

Targeted Constraint Optimality Theory and Overlapping Violations*

Joan Chen-Main

Johns Hopkins University

1. Introduction

This paper compares and contrasts Targeted Constraint Optimality Theory (TCOT) (Wilson, in prep) and rule-based phonology. Though the two systems share striking similarities, the TCOT system provides an analysis for a pattern involving overlapping violations that is difficult for the rule-based system. This pattern is attested in Acoma accent loss.

The difficulties for classic OT that preceded the development of TCOT are discussed in section 2. Section 3 introduces TCOT and highlights its similarities to rule-based phonology. Section 4 introduces the Acoma data. Section 5 compares Anderson's (1974) rule-based account with a TCOT account of the Acoma data. Section 6 argues for TCOT's place within the field's shifts from rule based theory to OT to variations of OT that incorporate aspects of traditional generative phonology. I will argue that Wilson's most recent version of TCOT is most accurately viewed as a system of rules and constraints but much more fully formalized than pre-OT proposals (e.g. Paradis 1988, Myers 1991).

2. Classic Optimality Theory: Motivations for Refinement

At the heart of Optimality Theory (Prince and Smolensky 1993/2004) is the notion that a surface form is the resolution of conflicting constraints rather than the result of rewrite rules. The architecture of competing constraints allows the exceptions to an otherwise general phonological pattern to be straightforwardly stated. Indeed, "Do X *only* when . . ." patterns and "Do X *except* when . . ." patterns are predicted by the theory.

* Special thanks to Paul Smolensky, Colin Wilson, Luigi Burzio, Bob Frank, Gaja Jarosz, and Sara Finley for their helpful discussion, encouragement, and valuable feedback. For a leaner, more to-the-point version, please see Chen-Main, Joan. (to appear) Rules, Constraints, and Overlapping Violations: the case of Acoma accent loss. Tatjana Scheffler et. al., eds. *Proceedings of the 30th Annual Penn Linguistics Colloquium*. University of Pennsylvania, Philadelphia.

(3) Nasal spreading constraint

SPREAD-R([+nasal], PrWd): For every [+nasal] autosegment n , assign 1 violation for every segment in the same prosodic word that is to the right of n 's domain.

It is this kind of non-local constraint that Wilson finds problematic. Consider the surface form of the hypothetical input /nawakast/ in a system with the non-local spreading constraint given in (2), SPREAD-R([+nasal], PrWd) and *CC#, a standard constraint against word-final consonant clusters. Suppose the latter, *CC#, eliminates word-final consonant clusters by forcing epenthesis, as exhibited in /dawakast/ → [dawakasət]. Wilson asks us to consider, however, the output form that this system favors when given the hypothetical input /nawakast/.

(4) Non-local blocking of vowel epenthesis

/nawakast/	SPREAD-R([+nasal], PrWd)	*CC#
a. nãwãkasət	*****!	
b. nãwãkast	****	*

Because of its epenthetic vowel, the candidate in (4a) incurs one additional violation of SPREAD-R([+nasal], PrWd). Repairing /nawakast/ in this system would exhibit non-local blocking of epenthesis. As Wilson notes, the predicted pattern is as follows:

“Vowel epenthesis applies to a form with a final cluster *except when* there is a preceding [+nasal] feature anywhere in the word that is blocked from spreading to the right edge.

This is obviously problematic, because naturally-occurring epenthesis processes are never sensitive to this type of global, feature-based condition. Any real language that maps /dawakast/ to an output with an epenthetic vowel will also do the same for /nawakast/; the [nasal] feature of the segment at the left edge will not have any influence on epenthesis at the right edge. But non-local spreading constraints predict that such distal effects are possible.”

(Wilson, in prep)

3. Targeted Constraint Optimality Theory

Wilson’s (in prep) alternative version of OT, Targeted Constraint OT (TCOT), is a derivational framework that extends the theory in Wilson (2001). TCOT both predicts opacity effects and avoids the sort of non-local interactions illustrated above. Because the framework is as yet unpublished, a significant amount of space is devoted to motivating and describing TCOT.

3.1 The Proposed System

TCOT is not the first variation of OT to incorporate a derivational aspect. However, there are several novel aspects of theory:

- 1) How changes are evaluated:
Individual constraints reward certain changes but penalize others.
- 2) How change is integrated:
Changes are introduced by GENs, each of which is associated with a particular markedness constraint.

