Benua 1997; Beckman 1998, Zoll 1998; Flemming 1995, McCarthy & Prince 1994, 1995, 1997, Itô, Mester, Kitagawa 1996.*

(3) But an important current direction in OT is *probing its foundations*!

- What are the basic properties of mapping in Markedness/Faithfulness-OT?
- How can CON be defined so as to best predict the properties of human language?

  Today, we will be especially concerned to determine some basic consequences of assumptions about the nature of Faithfulness constraints.

(4) Because OT works by laying down a set of assumptions from which consequences rigidly follow via *factorial typology*, and because these consequences are not easily seen from mere inspection of the assumptions, it is particularly important to develop an understanding of the properties of the theory. (The notion that simple-seeming assumptions require no analysis is appealing but naive.) In other approaches it is presumably no less important, but those that provide a rich and easily amended descriptive formalism are perhaps more resistant to meaningful scrutiny.

(5) Some **architectural imperatives** in OT,

deriving from the occamite principle ‘maximizing the use of theoretical resources’:

a. OT does neutralizing mappings through Markedness/Faithfulness interaction:

∴ No constraints on input. Derive character of input from effects of M/F Grammar.

b. OT gives interactive suppression of a constraint’s effects through domination:

• Hence no further mechanism of constraint removal (simple omission)

• Hence much less interesting to have simple opposites ≈ parameters.

c. OT expresses a variety of interactions through domination relation *between* constraints:

∴ No constraint-internal logic that mimics effects typical of the domination relation:

• E.g. no reference to “except when” inside constraints

Not possible, then: “Syllables have onsets, *except when* phrase-initial”

d. OT works through optimization/competition over a hierarchy:

∴ No constraint-internal reference to “markedness” or competition.

No C-internal reference to *complexity, maximization, minimization, default, marked structure, unmarked structure...* All these are independently computed by separate constraints and their interaction.

e. OT works with M/F constraints to achieve mappings between representations.

∴ No “antifaithfulness” constraints.

(6) **Some differences** with respect to rule-package serialism.

(a) RPS deals with *composition* of mappings via sequential derivation.

(b) In OT, the relation between mappings is more like *superposition*.

• Question: what happens when you try to superpose two mappings in one hierarchy?

(7) **Repetition**. A constraint in OT cannot be meaningfully repeated in the same hierarchy.

...C>>....C... is completely equivalent to ...C>>......

• But a *rule* may be repeated in a serial order to great effect! (cf. ‘everywhere rules’)

(8) **Antagonism**. A constraint and its “anti-constraint” cannot both be active in one hierarchy: the lower ranked of the pair may be simply removed. No such property holds of the rule in serial derivation.

(9) **Constraint theory**. Of particular interest is role of Faithfulness. There are many ideas about Markedness from the literature (though it remains a very lively issue what is right). But Faithfulness, in the sense of individuated constraints demanding identity along various dimensions, is proper to OT, and there is no OT without Faithfulness.

• Existence of F allows us to fix M for a language, and generate various restricted sublanguages (as through *reduplicative correspondence*) without fiddling the M hierarchy.

• Formulation of F-theory is absolutely crucial so that interactions entail the general properties of human language.

We develop a two-part argument below: culminating in partial conclusions in (15) and (49), which together yield a full conclusion in (51) about the necessary symmetry of F constraints wrt the elements whose exchange they control.

(10) Assume a markedness hierarchy: *p >>*k >>*t . (So: *p* is more marked than *k*, *k* than *t*.)

Assume a faithfulness constraint F(Place) — "input and output correspondents have the same place of articulation."

Now consider various placements of F(Place) within the hierarchy.

(Cf. *Prince & Smolensky 1993*, Chs.8-9, *Itô & Mester 1995, 1998* on the Japanese lexicon).

(11)

Grammar	*Mapping Effects*		*Resulting System*
F(PL) >> *p >> *k >> *t	p,k$\nrightarrow$t	fatal *F(PL)	{p, k, t}
*p >> **F(PL)** >> *k >> *t	p$\rightarrow$t	but *k$\nrightarrow$t by F(PL)	{k,t}
*p >> *k >> **F(PL)** >> *t	p$\rightarrow$t, k$\rightarrow$t		{t}

(12) Since in **H**>>F, everything in subhierarchy **H** impinges on F, we see a cumulative effect. So we project from strict domination and constraints against *individual elements* to a hierarchy of inclusion among *languages*.

(13) **Harmonic completeness.** Each resulting system in (11) is "harmonically complete" — if it contains an element α, it contains all elements of lesser markedness (greater harmony).

• Markedness theory programmatically assumes that something like harmonic completeness is true of language.

(14) But the result depends entirely on the character of F! Suppose we distinguish F(p) from F(k).

