Locality of Conjunction

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1. Point of Departure

A locally-conjoined constraint C (Smolensky 1993) is violated iff both of its conjuncts, C_1 and C_2, are violated in a local domain D. This is defined in (1). Coda condition against labials, for example, can be understood as local conjunction of markedness constraints, NO-CODA and *PL/LAB, in the domain of a coda, [NO-CODA&*PL/LAB]$_{CODA}$. This is illustrated in (2).

(1) Definition of LC (Smolensky 1993)
  $C=[C_1\&C_2]_D$ is violated iff both C_1 and C_2 are violated in a local domain D.

(2) Illustration (Smolensky 1993, Ito & Mester 1998)

	NO-CODA	*PL/LAB	[NO-CODA&*PL/LAB]$_{CODA}$
a. tad.ga	*		
b. tad.ba	*	*	
c. tab.da	*	*	*

Candidate (2a) does not violate the locally-conjoined constraint, [NO-CODA&*PL/LAB]$_{CODA}$, since it violates only one of the conjuncts, NO-CODA. Candidate (2b) violates both conjuncts, NO-CODA and *PL/LAB, but in different locations, thus satisfying the locally-conjoined constraint. Finally, candidate (2c) violates the locally-conjoined constraint because it violates both NO-CODA and *PL/LAB and the violations are in the same segment. The domain restriction is crucial to local conjunction.

Local constraint conjunction (Smolensky 1993, 1995, 1997) has been argued to account for diverse phonological processes. These include coda condition (Smolensky 1993, Ito & Mester 1998), sonority hierarchy (Smolensky 1995), cluster restrictions and syllable contact (Baertsch 1998, 2002, Baertsch & Davis 2003, Davidson *et al.* 2004), derived environments (Lubowicz 2002, Ito & Mester 2002, Downing 2001), vowel harmony (Smolensky 1997, 2005, Bakovic 2000, Ito & Mester 2002, Sasa 2004), chain shifts (Kirchner 1995, Moreton & Smolensky 2002, Beckman 2003), OCP (Alderete 1997, Ito & Mester 1998, Suzuki 1998), accentual phenomena (Alderete 1999), and language acquisition (Levelt & van de Vijver 1998). For a different understanding of local conjunction see Hewitt & Crowhurst (1996), Crowhurst & Hewitt (1997), Crowhurst (1998), Downing (1998, 2000).

The idea behind local conjunction is that constraint violations are worse when they occur in the same location than in separate locations. This is expressed by the domain condition on local conjunction (see (1)). But since the domain D is a free variable, in principle any domain can be proposed. As I will show below, domains that are too large lead to unattested results.

In Polish (Rubach 1984) underlying post-alveolar affricates /ǰ/ map onto *ǰ* but *ǰ* cannot come from /g/. This is a phonologically derived environment (Kiparsky 1973, Lubowicz 2002), shown in (3).

(3) Derived Environment Effect
  a. /brɨ**ǰ**+ek/ → brɨ**ǰ**ek
  b. /ro**g**+ek/ → rožek, *ro**ǰ**ek

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Following Rubach (1984), I will assume that the /g/ to *ǰ* mapping violates IDENT(coronal) and the /ǰ/ to *ž* mapping violates IDENT(continuant). Thus, the actual mapping from /g/ to *ž*, as shown in (3b), incurs a seemingly unmotivated violation of faithfulness. It violates both IDENT(coronal) and IDENT(continuant).

Lubowicz (2002) accounts for the /g/ to *ž* mapping by locally conjoining a markedness constraint with a faithfulness constraint in the domain of a segment, as illustrated in (4). As a result of local constraint conjunction, only derived *ǰ's* are ruled out.

(4) M&F Conjunction (Lubowicz 2002)
[*ǰ & IDENT(coronal)]$_{\text{SEGMENT}}$ >> IDENT(continuant)>> *ǰ

According to the ranking in (4), underlying /ǰ/ surfaces (IDENT(continuant)>> *ǰ) but *ǰ* cannot arise from a violation of IDENT(coronal) ([*ǰ & IDENT(coronal)]$_{\text{SEGMENT}}$ >> IDENT(continuant)). The violation of IDENT(coronal) is compelled by the need to palatalize (PAL >> IDENT(coronal)).[1]

The problem lies in the domain of conjunction. If the domain of conjunction is too large, palatalization somewhere else in the word can cause underlying /ǰ/ to map onto *ž*. This unattested prediction is shown in (5). Assume the domain of conjunction to be a word.

