Typological Consequences of Local Constraint Conjunction

Elliott Moreton and Paul Smolensky
Department of Cognitive Science, Johns Hopkins University

1. Introduction

Local conjunction is a mechanism in Optimality Theory for constructing complex constraints from simpler ones (Green 1993, Smolensky 1993). If C_1 and C_2 are constraints, and D is a representational domain type (e.g. segment, cluster, syllable, stem), then $(C_1 \& C_2)_D$, the *local conjunction of C_1 and C_2 in D*, is a constraint which is violated whenever there is a domain of type D in which both C_1 and C_2 are violated. It is used in situations where violations of C_1 alone or of C_2 alone do not eliminate a candidate, but violations of both constraints simultaneously do.

A good illustration is the coda condition for German Final-Obstruent Devoicing, in which underlyingly voiced obstruents become voiceless in syllable codas (Itô & Mester in press):

(1)	a.	[ʁaː.**d**əs]	[ʁaː**t**]	[ʁɛː**t**.çən]
		wheel-PL	wheel	wheel-DIM
	b.	[taː.**g**əs]	[taː**k**]	[tɛː**k**.liç]
		day-PL	day	daily

What is forbidden is a segment (D = segment) which is in a coda (violating C_1 = NOCODA) and is a voiced obstruent (violating C_2 = *[+voi, –son]). The constraint driving Final Obstruent Devoicing is therefore (NOCODA & *[+voi, –son])$_{segment}$, a markedness constraint which is violated by voiced coda obstruents but satisfied by voiceless coda obstruents and all non-coda segments, as shown in (2).

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(2) The conjoined coda condition causes coda devoicing (a) but not onset devoicing (b) (Itô & Mester in press).

a.

/li:b/ *lieb* 'dear, pred.'	NoCoda & *[+voi, –son]	Ident	*[+voi, –son]	NoCoda
li:b	*!		*	*
☛ li:p		*		*

b.

/li:bə/ *liebe* 'dear, attr.'	NoCoda & *[+voi, –son]	Ident	*[+voi, –son]	NoCoda
☛li:.bə			*	*
li:.pə		*!		*

This paper investigates the typological implications of local conjunction within the Correspondence framework of McCarthy and Prince (1995) for one of its principal applications, chain-shift (counterfeeding) opacity, and shows that they hold up in the light of currently known data. Since these predictions do not follow from an ordered-rule account, they consititute something unusual: an opacity-based argument *for* Optimality Theory.

§2 shows that constraints which do not share a "common domain" cannot be conjoined (more precisely, the conjoined constraint is formally possible but cannot be violated). In particular, segmental Max requires an underlying domain, and hence cannot be conjoined to segmental Dep or markedness, which require a surface domain. §3 shows that OT analyses of chain shifting can differ only in how they formulate one particular faithfulness constraint. §4 considers what happens when that constraint is made by conjunction, and derives a typology of predicted possible and impossible chain shifts. §5 lays out the data from a survey of 35 chain shifts. §6 argues that the chain-shift predictions are supported by the known data, and discusses consequences and alternatives.

2. The common-domain condition

Unrestricted local conjunction predicts bizarre and implausible constraints. Restrictions have therefore been proposed on conjuncts and domains (Crowhurst & Hewitt 1997, Fukazawa & Miglio 1998, Bakovic 1999, Lubowicz 2002, Itô & Mester in press). The requirement discussed here, that the two constraints share a common domain, is less restrictive than any of these proposals, and hence compatible with them all. It is not a postulate of ours, but a part of the definition of local conjunction.

Of the constraint families proposed in McCarthy and Prince (1995), three can only be violated at a single level of representation. DEP is violated by a surface segment with no underlying correspondent, MAX by an underlying segment with no surface correspondent, and markedness constraints by a forbidden surface configuration.

In example (3), there has been both epenthesis and deletion. Both MAX and DEP have been violated.

(3) /AxB/ Underlying representation
| | Correspondence relations
[AyB] Surface representation

However, the conjunction (MAX & DEP)$_D$ cannot be violated, no matter what D is: If D is a surface domain, MAX cannot be violated in D; if D is an underlying domain, DEP cannot be violated in D.