Grammar	*Effect*	*Resulting System*	
F(p) >> *p >> *k >> **F(k)** >> *t	k$\rightarrow$t	{p, t}	k is missing, but p is present!

(15) **Faithfulness & Markedness I**. In general, to preserve harmonic completeness in a hierarchy like this, we must have NOT [F(p)>>F(k)].

• Either F(k) >> F(p), or there is only one constraint F(k,p).

• We use *p* and *k* to stand for any elements of greater (p) or lesser (k) markedness.

(16) To discover what the theory of F must be, we have no choice but to examine the interactions of the theory and confront them with generalizations about the form of linguistic systems. We cannot expect guidance from the synthetic or analytic *a priori*.

(17) **Winning in OT.** (Cancellation-Domination Lemma, *Prince & Smolensky 1993*)

(**a** > **b**; R) iff *every* constraint favoring **b** is dominated by *some* constraint favoring **a**.

Since R is a total order, some constraint is highest among those preferring **a**. So—

■ *Some* constraint favoring **a** dominates *every* constraint favoring **b**

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
a ~ b		**a**	**b**		**b**	**a**	**b**

(18) Attaining a mapping in M/F-OT. What patterns of relations among M,F constraints are necessary, sufficient to attain a desired mapping?

(19) How can we *escape* the identity map $\alpha \to \alpha$?
Compare the constraint violations of a map $\alpha \to \beta$ to those of the identity map $\alpha \to \alpha$

Relation between $\alpha \to \alpha$ *and* $\alpha \to \beta$.
NB: Constraints *against* are tabulated — these are the **dis**advantages of the candidate mapping.

/α/	F	M
$\alpha \to \alpha$		$M^{\checkmark\beta}(\alpha) \approx *\alpha$
$\alpha \to \beta$	$\mathscr{F}(\alpha \not\to \beta)$	$M^{\checkmark\alpha}(\beta) \approx *\beta$

Notation:
$M^{\checkmark\beta}(\alpha) = \{M: M \vdash \beta > \alpha\}$ "all M preferring β to α" $\approx \{*\alpha\}$
$M^{\checkmark\alpha}(\beta) = \{M: M \vdash \alpha > \beta\}$ "all M preferring α to β" $\approx \{*\beta\}$
$\mathscr{F}(\alpha,\beta) = \{F: F \vdash \alpha \to \alpha > \alpha \to \beta\}$ "all F violated by α→β" $= \{\alpha \not\to \beta\}$

(20) **Escape Lemma.** Because the only disadvantages of the Identity map are in the M column:
To prefer $\alpha \to \beta$ to $\alpha \to \alpha$,
▮▮ *Some* constraint $*\alpha$ from $M^{\checkmark\beta}(\alpha)$ must dominate all of $\mathscr{F}(\alpha,\beta)$ and $M^{\checkmark\alpha}(\beta)$

(21) The basic diagram::

```
      *α
    /    \
 {*β}   {α↛β}
```

(22) **Corollary**: If there are no markedness constraints *against* α, then $\alpha \to \alpha$ is universal.
E.g. Every language has open syllables.

(23) **Harmonic Ascent/Markedness Descent**. (*Moreton 1996*). If $\alpha \to \beta$, $\beta \neq \alpha$, then $(\beta > \alpha; R|M)$.
"If R maps α to β, then β does better on the markedness subhierarchy in R (= R|M) than α"
Proof. Note that β can't be more *faithful* to α than α is! So only M-constraints are left for it to win on.
Assumption: $\alpha \to \alpha$ is in the candidate set.
Assumption: No *anti*faithfulness constraints.

(24) **Identity Confinement**. How can $\alpha \to \alpha$ survive when $\exists\beta, (\beta > \alpha; R|M)$, a less-marked form?
▮▮ If β is more harmonic (less marked) than α, then $\alpha \to \alpha > \alpha \to \beta$ only by virtue of a *Faithfulness* constraint $\alpha \not\to \beta$ militating against $\alpha \to \beta$.

(25) The Escape Lemma provides a *necessary* condition for $\alpha \to \beta$, not a sufficient one.
•This means that if the conditions of the EL are *not* met, we absolutely don't get $\alpha \to \beta$.
But if they are met, it could still happen that $\alpha \to \gamma$!
•To assure $\alpha \to \beta$, we must show it's better than $\alpha \to \gamma$, for **every** γ.
▮▮ Suppose γ wins on Markedness: $(\gamma > \beta; R|M)$. Then $\alpha \to \beta$ can only win *via* Faithfulness.
▮▮ Suppose γ wins on Faithfulness: then β must be less marked than γ.

(26) **Moreton's Theorem**.(*Moreton 1996*). There can be no circular chain shifts in M/F-OT.

Proof. if we have α→β, β→γ, γ→δ,....., ψ→ω , then by Harmonic Ascent (ω>ψ>...>α;R|M).