(5) Unattested Prediction (D=word)
/ǰem+ik+ek/ → *ž e m i č e k, ǰemiček (actual)
⇧ spir ⇧ pal

As shown above, with the domain being a word, non-local palatalization (/k/→*č*) triggers spirantization (/ǰ/→*ž*) somewhere else in the word. To rule out this unattested prediction, we need to ensure locality of conjunction.

In this article, I propose to derive locality from the properties of constraints that are being conjoined rather than treat it as a separate entity. To do so, I use the notion of **locus of violation** for constraints (McCarthy 2003ab, 2004, 2005, McCarthy & Wolf 2005, Riggle & Wilson 2004). In Polish, only *ǰ*'s that are derived by a violation of IDENT(coronal) spirantize. The markedness constraint *ǰ is locally conjoined with a faithfulness constraint IDENT(coronal), the violation of which "results in" *ǰ*. Non-local violation of faithfulness (shown in (5)) needs to be ruled out.

Following McCarthy (2003ab, 2004), I propose that constraints define locus of violation in their definition in addition to the number of violation marks. Since local conjunction is itself a constraint it needs locus of violation. For local conjunction to be interpretable, the locus of violation needs to be the same for each conjunct.

2. The Proposal: Restricted Conjunction

The core of the proposal is that a constraint specifies locus of violation in its definition in addition to the number of violation marks. Thus, we get more information out of a constraint than just the number of its violation marks. I then restrict local conjunction in terms of locus of violation.

2.1 Locus for Markedness Constraints

Markedness constraints evaluate well-formedness of the output string (McCarthy & Prince 1995). McCarthy (2003ab) proposes that markedness constraints in addition to the number of violation marks can be distinguished by their locus of violation, called LOC$_{\text{MARK}}$ (also Riggle & Wilson 2004). LOC$_{\text{MARK}}$ is a function mapping a candidate output to a set of loci of violations which are segments in this candidate. This is defined in (6).

[1] An alternative OT proposal for derived environment effects is in McCarthy (2003a). See Lubowicz (2003) for a comparison.

(6) Loc Function for Markedness (cf. McCarthy 2003a)
$\text{LOC}_{\text{MARK}}(\text{output}) \rightarrow \{\text{locus}_1, \text{locus}_2, \ldots\}$, where locus_j is a segment in the output that violates markedness.

The locality function for markedness takes the candidate output as its argument and returns segments that violate a particular markedness constraint.

For example, the locus function for a markedness constraint against voiced obstruents, NOVCDOB, takes the candidate output and returns every C, where C is [-sonorant, + voice]. This is defined in (7). The illustration is in (8).

(7) Loc Function for NOVCDOB
$\text{LOC}_{\text{NOVCDOB}}$= Return every C, where C is [-sonorant, + voice].

(8) Illustration

	NOVCDOB
a. b_1 a_2d_3	b_1, d_3
b. b_1 a_2t_3	b_1
c. p_1 a_2t_3	
d. p_1 a_2d_3	d_3

The table in (8) shows output [bad] with different obstruent voicing in word-initial and word-final positions. Form (8a) contains two segments that violate markedness NOVCDOB. Form (8c) does not violate markedness NOVCDOB since it contains no voiced obstruents. Forms (8b) and (8d) are crucial to our analysis. They have the same number of segments that violate markedness, one segment each, but differ in the location of violations in the segmental string. Under the standard version of markedness (McCarthy & Prince 1995), these two forms would tie. But the locus function for markedness distinguishes between them since it defines locus of violation. Under the proposal in (6), markedness constraints are distinguished by the number of violation marks and/or their location in the string of segments.

2.2 Locus for Faithfulness Constraints

Faithfulness constraints (McCarthy & Prince 1995) militate against input-output disparity. Building on McCarthy (2003ab), I propose that faithfulness constraints can also be distinguished by their locus of violation (see also McCarthy 2004, 2005.) Following Correspondence Theory (McCarthy & Prince 1995), I assume there exists a segmental correspondence relation between the elements of the input and the output, as defined in (9).