(4) a. D = syllable (surface)
/AxB/
| |
[A<u>yB</u>]

b. D = stem (underlying)
/<u>AxB</u>/
| |
[<u>A</u>y<u>B</u>] (assuming surface correspondents inherit stem affiliation)

c. D = segment (surface or underlying)
/AxB/ /A<u>x</u>B/
| | | |
[A<u>y</u>B] [AyB]

Similarly, (MAX & Markedness)$_D$ cannot be violated, since there is no domain within which both conjuncts can be violated. Table (5) shows the combinatorial possibilities.

(5) Conjunctions yielding violable constraints in some domain

&	Markedness	DEP	Max
Max	X	X	√
Dep	√	√	
Markedness	√		

Local conjunction of two faithfulness constraints has been used to account for synchronic chain shifts (Kirchner 1996). If this analysis is correct, the impossibility of a (MAX & DEP) violation means that certain chain shifts ought not to exist. Local conjunction of a markedness and a faithfulness constraint has been applied to derived-environment effects (Lubowicz 2002), asymmetric assimilation (Bakovic 1999), and conditional assimilation (Morris 2000); lack of (MAX & Markedness) may predict the nonexistence of some such processes. This paper will focus on the chain-shift predictions.

3. Synchronic chain shifts[1]

In a synchronic chain shift, /x/→[y], while /y/→[z] (where x, y, and z can be segments or other units). The process can be captured straightforwardly using rewrite rules in a counterfeeding order (Kiparsky 1971):

(6)

	/x/	/y/
Input:	/x/	/y/
Rule 1: y→z	—	z
Rule 2: x→y	y	—
Output:	[y]	[z]

Under the classical assumption that there are only markedness and faithfulness constraints, we have remarkably little choice in devising an Optimality-Theoretic account of chain shifting.

Since inputs change only to become less marked (i.e., to score better on the markedness constraints as ranked in the grammar), we know that [x] is more marked than [y], which is more marked than [z]. The winning candidate /x/→[y] cannot beat /x/→[z] on markedness, so it must do so on faithfulness. Hence there is a faithfulness constraint F such that F/x/[y] is less (i.e., fewer violation marks) than F/x/[z].

The highest markedness constraint which gives different scores to [y] and [z] must favor [z], since [z] is less marked than [y]. Call that constraint *y. Then F must outrank *y in order for /x/→[y] to beat /x/→[z].

(7) F outranks *y

		F	*y
/x/	[x]	0	
☛	[y]	(*)	**
	[z]	**!	(*)
/y/	[x]		
	[y]	0	**
☛	[z]		(*)

1. Many of the ideas in this section were first developed by Prince (1998) and by Cable (2000).

Here "0" means zero violation marks, "**" means many, and "(*)" means zero or more, but fewer than "**".

Now, /y/→[z] wins over /y/→[y]. It cannot do so on faithfulness, so it must win on markedness—and the decisive constraint is this same *y, the highest-ranked markedness constraint that distinguishes [y] and [z].

All constraints which outrank *y must give the same score to /y/→[z] as to /y/→[y], because *y is the decisive constraint. In particular, F must do this: F/y/[z] = F/y/[y]. But F/y/[y] = 0 ([y] is fully faithful), so F/y/[z] = 0.

Finally, some other markedness constraint must make /x/→[x] lose to /x/→[y]; call it *x. Its ranking cannot be determined *a priori*; *x could even be identical to *y. The final schema, with *x arbitrarily ranked, is:

(8) General schema for chain shift (x→y→z)

		*x	F	*y
/x/	[x]	**!	0	
☛	[y]	(*)	(*)	**
	[z]		**!	(*)
/y/	[x]	**!		
	[y]	(*)	0	**!
☛	[z]		0	(*)

The only open question is, what is F? This constraint, with its peculiar properties, has been the crux of disagreement between competing accounts of chain shifting in the framework of classical markedness-and-faithfulness OT (Orgun 1995, Kirchner 1995, Gnanadesikan 1997).