I.e. the foot of the chain must be *less marked* than the head.

▮Thus we cannot have e.g. /α/→β and /β/→α (and the like) in the same M/F-OT grammar!

(27) How can we have any chain-shifts at all? How can we prevent the mappings from *composing*?

- This is equivalent to: Given conditions favorable to α→β, β→γ, how do we prevent α→γ?
- We have the answer: it can only be done by Faithfulness.

(28) **The Chain-Shift Criterion.** By Moreton, a chain-shift /α/→β, /β/→γ entails γ less marked than α. So there must be at least one Faithfulness constraint F:α↛γ, distinct from all F:α↛β, that blocks α→γ, since markedness can't do it. Furthermore, this F must dominate *every* faithfulness constraint α↛β and *every* markedness constraint preferring γ to β. Schematizing somewhat oversimplistically, we have —

/α/	*α	**F:α↛γ**	α↛β	*β	*γ
α→β ~ α→γ		**α→β**	α→γ	α→γ	α→β
α→β ~ α→α	**α→β**		α→α	α→α	

(29) The question then arises: **does this F constraint exist in CON**?? Consider some shifts:

(a) Bedouin Arabic Vowel Raising & Loss (*McCarthy 1993, Kiparsky 1994*)
/a/→ i, /i/→ Ø (in nonfinal open syllables)

(b) Finnish Consonant Gradation (noninitial, _VC]$_\sigma$)
/tt/→t , /t/→d

(c) Nbɛzi Vowel Raising (*Kirchner 1996*)
/a/→ ɛ , /ɛ/ →e , /e/→i (before certain suffixal -i)

(30) We are by no means guaranteed the *existence* of the relevant constraints!

- MAX-V, for example, does not distinguish between a→Ø and i→ Ø.

Kirchner (1996) proposes that the relevant F-constraints **do** exist — by virtue of *Local Conjunction* (Smolensky 1993/94, 1995): here, [DEP-μ & DEP-μ]. Above, [Ident(ATR) & Ident (Lo)], [Ident(ATR) & Ident(Hi)], and perhaps [Max-μ&Ident(Voi). *Gnanadesikan 1997* explores another avenue of attack via the theory of representations.

(31) Useful, in the manner of Galilean science, to study the properties of constraints and the mapping theory in the context of the most basic revealing typologies.

(32) Consider a simple system based on two elements: u, m. (for *unmarked*, *marked*), with appropriate markedness and faithfulness constraints:

*m 'No m's allowed'
*u 'No u's allowed'
u↛m 'Faithfulness to u'
m↛u 'Faithfulness to m'

(33) Since m is marked, we fix the ranking *m >> *u . (We could just as well omit the constraint *u).

(34) Spice: add a contextual markedness constraint against u in a certain environment: *u/E.

(35) Systems of this type are plentiful indeed:

u	V_{oral}	s	t	V̆ (short vowel)	...
m	V_{nasal}	š	d	Vː (long vowel)	...
***u/E**	$*NV_{oral}$	*si	*VtV	*V̆ under main stress	....

(36) The factorial typology consists of 5 distinct systems.

(37) What individual mappings are possible? To analyze, we need to divide the world up into its derived parts: *m* and *u* in the environments in which they're evaluated: u/E, u/E′; m/E, m/E′.

- For example, in the nasal/oral system, some typical instances would be:

  u/E = na u/E′ = ta

  m/E = n***ã*** m/E′ = t***ã***

(38) Unfaithful maps, with their escape-from-identity conditions.

Maps in env. E′	**Maps in env. E**	
(0) u/E′→m/E′ (ta→t***ã***) *Not possible.* *No constraint against u/E′*	**(i)** u/E→m/E (na→n***ã***) *u/E / \\ *m u↛m	} **u→m**
(ii) m/E′→u/E′ (t***ã***→ta) *m / \\ *u m↛u	**(iii)** m/E →u/E (n***ã***→na) *m / | \\ *u *u/E m↛u	} **m→u**

(39) **Fully Faithful**: u→u, m→m *everywhere.* **System:** {na, n***ã***, ta, t***ã***}

- m→m. Since *m >> *u, the mapping m→u can only be blocked by Faithfulness:

  ▮ *m↛u* >> **m*

  ▮▮ This breaks up maps (ii) and (iii)

- u→u. There are two ways of breaking up map (i) u→m: either will suffice.

  [****m***>>**u/E*] ***OR*** [***u↛m***>>**u/E*] (M or F reasons forbidding resolution of u/E.)

(40) **Fully Unmarked**. u,m→u *everywhere.* **System**: {na, ta}

- This is obtained by subhierarchy (iii), no matter where u↛m is placed.