Both aspects utilize both pieces of information carried by targeted constraints: marked patterns and the preferred repair. The latter is information that is not carried by non-targeted markedness constraints, which can be thought of as statements of marked or unmarked patterns.

- (5) Formal proposal for a targeted constraint (Wilson, in prep)
A targeted constraint C is a pairing of a locus of violation (λ) with a change (δ).

Wilson's claim is that δ is limited to the minimal perceptual change (e.g. Steriade's 2001 P-map). The formal machinery, however, allows any rewrite rule to have a targeted constraint analogue. For example, a relatively complex rewrite rule, such as (6), can be converted into a targeted constraint, as in (7). The rewrite part of the rule, the section to the left of the slash, corresponds to δ . The context part of the rule plus the segment to be changed, the section to the right of the slash, corresponds to λ . The symbol "T:" indicates that the constraint is targeted.

- (6) $V \rightarrow [-\text{accent}] / [+obst] ___ [+obst] C_0 [+ \text{syll}, + \text{accent}]$

- (7) T:*CLASH:
 λ : two consecutive [+accent] syllables, where the first vowel is short and is flanked on both sides by an obstruent.
 δ : [+accent] \rightarrow [-accent] in the first syllable

Note that because an accented syllable may be either the target or the context of a change, a segment may be simultaneously part of two instances of λ . These are the cases we refer to as *overlapping violations*.

The first novel aspect, a revision of how candidates are generated, is motivated by the proof in Moreton (1996/2004) that unfaithful outputs only occur when markedness constraints are ranked highly enough. TCOT places the responsibility of candidate generation largely on GENs associated with each targeted-constraint. For each constraint C, there is a constraint-specific GEN_C that takes as a single candidate as an input and returns a set of candidate as an output. The candidates in the output of GEN_C are derived by applying change δ to zero or more instances of λ in the input candidate. For example,

Targeted Constraint Optimality Theory and Overlapping Violations

given an input with two overlapping violations, $C\acute{V}C\acute{V}C\acute{V}$, $GEN_{T:*CLASH}$ produces four candidates:

0 applications of δ	$C\acute{V}C\acute{V}C\acute{V}$	completely faithful candidate
1 application of δ	$CVC\acute{V}C\acute{V}$	δ applies to left λ
1 application of δ	$C\acute{V}CVC\acute{V}$	δ applies to right λ
2 applications of δ	$CVCVC\acute{V}$	δ applies to both λ 's

Thus, $GEN_{T:*CLASH}(C\acute{V}C\acute{V}C\acute{V}) = \{C\acute{V}C\acute{V}C\acute{V}, CVC\acute{V}C\acute{V}, C\acute{V}CVC\acute{V}, CVCVC\acute{V}\}$.²

The second novel aspect, how changes are evaluated, requires that each member of the set of candidates generated by GEN_C be evaluated relative to the particular input form from which it was derived.

(8) Constraint evaluation in TCOT

Let C be any constraint that specifies both a locus λ and a change δ ,

x be an input representation to GEN_C ,

y be a member of $GEN_C(x)$, and

Δ be the change from x to y .

a. For every $\lambda \in C(y)$, assign one mark to y .

b. For every $\lambda \in C(x)$ that is repaired in the way specified by δ , remove one mark from y .

b'. For every $\lambda \in C(x)$ that is repaired in a way not specified by δ , add one mark to y .³

Let us see how the members in our earlier example output set, $GEN_{T:*CLASH}(C\acute{V}C\acute{V}C\acute{V}) = \{C\acute{V}C\acute{V}C\acute{V}, CVC\acute{V}C\acute{V}, C\acute{V}CVC\acute{V}, CVCVC\acute{V}\}$, are evaluated. . The tableau in (9) shows us that the candidate most preferred by our example targeted constraint is the fourth candidate, the candidate in which all violations λ of $T:*CLASH$ are repaired as specified by δ .

²In Wilson's conception of the TCOT architecture, candidate prosodic parses arise from GEN_{Pros} , which is not associated with a targeted-constraint. GEN_{Pros} is more similar to the classic OT notion of GEN in that the members in its output set are not determined by applying a specific repair. When it applies to the output set of GEN_C , GEN_{Pros} adds all universally-possible prosodic parses of the candidates. If x is the original candidate, then the resulting candidate set is $GEN_{Pros}(GEN_C(x))$. For our purposes, we will not need to make a distinction between two types of $GENs$.