4. Chain shifts via local conjunction: typological predictions

A solution using local conjunction of two faithfulness constraints was proposed by Kirchner (1995, 1996). It is illustrated here with the example of Western Basque Hiatus Raising, in which /a/→[e] and /e/→[i] before vowels (Kirchner 1995, Kawahara 2002).

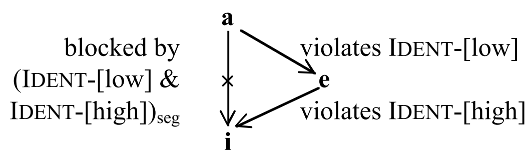
(9) Western Basque Hiatus Raising (Kawahara 2002:82)

	Indefinite	Definite	Gloss
/a/→[e]/_V	alab**a** bat	alab**e**a	'daughter'
	nesk**a** bat	nesk**ea**	'girl'
/e/→[i]/_V	sem**e** bat	sem**i**e	'son'
	at**e** bat	at**i**e	'door'

The markedness constraint favoring higher vowels before another vowel, HIATUS RAISING, is ranked high enough to compel violations of

IDENT-[low] (when /a/ becomes [e]) and of IDENT-[high] (when /e/ becomes [i]), but something prevents it from violating both at once and changing /a/ to [i]. Kirchner's analysis blocks the /a/→[i] transition using F = (IDENT-[low] & IDENT-[high])$_{seg}$, as shown schematically in (10).[2]

(10) Western Basque Hiatus Raising: Local conjunction blocks /a/→[i].



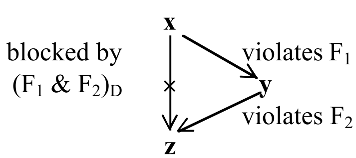
The conjoined constraint outranks the markedness constraint driving the chain shift, which outranks the unconjoined faithfulness constraints:

(11) Western Basque Hiatus Raising (Kawahara 2002, after Kirchner 1995)

		ID-[lo] & ID-[hi]	HIATUS RAISING	ID-[lo]	ID-[hi]
/alab**a**+a/	[alab**a**a]		**!		
☛	[alab**e**a]		*	*	
	[alab**i**a]	*!		*	*
/sem**e**+e/	[sem**e**e]		*!		
☛	[sem**i**e]				*

As discussed in §3 , this schema generalizes to all chain shifts of the form /x/→[y], /y/→[z], except that the losing candidates /x/→[x] and /y/→[y] do not necessarily fail on the same markedness constraint. In general:

(12) x→y→z



2. Kirchner actually uses the PARSE constraints of Prince and Smolensky (1993) rather than IDENT; we have adapted his analysis to the Correspondence framework following Kawahara (2002). No domain is specified; we assume the segment.

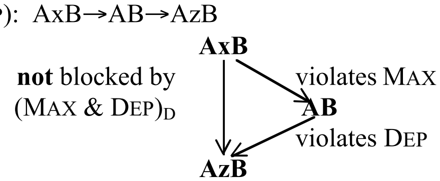
(13) General schema for x→y→z using local conjunction

		*x	$(F_1$ & $F_2)_D$	*y	F_1	F_2
/x/	[x]	*!		?		
☛	[y]			*	*	
	[z]		*!		*	*
/y/	[x]	*!		?		
	[y]			*!		
☛	[z]					*

NOTE: *x and *y may be the same constraint.

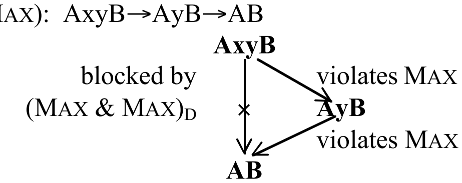
If this is the correct account of chain shifts, then the chain shift corresponding to $(\text{MAX}$ & $\text{DEP})_D$ should be impossible, since the conjunction cannot be violated. That chain shift would be[3]

(14) (MAX & DEP): AxB→AB→AzB

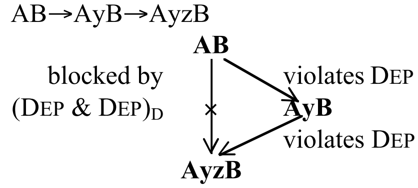


On the other hand, the chain shifts corresponding to (MAX & MAX) and (DEP & DEP) ought to exist.