(9) Segmental Correspondence Relation (McCarthy & Prince 1995, cf. McCarthy & Wolf 2005)
Given two strings Input and Output, correspondence is a relation $\Re$ from the elements of the Input to those of the Output. Elements $\alpha \in$Input and $\beta \in$Output are referred to as correspondents of one another when $\alpha \Re \beta$.

Given this relation, a candidate consists of the input, the output and the correspondence relation $\mathscr{R}$. In effect, a candidate is a set of ordered input-output pairs, shown in (10).

(10) A Candidate is a set of Ordered Input-Output Pairs
A Candidate = $\mathscr{R}$ (input, output) = $\{(\text{in-locus}_1, \text{out-locus}_1), (\text{in-locus}_2, \text{out-locus}_2)\ldots\}$, where $(locus_i, locus_j)$ is an ordered input-output pair.

For example, a candidate that consists of the input /bad/ and the output [bat] can be defined in terms of a set of ordered input-output pairs, shown below.

(11) Example of a Candidate
A Candidate = $\mathscr{R}$(bad, bat) = $\{(b_1,b_1), (a_2,a_2), (d_3,t_3)\}$

The example in (11) shows a candidate whose input, /bad/, and output, [bat], differ on final obstruent voicing. This is a violation of a faithfulness constraint, IDENT(voice).

We can now define the locality function for faithfulness constraints. I propose that the locality function for faithfulness takes the candidate (the set of ordered input-output pairs), looks for those pairs that violate a particular faithfulness constraint and returns their outputs.

(12) Loc Function for Faithfulness (cf. (6))

$\text{LOC}_{\text{FAITH}}(\mathfrak{R}\text{ (input, output)}) \rightarrow \{\text{locus}_1, \text{locus}_2, \ldots\}$, where $locus_j$ is an out-locus of $\mathfrak{R}$ whose ordered input-output pair violates FAITH.

The locus function for a faithfulness constraint IDENT(voice) returns those output segments whose ordered pair violates IDENT(voice). This is defined in (13) and illustrated in (14).

(13) Loc Function for IDENT(voice)

$\text{LOC}_{\text{IDENT(voice)}}(\mathfrak{R}\text{(bad, bat)}) \rightarrow \text{LOC}_{\text{IDENT(voice)}}(\{(b_1,b_1), (a_2,a_2), (d_3,t_3)\}) \rightarrow \{t_3\}$

(14) Illustration

$/b_1\ a_2\ d_3/$	IDENT(voice)
a. $b_1\ a_2\ d_3$	
b. $b_1\ a_2\ t_3$	t_3
c. $p_1\ a_2\ t_3$	p_1, t_3
d. $p_1\ a_2\ d_3$	p_1

Form (14a) does not violate faithfulness, IDENT(voice). Form (14c) violates faithfulness twice. Forms (14b) and (14d) are crucial to our analysis. They violate faithfulness once but in different locations in the segmental string. Like markedness constraints, faithfulness constraints under the locus proposal are distinguished by the number of violation marks and/or their location in the string of segments and thus are able to distinguish between forms (14b) and (14d).[2]

2.3 Restricted Local Conjunction

We now have the tools to restrict local conjunction. The logic of the argument is as follows. The conjuncts specify locus of violation in their definition. Local conjunction is itself a constraint, thus needs locus of violation. For local conjunction to be interpretable, the conjuncts need to share locus of violation.

To capture this argument, I propose that in local conjunction of markedness and faithfulness constraints, the locality function for markedness (see (6)) and the locality function for faithfulness (see (12)) must share locus of violation. Formally, their loci of violation must intersect and this intersection must be a non-empty set. The locus of violation for local conjunction is the intersection of these sets. This is shown in (15) and (16).

(15) Restricted Local Conjunction (LC)

$C=C_1\&C_2$ is violated iff $\text{LOC}_{C1} \cap \text{LOC}_{C2} \neq \varnothing$

(16) Locus for LC

The locus for local conjunction is the intersection of the sets LOC_{C1} and LOC_{C2}.[3]

By restricting locally conjoined constraints to the ones that share locus of violation, locality follows from the kinds of constraints that are conjoined and is not stated as a free variable (cf. (1)).

[2] Epenthesis and deletion require that a segment be an empty slot (cf. Containment, Prince & Smolensky 1993). See recent work on string correspondence by McCarthy & Wolf (2005).