³For (b'), Wilson's formalization actually states that for every $\lambda \in C(x)$ that is repaired in a way not specified by δ , one mark is removed from the completely faithful candidate. However, he later states, "The alternative solution would be to *add* a mark to y ." For Wilson, the two formalizations of b' are equivalent because he compares only two candidates at a time. His examples have only one violation and thus, only one y . The version here facilitates comparison between more than two candidates at a time.

(9) Example Evaluation

input x : $\tilde{C}\tilde{V}\tilde{C}\tilde{V}\tilde{C}\tilde{V}$

Candidate y	Violations that remain	Violations fixed as specified by δ	Violations fixed, but not as specified by δ	Total
$\tilde{C}\tilde{V}\tilde{C}\tilde{V}\tilde{C}\tilde{V}$	+2	0 + 0	0 + 0	= +2
$\tilde{C}\tilde{V}\tilde{C}\tilde{V}\tilde{C}\tilde{V}$	+1	(-1) + 0	0 + 0	= 0
$\tilde{C}\tilde{V}\tilde{C}\tilde{V}\tilde{C}\tilde{V}$	0	0 + (-1)	+1 + 0	= 0
$\tilde{C}\tilde{V}\tilde{C}\tilde{V}\tilde{C}\tilde{V}$	0	(-1) + (-1)	0 + 0	= -2

The targeted constraint continues to generate candidates and evaluate until a faithful pairing wins. In our example, $\tilde{C}\tilde{V}\tilde{C}\tilde{V}\tilde{C}\tilde{V}$ becomes the new input to $\text{GEN}_{\text{T}:\text{*CLASH}}$. Since there are no λ 's in $\tilde{C}\tilde{V}\tilde{C}\tilde{V}\tilde{C}\tilde{V}$, the output set $\text{GEN}_{\text{T}:\text{*CLASH}}(\tilde{C}\tilde{V}\tilde{C}\tilde{V}\tilde{C}\tilde{V}) = \{\tilde{C}\tilde{V}\tilde{C}\tilde{V}\tilde{C}\tilde{V}\}$. As there is only a single member of the output set, it is necessarily the preferred candidate of $\text{GEN}_{\text{T}:\text{*CLASH}}$ at this step of the derivation. The faithful candidate is the winning candidate, so the system moves on: $\tilde{C}\tilde{V}\tilde{C}\tilde{V}\tilde{C}\tilde{V}$ becomes the input to the GEN_{C} associated with next highest ranked targeted constraint. The architecture of the whole system is given below.

(10) Derivational TCOT (Wilson's (33) repeated)

Let $H = [C_1 \gg C_2 \dots \gg C_n]$ be any constraint hierarchy and in be any input.

- a. The initial output, out_0 , is the surface form that is identical to in .
- b. For every constraint C_k where $(1 \leq k \leq n)$, an output is derived by repeatedly generating with $[\text{GEN}_{\text{Pros}} \circ \text{GEN}_{\text{Ck}}]$ and selecting the most harmonic member of the candidate set with the entire hierarchy H .
 - i. The initial output for C_k , $out_{k,0}$, is equal to out_{k-1} .
 - ii. For $m > 0$, $out_{k,m} = \text{H-max}([\text{GEN}_{\text{Pros}} \circ \text{GEN}_{\text{Ck}}](out_{k,m-1}))$.
If $out_{k,m} = out_{k,m-1}$, then the final output for C_k , out_k , is equal to $out_{k,m}$ and generation with C_k ends.
- c. The final output of the last constraint, out_n , is the output that the grammar generates for input in .

3.2 TCOT and Rule-based Phonology

The presentation thus far emphasizes the aspects shared by TCOT and rule-based phonology. Both specify preferred repairs, generate intermediate representations, and avoid difficulties of classic OT. Note that in our example, the outcome in (9) is the same outcome expected in a rule-based framework where an output form is rewarded for each application of the rewrite rule. In fact, the same profile of output wellformedness can be obtained by rewarding an output form by subtracting (-2) for each rule application from the output form's "wellformedness score" from the number of times the input form satisfied the conditions for the rewrite rule to apply.