(15) (MAX & MAX): AxyB→AyB→AB



(16) (DEP & DEP): AB→AyB→AyzB



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3. AB→AyB→AB would also be a (MAX & DEP) chain shift, but, being circular, it is independently ruled out by a more basic property of classical OT, Harmonic Ascent (Prince 1998, Moreton in press).

Thus, despite its permissive appearance, local conjunction—even in its most unconstrained form—is a restrictive hypothesis, ruling out some conceivable phonological processes while predicting others. The next section examines the relevant empirical data.

5. Observed typology of chain shifts

The 35 chain shifts we have examined to date are listed in the Appendix. Most are not relevant here, being featural or prosodic rather than segmental. The relevant ones are:

(17) Typological predictions and cases known to date

Conjunction	Chain shift	Pred.	Known cases
(MAX & DEP)	AxB→AB→AzB	no	—
(MAX & MAX)	AxyB→AyB→AB	yes	Catalan, Hidatsa, Chemehuevi
(DEP & DEP)	AB→AyB→AyzB	yes	—

5.1. (MAX & DEP), AxB→AB→AzB, predicted impossible

One claimed example of the "impossible" AxB→AB→AyB pattern is known to us. According to Donegan and Stampe (1979), English nasal-fricative clusters can optionally be broken up by inserting a voiceless oral stop: *an[t]swer, con[t]ceal, com[p]fort, lym[p]ph,* while casual-speech syncope of unstressed vowels can create a nasal-fricative cluster: *sin'ster, Tim'thy.* However, nasal-fricative clusters created by casual-speech syncope do not undergo stop insertion: **sin[t]ster, *Tim[p]thy*, resulting in a chain shift of the form NVF→NF→NCF.

We do not accept that English fast-speech schwa "deletion" actually deletes the schwa. Manuel et al. (1992) found that fast-speech *support* (*s'port*) is acoustically different from *sport*, the [s] in *s'port* being always followed by either voicing or aspiration (implying that the [s] was released into an open vocal tract). They also found that *below* (*b'low*) and *derive* (*d'rive*) differed from *blow* and *drive*. Where the schwa sounded like it had been deleted, measurement "almost always" showed that the sonorant was longer than in words with no underlying schwa, and listeners could tell them apart. Davidson (2002) has found that complete deletion of schwa (removing both voicing and aspiration) is rare outside of /sC/ clusters. In her study of 23 different word-initial /CəC/ clusters, speakers deleted 2.5% of schwas at a normal speaking rate and 4.5% when speaking "as fast as you can without making mistakes" when the initial consonant was not /s/. These were all acoustical studies. If articulation had been measured, traces of the "deleted" schwa might have been found in even more tokens. The persistence of a phonetically reduced (rather than phonologically deleted) schwa would block epenthesis into derived "nasal-fricative clusters".[4]

5.2. (MAX & MAX), AxyB→AyB→AB, predicted possible

We know of three instances of this pattern. The best-known is from Catalan (Mascaró 1978, Wheeler 1979): [t d p b] are deleted word-finally, as is [n] in certain circumstances. But final [n] is not deleted if it becomes final through stop deletion. This is a chain shift of the form nC#→n#→#.

(18) Catalan word-final stop and [n] deletion (Wheeler 1979)

nC#→n#	Gloss	n#→#	Gloss
kunten**t**→kunten	'happy'	pla**n**→pla	'flat'
fəkun**d**→fəkun	'fertile'	katala**n**→katala	'Catalan'

Boersma (1999) proposes an analysis using local conjunction of "*DELETE (t/n_#)" and "*DELETE (n/_#)" in an unspecified domain, presumably the root or underlying two-phoneme cluster.[5] In the Correspondence framework, these would be MAX constraints—conjunction of plain MAX-SEG with itself would suffice.