[3] There are conjunctions where the locus of violation of one conjunct is a superset of the locus of violation of the other or their loci overlap, thus conjunction needs to refer to the intersection (i.e., contextual markedness).

3. Application

This section applies the proposal to Polish. In Polish (Rubach 1984) there are post-alveolar affricates *ǰ* but *ǰ* cannot come from /g/. As argued in Łubowicz (2002), this can be analyzed as markedness and faithfulness conjunction (cf. (4)):

(17) Local Conjunction Analysis (cf. (4))

[*ǰ & IDENT(coronal)]$_{\text{SEGMENT}}$ >> IDENT(continuant)>> *ǰ

The problem is that when the domain of conjunction is too large, we get unattested results (see (5)). I will show below that the domain problem goes away under the restricted version of local conjunction, as defined in (15).

Let us first establish the locus of violation of the relevant markedness and faithfulness constraints, *ǰ and IDENT(coronal). The locus of violation of *ǰ returns every consonant that is a post-alveolar affricate *ǰ* (see (18)). The locus function for IDENT(coronal) returns every output segment whose ordered pair violates IDENT(coronal) (see (19)).

(18) Loc Function for *ǰ

LOC$_{*ǰ}$ = Return every C, where C is a post-alveolar affricate *ǰ*.

(19) Loc Function for IDENT(coronal)

Returns those output segments whose ordered pair violates IDENT(coronal).

We now have the tools to see how these constraints interact in local conjunction.

Local conjunction is violated when the post-alveolar affricate *ǰ* is a result of palatalization. Formally, the conjoined markedness and faithfulness constraints share locus of violation. Consider a candidate with stem-final /g/ in the environment of palatalization which maps onto a fricative [ž] and not an affricate [ǰ].

(20) Local Conjunction Violated

/r$_1$ o$_2$ **g**$_3$+e$_4$k$_5$/	*ǰ & IDENT(coronal)	IDENT(continuant)	*ǰ	IDENT(coronal)
a. r$_1$o$_2$**ǰ**$_3$e$_4$k$_5$	ǰ$_3$!		ǰ$_3$	ǰ$_3$
b. ☞r$_1$o$_2$**ž**$_3$e$_4$k$_5$		ž$_3$		ž$_3$

Candidate (20a) violates local conjunction because the two constraints are violated locally.

Local conjunction is satisfied when the post-alveolar affricate *ǰ* is not a result of palatalization. Formally, the conjoined markedness and faithfulness constraints do not share locus of violation. Consider a candidate with stem initial affricate [ǰ] but palatalization occurring in the suffix.

(21) Local Conjunction Satisfied

/**ǰ**$_1$ e$_2$m$_3$ +i$_4$**k**$_5$+e$_6$k$_7$/	*ǰ & IDENT(coronal)	IDENT(cont)	*ǰ	IDENT(coronal)
a. ☞**ǰ**$_1$e$_2$m$_3$i$_4$**č**$_5$e$_6$k$_7$	√		ǰ$_1$	č$_5$
b. **ž**$_1$e$_2$m$_3$i$_4$**č**$_5$e$_6$k$_7$		ž$_1$!		č$_5$

The candidate (21a) does not violate the locally-conjoined constraint since the constraint violations are in separate locations. Due to the restriction on local conjunction (as defined in (15)), non-local interaction is ruled out.

The locus proposal does not admit self-conjunction of markedness constraints (Alderete 1997, Ito & Mester 1998). I argue that self-conjunction of markedness is different from other types of conjunctions. Unlike other conjunctions, the domain for this conjunction is language-specific (Gouskova 2005). It also requires conjoining constraints against both marked and unmarked segments, which is problematic for the theory. My proposal predicts that self-conjunction is different from other types of conjunctions. See Walker & Rose (2004) for an alternative. Some other conjunctions that do not meet the shared locus requirement include no long-distance spreading (Smolensky 1997, 2005) and *VC syllables (Levelt & van de Vijver 1998). These can be captured in other ways. See work by Gafos (1999) on locality in spreading, and Levelt & van de Vijver (1998) on alternative explanation in terms of foot structure. For discussion of other types of conjunctions, see the Appendix.

