Solving Optimality Theory's Chain Shift Problem

Charles Reiss *

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Abstract

The well-known computational problem of generating chain shifts in a classic Optimality Theory grammar has a simple representational solution. Chain shift patterns can be generated by using underspecified inputs and MAX and DEP faithfulness constraints.

Keywords: *phonology, feature logic, counterfeeding, chain shift, Optimality Theory, underspecification*

1 Introduction

It has been universally accepted since the advent of Optimality Theory (OT) that "chain shifts cannot be analyzed under standard OT" (Kager, 1999, 394). This belief led to suggestions for radical innovations of the original OT model, conveniently discussed by McCarthy (2002, 162), such as local constraint conjunction (Kirchner, 1996; Smolensky, 1995), scalar faithfulness (Gnanadesikan, 1997) or faithfulness to input context. I show that this belief was false and that all necessary components of an analysis of chain shifts had already been proposed by 1995. The implications of this result are twofold: (1) arguments for machinery like local conjunction need to be re-evaluated, since one argument for them has now evaporated; and (2) the perceived failure of simple OT models to handle chain shifts can no longer be relevant to evaluating OT as opposed to, say, derivational models.

Crucially, my claim is not that chain shifts can be derived under *every* set of 'classic' OT assumptions, but rather that there is a set of classic assumptions under which they can be derived. Furthermore, it is not necessary for me to justify each constraint I invoke, as long as the constraints do not introduce new mechanisms into the model: the argument against the possibility of generating chain shifts (see, e.g., Kager 1999, ch. 9) is made on the basis of the logic of how Faithfulness and Markedness constraints interact, not on the basis of the particular constraints invoked. This stance is consistent with the view that "Optimality Theory is a theory of constraint interaction, not of representations. We want our deductions about OT to hold even if the theory of representations changes" (Moreton, 2008, 142).

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2 Assumptions

Suppose that a language contains some morphemes that surface with a [b] when the segment is between vowels, but with a [p], elsewhere. We can model this situation with a rule like (1):

(1) Rule A: p →b / V ___V

Suppose further that other morphemes surface with a [β] when the segment is between vowels, but with a [b] elsewhere. This can be modeled with another rule (2):

(2) Rule B: b →β / V ___V

In order to derive the pattern described above, the ordering of these rules must be that B precedes A, so that underlying /p/ does not become [b] by rule A, then surface as [β] between vowels by rule B. The order AB would be a feeding ordering, so the correct order BA is counterfeeding.

This situation, with this relationship among the surface segments *p,b,β*, is a chain shift, and Optimality Theory has a problem generating such a pattern because of its surface-orientation: if it's okay to violate input-output identity relations to avoid intervocalic *b* by changing an underlying *b* to *β*, then it should be okay to violate those relations and change a derived *b* to *β* as well. In order to get the correct result, some kind of notion of 'faithfulness distance' seems to be needed. Informally, the idea is that being a little bit unfaithful is allowed—a *p* can surface as a *b* between vowels—but the change from *p* to *β* involves too many violations of faithfulness. Mechanisms like local constraint conjunction were proposed to capture this idea of various faithfulness distances.

I propose an alternative solution that does not require any radical enrichment of the theory such as the possibility of constraint conjunction. The proposal has two crucial aspects. First, it is necessary to stop thinking in terms of relations among surface segments and accept that input segments might not be identical to any of their surface alternants. Of course, most phonologists accept in principle that the "relation between a phonemic system and the phonetic record . . . is remote and complex" (Chomsky, 1964, 38), but in practice, for example in the literature on chain shifts, surface segments frame the discourse. Instead of modeling input-ouput relations among segments *p,b,β*, we need to think about the possibility of finding two segments, call them *P* and *B*, such that *P* maps to *p* and *b* in environments X and Y, respectively; and *B* maps to *b* and *β* in environments X and Y, respectively. We'll identity *P* and *B* below.

In particular, I make use of underspecified representations in input segments. Following Inkelas (1995), I use binary features and allow underspecification. Again, the point of this paper is not to justify such decisions, since our goal is to show that some set of assumptions allows us to get chain shifts in a 'classic' OT grammar. However, we can mention that the apparent existence of *surface* underspecification (Keating, 1988) supports a model that allows underspecification in inputs as well. Furthermore, we can appreciate that allowing underspecification is simpler than prohibiting it, since we allow it by removing a stipulation that all segments must be specified for all features. Once we accept underspecification we can adopt the MAX and DEP constraints that treat insertion and deletion of feature values as separate violations of faithfulness (see Lombardi 1995/2001 and McCarthy 2011, sec. 4.6). With this machinery, a feature-filling mapping can violate a single DEP constraint, whereas a feature-changing mapping will violate at least a MAX constraint and a DEP constraint.

The second crucial aspect of the analysis is to use underspecification to build distantial faithfulness into the relevant representations. In this vein, we can derive the surface 'chain shift' pattern, not from underlying /p/ and /b/, but by defining /P/ as a bilabial stop unspecified for VOICE, but specified −CONTINUANT and /B/ as +VOICED bilabial obstruent, unspecified for CONTINUANT. We will see how this works below.