Further cases occur in Chemehuevi (Press 1979) and Hidatsa (Kenstowicz & Kisseberth 1977). In both languages, there is a rule deleting word-final vowels which does not apply to its own output, giving the chain shift V_1V_2#→V_1#→#. Local self-conjunction of MAX-SEG in the domain of the two-vowel sequence would block V_1V_2#→#.

5.3. (DEP & DEP), AB→AyB→AyzB, predicted possible

Although all theories predict it, we know of no instances of this pattern. If they exist, our failure to find them means we have not looked hard enough, and hence might have missed a (MAX & DEP) counterexample.

However, there are independent grounds for AB→AyB→AyzB to be rare. With no underlying segment to be faithful to, the epenthetic segment (regardless of why it was inserted) is perfectly adapted to its environment and insures minimal contextual markedness violations. Hence AyB will not

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4. Moreover, the stop-epenthesis process is probably not phonological epenthesis either, but a phonetic change in gestural timing relations, as the "epenthetic stop" is shorter than an underlying stop (Fourakis & Port 1986).

5. The cluster has been proposed as a domain by Smolensky (1993) on the basis of the English phonotactic ban identified by Yip (1991:63): "In monomorphemic words, English clusters never include more than one non-coronal....".

undergo further *phonotactically*-motivated epenthesis when it is fed to the grammar again as an input. AyB→AyzB will thus not occur unless a non-phonotactic markedness constraint, such as word minimality, happens to be active and not to have been satisfied by AyB. Since most epenthesis is phonotactically motivated, this is unlikely (though not impossible).

By contrast, deletion does *not* always create a phonotactically ideal output. Where epenthesis can choose the best of all possible segments, deletion can only use ∅. The output of deletion could therefore be eligible for further phonotactically-motivated processes, such as deletion (§5.2) or epenthesis (§5.1).

6. Summary and discussion

This paper has argued two principal points. One is theoretical: that local constraint conjunction in Correspondence OT is an inherently restrictive theory, predicting a typology of chain shifts which involve segmental epenthesis and deletion. The other is empirical: that there are, as predicted, no chain shifts of the form AxB→AB→AzB.

The (apparent) lack of genuine counterfeeding interactions between epenthesis and deletion is predicted only by local conjunction. Epenthesis and deletion often occur in the same grammar, and can interact in other ways: High Vowel Deletion feeds Epenthesis in Bdull Arabic (Bani-Yasin & Owens 1984), and epenthesis counterbleeds a consonant-deletion rule in Turkish (Sprouse 1997). Aside from the limitations of conjunction, there is no obvious reason why we should not find, for example, a language with blocking of epenthesis at a deletion site—$VC_1\mathit{C}_2C_3V \rightarrow VC_1C_3V \rightarrow VC_1\square C_3V$—or one in which vowels were deleted to satisfy Onset, and epenthesized to satisfy NoCoda, but not in the neighborhood of the same consonant: $CV_1\mathit{V}_2C \rightarrow CV_1C \rightarrow CV_1C\square$. This conclusion is somewhat weakened by our failure to find the predicted AB→AyB→AyzB shifts (Dep & Dep), though that may be due to the unrelated factors discussed in §5.3.

The prediction of no AxB→AB→AzB shifts depends crucially on the representational assumptions of Correspondence theory—specifically, that the candidates emitted by Gen do not mark deletion sites in the surface representation. In fact, we do not see how *any* of the existing Correspondence-based chain-shift theories, whether local conjunction, ternary scales (Gnanadesikan 1997), or segment-specific faithfulness (Orgun 1995) could be adapted to generate AxB→AB→AzB.