4. Markedness Reversals

Certain markedness and faithfulness conjunctions satisfy locality but lead to unattested results, called markedness reversals.[4] For example, the conjunction [NO-CODA & IDENT(voice)]$_{\text{CODA}}$, which prohibits a change of voicing in final obstruents (Ito & Mester 1998), can result in devoicing of all obstruents except those in the coda. This would be the opposite of final devoicing. The markedness reversal ranking is in (23) and the relevant tableau is in (24). The core idea is that voiced obstruents are avoided but not in the coda.

(23) The Markedness Reversal Ranking
[NO-CODA & IDENT(voice)]$_{\text{CODA}}$ >> NOVCDOB>> IDENT(voice)

(24) Markedness Reversal

/**bad**/	[NO-CODA & IDENT(voice)]$_{\text{CODA}}$	NOVCDOB	IDENT(voice)
a. **pat**	*!		**
☞b. **pad**		*	*
c. **bad**		**!	

Candidate (24a) violates the locally conjoined constraint since it devoices a coda obstruent. Candidate (24c), with no devoicing, loses on markedness. Candidate (24b), /**bad**/→[**pad**], which devoices all obstruents except those in the coda, wins under the above ranking. It satisfies the locally conjoined constraint and incurs a minimal violation of markedness.

But this set of mappings is unattested. Thus, in addition to establishing locality of conjunction, we need to filter out conjunctions of the [NO-CODA & IDENT(voice)] type. I will refer to them as markedness reversal conjunctions.[5]

The difference between licit conjunctions and conjunctions that lead to markedness reversals lies in the relation between conjoined faithfulness and markedness constraints. In the Polish conjunction ([*ǰ & IDENT(coronal)]$_{\text{SEGMENT}}$), the violation of IDENT(coronal) results in *ǰ*. It is the faithfulness violation that is responsible for the markedness violation. In the markedness reversal conjunction ([NO-CODA & IDENT(voice)]$_{\text{CODA}}$),on the other hand, the violation of IDENT(voice) is irrelevant to having a coda. Whether you change voicing or not does not change a segment's coda status. The violation of faithfulness is irrelevant to the presence of the marked structure in the output. In those cases, the markedness constraint provides a mere context for the violation of faithfulness. Thus, we need to ensure that the only markedness and faithfulness conjunctions possible are the ones where the violation of faithfulness leads to the markedness violation.

The proposal here is to restrict local conjunction based on locus of violation (section 2-3), and in cases of markedness and faithfulncess conjunctions also require that faithfulness leads to markedness violation (section 4).

(25) Restricted Local Conjunction (LC) (cf. (15))
$C=C_1\&C_2$ is violated iff
(i) $\text{LOC}_{C1} \cap \text{LOC}_{C2} \neq \varnothing$
(ii) C_1 results in C_2 if C_1 is Faithfulness and C_2 is Markedness.

[4] The ideas presented in this section were first raised in my discussion with Alan Prince in 1998.
[5] Other markedness reversal conjunctions include: [PARSE-SYLL & IDENT(F)] - unfooted syllables are more faithful, [WEIGHT-TO-STRESS & IDENT(F)] - unstressed heavy syllables are more faithful etc.

The implicational relation finds support in the nature of local constraint conjunction. Local constraint conjunction (Smolensky 1993) is a logical disjunction, which is equivalent to implication. A locally conjoined constraint is violated iff both conjuncts are violated (in the same domain). The same truth value holds of logical disjunction, C_1 or C_2 ($C_1 \vee C_2$). This is equivalent to implication, if not C_1 then C_2 ($\sim C_1 \rightarrow C_2$).

(26) Local conjunction as logical disjunction

C_1	C_2	$C_1 \vee C_2$	$\sim C_1 \rightarrow C_2$
1	1	1	1
1	0	1	1
0	1	1	1
0	0	0	0

As discussed, the implication relation holds of licit conjunctions but not of markedness reversals.[6]

5. Comparison with Previous Proposals

Previous proposals on how to restrict local conjunction can be divided into those that limit conjunction by either the domain or the type of conjunct.