I assume the markedness constraints in (3).

(3) Markedness constraints

- SURFACE-SPEC : This constraint is undominated for the patterns of interest. This constraint is violated by output segments that manifest surface underspecification. In other words, all outputs are fully specified in the language.
- *VTV: no stops between vowels (This is a kind of 'lenition' constraint.)
- *VSV: no voiceless obstruent between vowels (Another 'lenition' constraint.)
- *FRIC: Obstruents should be stops; e.g., /β/ is more marked than /b/ (A typologically justified constraint.)
- STOP-VLESS: Stops should be voiceless; e.g., /b/ is more marked than /p/. (Another typologically justified constraint.)

These constraints are analogous to ones found in the literature, but as noted above, the point of this paper is to demonstrate that classical OT logic can, in fact, generate chain shifts, so we need not be concerned with the biolinguistic plausibility of this particular set of constraints. This position is consistent with Prince's (2007, 57) explanation for why functionalist, phonetic grounding is irrelevant to deciding whether a constraint should be recognized:

> A constraint . . . is a principle within a theory and, like any other principle in any other theory, is justified by its contribution to the consequences of that theory. Since OT is a theory of grammar, the consequences are displayed in the grammars predicted and disallowed—'typological evidence'. A constraint which cannot be justified on those grounds cannot be justified. Further, 'justifying' a constraint functionally (or in any other extrinsic way) can have no effect whatever on its role within the theory. A constraint, viewed locally, can appear wonderfully concordant with some function, but this cannot supplant the theory's logic or compel the global outcome ('efficiency') that is imagined to follow from the constraint's presence, or even make it more likely.

Faithfulness constraints are divided into the two classes in (4):

(4) Faithfulness constraints families

- MAX-F constraints penalize deletion of +F or −F for a given feature in the mapping from input to output
- DEP-F constraints penalize insertion of +F or −F for a given feature in the mapping from input to output

For our purposes, the features VOICE and CONTINUANT will be arguments of MAX and DEP.

3 Demonstration

To reiterate, the *p/b* alternation will be derived from /P/, which is a bilabial stop unspecified for VOICE and the *b/β* alternation derives from /B/, an underlying voiced bilabial unspecified for CONTINUANT. Recall that filling in unspecified values incurs only DEP violations: for example, a candidate with [p] corresponding to underlying /P/ incurs a violation of DEP-VOICE, but no MAX violation, because no VOICE value has been deleted. Changing a value on a feature incurs a MAX violation and a DEP violation: for example, a candidate with [β] corresponding to underlying /P/ incurs a MAX-CONTINUANT violation for deleting −CONTINUANT, as well as a violation of DEP-CONTINUANT for inserting +CONTINUANT.

The tableaux deriving outputs that surface as [pa, aba] from input /Pa, aPa/, and [ba, aβa] from underlying /Ba, aBa/, are presented below in (5-8). In all four tableaux, the two outputs with underspecified segments can never be optimal because SURFACE-SPEC is undominated. In (5), candidate (c) with [β] involves deletion of −CONTINUANT, a fatal MAX-CONT violation, as well as insertion of +CONTINUANT. Candidate (b) with [b] is eliminated by the lowest ranked constraint STOP-VLESS, since [b] is voiced.

(5) /P/ surfaces as [p] when not intervocalic

/Pa/	SURFACE-SPEC	MAX-CONT	DEP-VOICE	*VTV	DEP-CONT	*VSV	*FRIC	STOP-VLESS
☞ a. pa			*					
b. ba			*					*!
c. βa		*!	*		*		*	
d. Pa	*!							*
e. Ba	*!							

In (6), candidate (c) is eliminated by MAX-CONT because the input is −CONT and [β] is +CONT. Candidates (a) and (b) both violate constraint DEP-VOICE because they each contain a value for VOICED which is not in the input; and they both violate *VTV because they contain intervocalic stops. Candidate (a) is eliminated by *VSV, because it contains a voiceless obstruent [p] between vowels.

(6) /P/ surfaces as [b] between vowels

/aPa/	SURFACE-SPEC	MAX-CONT	DEP-VOICE	*VTV	DEP-CONT	*VSV	*FRIC	STOP-VLESS
a. apa			*	*		*!		
☞ b. aba			*	*				*
c. aβa		*!	*		*		*	
d. aPa	*!			*				*
e. aBa	*!							

In (7) candidate (a) is eliminated by DEP-VOICE because the input is +VOICED and [p] is −VOICED. Candidate (c) with [β] is eliminated by *FRIC. So the output is candidate (b) with [b].

(7) /B/ surfaces as [b] when not intervocalic

/Ba/	SURFACE-SPEC	MAX-CONT	DEP-VOICE	*VTV	DEP-CONT	*VSV	*FRIC	STOP-VLESS
a. pa			*!		*			
☞ b. ba					*			*
c. βa					*		*!	
d. Pa	*!							*
e. Ba	*!							