In the Containment model of representations (Prince & Smolensky 1993), deletion and epenthesis can be detected in the same surface domain. The effect of (Max & Dep) could be obtained by conjoining (Parse & Fill) in the domain of the surface sequence:

(19) AxB→A<x>B, AB→A□B (homophonous with AxB→AB→AzB)

		*x	(Parse & Fill)	*AB
AxB	AxB	*!		
	☛ A<x>B			*
	A<x>□B		*!	
AB	AB			*!
	☛ A□B			

Should such a chain shift be found, it can be used as evidence in favor of enriched surface representations like those of Containment or Turbidity Theory (Goldrick 2000)—or of ordered-rule derivations. Its absence, however, argues for local conjunction in a Correspondence framework.

Appendix: Corpus of chain shifts

This list includes some cases whose existence is inferred via "richness of the base" (Prince & Smolensky 1993:191): If all surface [y] are derived from underlying /x/, then underlying /y/ must surface as some unknown [z].

Sources include an Optimality-Theoretic analysis if available.

Language	Mapping	Sources
Barrow Inupiaq	ɨgl →igl→igʎ	McCarthy 2002
Basaa	ɛ → e → i ɔ → o → u	Schmidt 1996
Bedouin Arabic	badw → badu → bidu	McCarthy 1998
Bedouin Arabic	a→i→∅	Kirchner 1996.
Catalan	nt#→n#→#	Boersma 1999, Wheeler 1979
Chemehuevi	V_1V_2#→V_1#→#	Press 1979 §1.33.
Chukchee	#CCV → #əCCV → #əCCə [underlying ə can trigger harmony]	Spencer 1999 citing Bogoraz 1922
Egyptian Arabic	V:h#→V:#→V#	M. Becker p.c. 2002
English (1)	aɪtə→aɪɾə→aːɾə	Thomas 2000
English (2)	nIs → ns → nts (doubtful)	Donegan & Stampe 1979
English (3)	aɪd→aːt→aɪt	Anderson 1999

Language	Mapping	Sources
Etxarri Navarrese Basque	e → i → i^y o → u → u^w	Kirchner 1995
Finnish	pp tt kk → p t k → v t Ø (complex envir.)	Jensen & Stong-Jensen 1976
Hellendoorn Dutch	ktn→kn→kŋ	van Oostendorp 2002
Hidatsa	V_1V_2#→V_1#→#	Kenstowicz & Kisseberth 1977:178f.
Irish	ptk→fhx→∅h? (RotB for x→?)	Gnanadesikan 1997:189ff.
Karok	V::→V:→V	Bright 1957 §§321, 331
Lena Spanish	stressed a→e→i before u	Gnanadesikan 1997:209ff.
Mwera	mp → mb → m	Kenstowicz & Kisseberth 1977:157
Nzebi	a → ɛ → e → i; ɔ → o → u	Kirchner 1996
Nzema	nt → nd → nn	Clopper 2001 IULCWP 1
Ojibwa	nk → ŋ → unknown	McCarthy 1998
Palauan	u: → u → ə	Zuraw 2001 AFLA 8
Pipil	VwV{C/#}→Vw{C/#} →Vh{C/#}	Campbell 1985:34
Sanskrit	ai → e: → unknown au → o:→unknown	Gnanadesikan 1997:140ff.
Santiago Tzutujil	VʔCˀ→V:Cˀ→VCˀ	Dayley 1985 44–45, 50
Sea Dyak	ŋga→ŋa→ŋã	Kenstowicz & Kisseberth 1979:298
Southeastern Pomo	Ci→iC→eC (doubtful)	Moshinsky 1974 §§3.2., 3.3.11, 3.3.13
Tarascan	ae→ee→e	Foster 1968 §131
Tümpisa (Panamint) Shoshone	V → VʔV → VV (very doubtful)	Dayley 1989 §§ 9.3.5–6
Wikchamni	i:→e→unknown	Gamble 1978 §158
Wintu (1)	rh→θ→ unknown	Pitkin 1984 §321; L. Wilbur IUWPL 1
Wintu (2)	ɛCCa → ɛCa → iCa	Pitkin 1984 §§310, 321
Yagua	V_1hV_2→V_1V_2→V_2V_2	Payne & Payne §22.2.3

Language	Mapping	Sources
Yawelmani Yokuts	u:-a → o:-a → o:-o	McCarthy 1998

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