(11) Outcome of Rewarding Rule Application

input x : CVCVCV

Output y	Number of times rewrite rule could apply	(-2) reward for each rule application	Total
CVCVCV	2	0 * (-2)	= +2
CVCVCV	2	1 * (-2)	= 0
CVCVCV	2	1 * (-2)	= 0
CVCVCV	2	2 * (-2)	= -2

Such striking similarities raise the question of whether or not TCOT and rule-based phonology are in fact notational variants of one another. It is unclear whether one is to be preferred over the other on principled grounds. For Wilson, the notion of minimal perceptual change sets the δ of targeted constraints apart from the stipulative changes of rewrite rules. It is not clear yet, however, that all observed changes can be independently perceptually motivated or that the notion of minimal perceptual change could not be incorporated into rule-based theory as well. What is clear, however, is that that the architectures of the two systems diverge. TCOT retains the notion of competing output candidates evaluated against a set of ranked, violable constraints. In the next section, we see how this allows TCOT to straightforwardly account for a pattern that is difficult for rules.

Additionally, I would now like to make explicit an assumption that I believe is in line with Wilson (in prep): All constraints are persistent in the sense that they still penalize forms that violate them even when it is not “their turn” to generate candidates. That is, when C_i is generating and evaluating candidates, all $C_{j \neq i}$ function just like regular markedness constraints (i.e. $*\lambda$). $C_{j \neq i}$ only assign marks by looking at the output. When C_i is generating and evaluating candidates, I will call C_i the *active* or *current* constraint.

4. Accent loss in Acoma

Acoma is a Native American language spoken by the people group of the same name. Acoma pueblo, also called Sky City, is said to be the oldest continuously inhabited city in the United States and is located about sixty miles west of Albuquerque, New Mexico. Acoma is closely related to other pueblo languages, which together make up the Keres language family. The data given here are drawn from Miller’s (1965) book.

Miller’s (1965) work includes a pattern of accent assignment that is of special interest to Anderson (1974), as it is relevant to his proposal for how to apply a rule to a form. Anderson (1974) describes the complex pattern as follows.⁴ In Acoma, one of

⁴Anderson uses /a/ where Miller has used /a/. I keep the examples as they appear in Miller (p84), because he describes the vowel as a low to lower-mid front unrounded vowel (p 15).

three accents can appear on a given vowel: a high pitch (marked with an acute accent); a falling pitch (marked with a circumflex); and a ‘glottal’ falling pitch (marked with a glottal stop). The pattern is not easily characterized, but for a large group of forms, accent assignment is systematic. This is the set of forms which contain suffixes conditioning what Miller calls ‘accent ablaut’. Approximately twelve suffixes are ablauting suffixes, and when one is present, the high accent is assigned to every syllable of the word (together, in some cases, with the lengthening of the final vowel)⁵.

(12) A form with accent ablaut vs. a form without accent ablaut

- a. with accent ablaut: r ú u n í š í i z é ‘on Monday’
 b. without accent ablaut: r û u n i š i ‘Monday’

Miller also noted that certain circumstances lead to subsequent loss of the high accents assigned by the accent ablaut rule: a short syllable between obstruents followed by an accented syllable loses its accent.⁶ In the examples given below, a vowel that has lost its accent is underlined and italicized. Anderson’s rule for this change is the rewrite rule given above in (6) in illustrating how a targeted constraint analogue can be created from a rewrite rule. It is repeated below:

(13) $V \rightarrow [-\text{accent}] / [+obst] \text{ ____ } [+obst] C_0 [+ \text{syll}, + \text{accent}]$

Anderson uses the term *context* to refer to the conditions for rule application and *focus* to refer to the segments that satisfy the conditions. Examples of accent loss in a form containing a single focus are given in (14). A vowel that has lost its accent is denoted with underling and italicization.

(14) Examples of accent loss in forms with ablauting suffixes.

- a. k *b* é n í ‘at sunset’
 b. š *i* s í u s d y á n í ‘when I roped him’
 c. ʔ ú u b *ə* k’ á a k’ á c i # ‘nail’
 d. s í u k *ə* č á n í ‘when I saw him’
 e. s é i n ú u s t’ *ə* z í m í ‘when I put the fire out’

When two consecutive vowels meet the conditions for application of the rule in (6/13), more than one syllable can lose its accent. This is particularly interesting because

⁵Certain final syllables are exceptions, but this will not affect our discussion.