It has long been recognized that we need to define the domain of conjunction. Smolensky (1993) proposes that the domain of conjunction is an independently required phonological constituent (e.g., syllable, segment). Though addressing the issue of the domain, this proposal does not avoid the non-local interaction problem discussed in section 3 because the domain can be too large. There is no limit on how big the relevant phonological constituent may be. Considering this issue, Lubowicz (2002) proposes that the domain for local conjunction is the smallest domain within which both of the locally-conjoined constraints can be evaluated. Though addressing the problem of non-local interaction, this proposal gives no definition on how to determine “the smallest domain”. Finally, Moreton & Smolensky (2002) propose that constraints which do not share a “common domain” cannot be conjoined. Again, there is no restriction on the size of the common domain. All three proposals address the domain issues in some way but none solves the markedness reversal problem discussed in section 4.

There is another set of proposals that limits local conjunction by the type of constraints that can be conjoined and thus indirectly addresses the markedness reversal problem. Hewitt & Crowhurst (1996), for example, propose that only constraints that share a fulcrum (an argument) can be conjoined. In their proposal, fulcrum is not defined and the proposal places no restriction on the domain. Similarly, Bakovic (2000, 1999) proposes that each conjunct mentions a particular feature also mentioned in the other conjunct (called, co-relevance). This proposal does not solve the domain problem either. Fukazawa & Miglio (1998) suggest that conjunctions are restricted to constraint families. Under their proposal, markedness and faithfulness conjunctions are prohibited.

This article has addressed both the domain problem and the type of conjunct and presented a uniform and falsifiable solution.

6. Conclusion

This article has defined a restricted version of local constraint conjunction. The proposal is that every constraint has a locus of violation (McCarthy 2003ab, 2004). Since local conjunction is itself a constraint it also needs a locus. Crucially, its locus of violation is interpretable only when the conjuncts

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[6] I am aware of two cases from the literature that do not meet this requirement. These are coda processes in German (Ito & Mester 2002) and morphologically-derived environments (Lubowicz 2002). I would argue that the conjunction in Ito & Mester (2002) would fall under this requirement if we assumed a more restricted version of markedness (against derived *k*) that participates in the conjunction. Lubowicz’s (2002) conjunction, in turn, involves anchoring. Anchor is partly a markedness constraint (Zoll 1997), thus it is likely that this conjunction does not need to meet the requirement F→M.

share their locus. Thus, conjunction is a priori local. In case of markedness and faithfulness conjunctions, it has been argued that the constraints in addition need to enter into a causal relation with each other rather than provide a mere context of violation. This follows from the truth value of local constraint conjunction.

The evidence for a restricted local conjunction was from markedness and faithfulness conjunction, but see the appendix for other conjunctions. This restricted version of local conjunction has advantages over non-restricted version as it solves the domain problem and rules out markedness reversals.

Appendix: Other Conjunctions

Conjunction	Properties	Source
Markedness and Faithfulness Conjunctions		
Derived Environment Effect [*V: & IDENT(μ)]$_{Seg}$	Locus – yes F→M – yes	Lubowicz (2002)
Assimilation to the Unmarked [*[-ATR] & IDENT(ATR)]$_{Seg}$	Locus – yes F→M – yes	Bakovic (2000), Sasa (2004)
Restrictions on Spreading in Lango [*-ATR/+Hi & IDENT(ATR)]$_{Seg}$	Locus – yes F→M – yes	Smolensky (1997)
Faithfulness Conjunctions		
Chain Shifts in Nzɛbi [IDENT(high) & IDENT(ATR)]$_{Seg}$	Locus-yes	Kirchner (1996)
Partial Assimilation in Fyem [IDENT(high) & IDENT(back)]$_{Seg}$	Locus –yes	Beckman (2003)
Markedness Conjunctions		
Coda Condition [*VoiObs & *Coda & *DorsPlos]$_{Coda}$	Locus-yes	Ito & Mester (1998)
Sonority Hierarchy $\text{ONS}^4 >> \text{ONS}^3 >> \text{ONS}^2 >> \text{ONS}$	Locus-yes	Smolensky (1993), Baertsch (2002)
Headedness in Vowel Harmony [*-ATR/+Front & *Domain/Head]$_{Seg}$	Locus-yes	Smolensky (1997)

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Abbreviations:
CLS = (Proceedings of the) Chicago Linguistics Society
NELS = (Proceedings of the) Northeast Linguistics Society
ROA = Rutgers Optimality Archive (http://ruccs.rutgers.edu/roa.html)
WCCFL = (Proceedings of the) West Coast Conference on Formal Linguistics

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