In (8) candidate (a) is eliminated by DEP-VOICE because the input is +VOICED and [p] is −VOICED. Candidate (b) with [b] is eliminated by *VTV. So the output is candidate (c) with [β].

(8) /B/ surfaces as [β] between vowels

/aBa/	SURFACE-SPEC	MAX-CONT	DEP-VOICE	*VTV	DEP-CONT	*VSV	*FRIC	STOP-VLESS
a. apa			*!	*	*	*		*
b. aba				*!	*			*
☞ c. aβa					*		*	
d. aPa	*!			*				*
e. aBa	*!							

Kirchner (1996, 341) points out that analyses of a particular chain shift involving just two steps, one of which is a deletion have been offered with ‘classic’ machinery, but insists that new mechanisms are needed for a chain shift that either does not involve deletion or involves more than two steps:

> McCarthy (1993.) and Orgun [1996] have given OT analyses of a particular chain shift, namely, $a \rightarrow i \rightarrow \emptyset$ reduction in Bedouin Hijazi Arabic; however, these solutions are limited to chain shifts with no more than two “steps,” where one of the steps involves deletion. I show that a more general solution to the chain shift problem can be obtained using local conjunction (Smolensky, 1995) of featural faithfulness constraints, the effect of which is to constrain the “distance” between input and output values along some phonetic scale.

Our *p,b,β* chain shift does not involve deletion. Furthermore, the logic of the example can be extended to a longer chain shift. For example, if a language shows not only *p,b* and *b,β* alternations, but also *β,v* alternations, we have a chain shift of three steps, *p,b,β,v*, parallel to the three-step chain shift in Nzebi vowels discussed by Kirchner. If we derive the *β, v* alternation from *V*, a voiced, bilabial continuant, unspecified for SONORANT, the same logic shown in the tableaux above will work. The problem of computing distance is avoided by building the solution into the input representations.

4 Conclusion

The preceding discussion is an existence proof for a classic OT grammar, without local conjunction or other machinery beyond that introduced by 1995, that can generate the surface pattern associated with counterfeeding ordering in rule-based systems.

Dispelling the myth that classic OT grammars cannot, by their nature, generate such patterns allows theory comparison to advance on firmer ground.

The apparent computational problem of generating chain shifts has a simple representational solution. The potential objection that I have just chosen the input segments in order to make things 'work' is not valid. Given the parameters of the model, of course we want to posit inputs that yield the right results. A better way to think of the issue is the following: If we assume a model that allows binary features and underspecification, as well as MAX-F and DEP-F constraints, is there a lexicon and a constraint ranking that a learner can posit that will generate the observed pattern? It appears that the lexical entries and classic OT grammar presented here provide an affirmative answer.

References

Chomsky, Noam. 1964. Formal discussion in response to W. Miller and S. Ervin. In *The Acquisition of Language*, ed. Ursula Bellugi and Roger Brown, 35–39. Chicago: University of Chicago Press.

Gnanadesikan, Amalia Elisabeth. 1997. *Phonology with ternary scales*. Doctoral Dissertation, University of Massachusetts, Amherst.

Inkelas, Sharon. 1995. The consequences of optimization for underspecification. In *Proceedings of the North East Linguistic Society 25*, ed. Jill Beckman, 287–302. University of Pennsylvania: Graduate Linguistic Student Association.

Kager, René. 1999. *Optimality Theory*. Cambridge: Cambridge University Press.

Keating, Patricia. 1988. Underspecification in phonetics. *Phonology* 5:275–292.

Kirchner, Robert. 1996. Synchronic chain shifts in optimality theory. *Linguistic Inquiry* 27:314–350.

Lombardi, Linda. 1995/2001. Why place and voice are different: Constraint-specific alternations in optimality theory. In *Segmental phonology in optimality theory: Constraints and representations*, ed. Linda Lombardi, 13–45. Cambridge: Cambridge University Press. First circulated in 1995. Available on Rutgers Optimality Archive, ROA-105.

McCarthy, John. 2002. *A thematic guide to optimality theory*. Cambridge: Cambridge University Press.

McCarthy, John J. 1993. The parallel advantage: Containment, consistency, and alignment. Paper presented at Rutgers Optimality Workshop, Rutgers University, October 1993.

McCarthy, John J. 2011. *Doing optimality theory: Applying theory to data*. John Wiley & Sons.

Moreton, Elliott. 2008. Non-computable functions in optimality theory. In *Optimality theory in phonology: A reader*, ed. John J McCarthy, chapter 6. John Wiley & Sons.

Orgun, C Orhan. 1996. Correspondence and identity constraints in two-level OT. In *Proceedings of the West Coast Conference on Formal Linguistics*, volume 15.

Prince, Alan. 2007. The pursuit of theory. In *The Cambridge Handbook of Phonology*, ed. P.V. De Lacy, 33–60. Cambridge University Press.

Smolensky, Paul. 1995. On the internal structure of the constraint component CON of UG. handout of talk at UCLA .