⁶Short syllables adjacent to a glottalized sonorant also lose their accents. Again, this will not affect our discussion.

Targeted Constraint Optimality Theory and Overlapping Violations

one focus of the rule may be part of the context for another possible application of the rule. That is, there is the potential to bleed a reapplication of a rule, though it seems that this is not what happens:

(15) Multiple accent loss when two foci are present (Miller p.84)

- a. k' a p i š ó n í 'at night'
- b. š' a p a g á n í# 'early evening'
- c. s' i p a k á a w á n í 'when I chopped wood'
- d. k' a c a k á n' í 'his cigarettes'

This pattern can be accommodated with directional rule application. If we posit the rule to apply right to left, we predict an incorrect form. If we posit the rule to apply left to right, we predict the correct form. (This pattern can also be accounted for if rules apply simultaneously to all foci of violation, the proposal discussed in Anderson (1974).)

(16) Derivation if the rule in (13) applies left to right:

- k' (á) p (í) š ó n í# # two foci for accent loss
- k' a p (í) š ó n í (13) applies to the leftmost focus
- k' a p i š ó n í (13) then applies to the next-leftmost focus

There are also forms that have three consecutive foci that are also part of one another's context. This time, however, it is not the case that all three lose their accents.

(17) Multiple accent loss when three foci are present

- a. k a z á c a k á n' í 'your cigarettes'
- b. k a g ó c a d í n.í 'when it was in bloom'
- c. s u č í t i s t á n í 'when I was thinking'

Again, this pattern can, by itself, be accommodated with directional rule application, but only inconsistently with the account in (16). If we posit the rule to apply left to right, we predict an incorrect form. If we posit the rule to apply right to left, we predict the correct form. (Simultaneous application wrongly predicts that the rule changes all three foci of violation.)

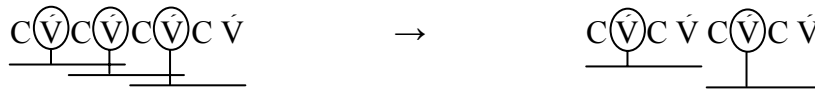
(18) Derivation if the rule in (13) applies right to left:

- # $s\overset{\circ}{\underset{\circ}{\dot{u}}}\overset{\circ}{\underset{\circ}{\dot{c}}}\overset{\circ}{\underset{\circ}{\dot{i}}}\overset{\circ}{\underset{\circ}{\dot{t}}}\overset{\circ}{\underset{\circ}{\dot{i}}}$ s t á a n í three foci for accent loss
- # $s\overset{\circ}{\underset{\circ}{\dot{u}}}\overset{\circ}{\underset{\circ}{\dot{c}}}$ í t í s t á a n í (13) applies to the rightmost focus.
Context for second-rightmost focus is destroyed
- # s u $\overset{\circ}{\underset{\circ}{\dot{c}}}$ í t í s t á a n í (13) applies to the third-rightmost focus.

The problem is that the rule in (13) must apply from left to right to account for the pattern in (16), while the same rule must apply in the other direction to account for the pattern in (18). The rules cannot be reformulated to avoid this inconsistency.

Anderson's solution is the following. First, identify all the contexts for a rule, denoted here with a bar, and all the foci for a rule, denoted with a circle. If any context for a rule contains a focus for the same rule, eliminate the minimal number of (focus+context) units from consideration to yield independent (focus+context) units. Indeterminacies, such as in the two-foci case, are resolved by choosing to maximize feeding and minimize bleeding. Such a solution must store multiple partial derivations, as choosing the derivation that maximizes rule application requires looking very far "downstream." Also illustrated by the two-foci case, some rules must be allowed to reapply.

(19) All potential rule applications and independent rule applications



The Acoma accent loss pattern can be accommodated within classic OT, so long as the constraints can distinguish between undergoers and non-undergoers of accent loss.