  **m* dominates every M constraint against *u* anywhere, and every F constraint against m→u.
- Map (iii) *contains* [**m*>>**u/E*], which forces u→u, as just seen in (39).
- We have reached our first implication: (iii) ⇒ ¬ (i) — and vice versa (cf. Moreton's Thm.)

  ▮ Maps (iii) and (i) cannot be superposed.

(41) **Complementary Distribution**. u→m/E, m→u/E′. System: {n***ã***, ta}

• This is simply the superposition of maps (i) and (ii): they join at *m.

I *u/E

/ \ Observe that m→m/E because subh. (iii) [m/E →u/E] is broken

/ u↛m up by **u/E >> *m.*

II *m

/ \ ■ ⟨I,II⟩ = (i) *na→nã*

III *u m↛u ■ ⟨II,III⟩ = (ii) *tã→ta*

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(42) **Neutralization to m in E**. u→m/E, m→m *everywhere*. System: {n***ã***, ta, t***ã*** }

•This is the superposition of map (i) with the break-up of (ii). They meet at *m

I II III

m↛u *u/E

\ / \ Observe that *m↛u >>*m* breaks up (ii) ⟨m/E′→u/E′⟩.

*m u↛m

/ . ■ ⟨II,III⟩ = (i) *na→nã*

*u ■ ⟨I,II⟩ = ¬ (ii) by virtue of F:m↛u, so *tã* → *tã* .

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(43) **Neutralization to u in E′**. m→u/E′ (m→m/E, u→u/E). System: {na, n***ã***, ta}.

•This is the superposition of (ii) [m→u/E′] with the breakup by faithfulness of (i) [u/E→m/E] and concomitantly the markedness-breakup of (iii) [m/E′→u/E′].

I u↛m This is like the CD system, with u→m/E blocked by Faith: *u↛m>>*u/E*

| **u/E>>*m* breaks up (ii).

II *u/E *u↛m>>*u/E* breaks up (i).

|

III *m ■ ⟨I,II,III⟩ = ¬ (i) by virtue of F:u↛m, so *na→ na*

/ \ ■ ⟨III,IV⟩ = (ii) *tã → ta.*

IV *u m↛u Notice that ¬(iii) = ⟨II,III,IV⟩ emerges from superposition ¬(i)+(ii).

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(44) **Force of Factorial Typology**. 8 systems are a priori possible. 5 are allowed.

• Missing are two based on circular shifts in E: m→u/E, u→m/E, which are out by Moreton.

Systems: *{na, n***ã***, ta, t***ã***}, {na, n***ã,*** ta}. These *systems* are in, but derive differently.

• Missing also is the one where m→u/E but not in E′.

System predicted impossible: *{ta, t***ã***, na}.

Neutralization to **a** *in the environment favoring nasalization.*

And surely this is most unlikely.

(45) **A distinct peculiarity.** System {na, n***ã***, ta} in (43) is odd!

The system {na, n***ã***, ta} preserves the *a ~ ã* **contrast** *only* in the environment favoring **neutralization**! This seems like an offense against the notion of markedness.

(46) This system represents a kind of ‘positional faithfulness’.

• The ranking ⟨*u* $\not\rightarrow$ *m* >> **u/E*⟩ forces *u* to stay in *E*. It’s equivalent to having F: (u$\not\rightarrow$m)/E.

Observe that we don’t need an F constraint to prevent u→m elsewhere: M does the work.

(47) This makes sense in some conditions where E is a *position of prominence*.

Suppose u= short vowel, m = long vowel. E = main stress.

Then this is: long-short contrast only under main stress, short vowels elsewhere.

(48) But this can’t be the story on positional faithfulness. A constraint *u/E is demanded: but not always available.

• Say *ü* is out except in Roots, by ü→i. Then we need *i/Root ! (which would have to dominate any constraint *ü/Root).

+

(49) The difficulty lies precisely in the distinction between F(u) = ⟨*u* $\not\rightarrow$ *m*⟩ and F(m) = ⟨*m* $\not\rightarrow$ *u*⟩ .

• They are ranked in the order F(u)>>F(m).

• The result is the preservation of u in E: contrast only the neutralization-happy environment.

(50) To eliminate, we must impose the ranking metacondition: NOT [F(u)>>F(m)].

(51) From this and from metacondition (15) NOT [F(m)>>F(u)], we deduce

■ F(u) = F(m). They must be the *same* constraint, since neither can dominate the other.

Like the IDENT constraints of *McCarthy & Prince 1995*, which forbid both +F→−F and −F→+F.

(52) **The Faithfulness finding**. To predict markedness profiles of inventories, Faithfulness constraints must be *fully symmetric* among the items on the scale they intervene in.

(53) **Conclusion:** Study of the mapping properties of M,F-constraint hierarchies leads to rich predictions about the nature of linguistic systems, and suggests many avenues for the development of further theory.

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