5. TCOT and Overlapping Violations

5.1 A Constraint Ranking for Acoma Accent Loss

Because the goal here is to compare the patterns allowed by the machinery of TCOT with those allowed by rules, using a targeted constraint that is transparently related to Anderson's rule makes comparison maximally straightforward. We have already introduced such a targeted-constraint in (7), and we repeat it in (20a). The remaining markedness constraints used in this analysis are modified constraints from the stress literature (Prince and Smolensky 1993/2004, Gordon 2002). *LAPSE-ACCENT is similar to FT-BIN: feet are binary under moraic or syllabic analysis (Prince and Smolensky 1993/2004). *EXTLAPSE-ACCENT is an extension of *LAPSE-ACCENT (Gordon 2002): whereas the latter penalizes two consecutive unaccented syllables, the former penalizes three consecutive unaccented syllables. T:*CLASH is similar to *CLASH: no stressed

syllables are adjacent (Lieberman 1975).⁷ In the analysis given here, only the constraint T:*CLASH is crucially a targeted constraint. The other two markedness constraints need not be targeted.⁸ For ease of explication, the discussion below assumes *EXTLAPSE-ACCENT and *LAPSE-ACCENT are untargeted markedness constraints of the usual kind.⁹

(20) Constraints used in TCOT analysis of Acoma accent loss

T:*CLASH:

λ: two consecutive [+accent] syllables, where the first vowel is short and is flanked on both sides by an obstruent.

δ: [+accent] → [-accent] in the first syllable

*LAPSE-ACCENT: penalize two consecutive unaccented syllables

*EXTLAPSE-ACCENT: penalize three consecutive unaccented syllables

FAITH-ACCENT: penalize changes in a syllable's accent

The ranking below yields the desired result:

(21) *EXTLAPSE-ACCENT >> T:*CLASH >> FAITH-ACCENT, *LAPSE-ACCENT

In the two overlapping λ's case, schematized as CVCVCV, T:*CLASH will prefer the form with two repairs, schematized as CVCVCV. Though this form violates *LAPSE-ACCENT, T:*CLASH's higher ranking overrides the preference of *LAPSE-ACCENT, making CVCVCV the correctly predicted output form.

In the three overlapping λ's case, schematized as CVCVCVCV, T:*CLASH will again most prefer the form with the maximum number of repairs, schematized as CVCVCVCV. The form with three repairs, however, violates the higher ranked *EXTLAPSE-ACCENT. T:*CLASH's next-most preferred candidates are those forms with two repairs: CVCVCVCV, CVCVCVCV, and CVCVCVCV. Among these three, only the latter satisfies *LAPSE-ACCENT. Thus, CVCVCVCV is the correctly predicted output.

Let us consider the derivation of (15a), [k'apíšóní], our example of the case of two overlapping λ's. We begin with the form that results after accent ablaut has assigned a high accent to every syllable, which we follow Miller in taking to be /k'ápíšóní/. At

⁷ Admittedly, the formulation of T:*CLASH that facilitates comparison with rules penalizes a very specific pattern. While there is certainly an aesthetic regarding acceptable constraints, the notion of a good constraint has not yet been formalized. T:*CLASH, as is, is certainly a possible targeted constraint. Further, note that it is possible to formulate T:*CLASH more generally (e.g. penalize two adjacent accented syllables) if we were also to include either a FAITH-NASAL-SYLLABLE or *UNACCENTED-NASAL-SYLLABLE CONSTRAINT. Either of these could be part of a hierarchy that interacts with T:*CLASH.

⁸Using targeted versions actually will not change the predictions. A discussion that treats all these markedness constraints as targeted is available upon request.

⁹This analysis owes significantly to direct suggestions by C. Wilson (p.c.).

Chen-Main

step 1, it is evaluated against *EXTLAPSE-ACCENT. Recall that candidate generation is the work of targeted markedness constraints. Since *EXTLAPSE-ACCENT is not targeted, no new candidates will be generated. As the only candidate, the faithful form will be the most harmonic candidate. Since the input is the same as the output, we can move to step 2, evaluation against T:*CLASH.

(22) Steps 0-1 for the derivation of [k'apĩšóní]

Step	Input	Candidate set	Output	Comments
0	k'ápíšóní		k'ápíšóní	
1	k'ápíšóní	{ k'ápíšóní }	k'ápíšóní	No change

There are two violations of T:*CLASH. As we saw in the generic CVCVCV example above in subsection 3.1, at step 2, GENT:*CLASH produces four candidates, the completely faithful candidate, the candidate where δ is applied to both λ 's, and two candidates where δ is only applied to one λ . Since targeted constraints will always prefer the form in which δ applied maximally, the most harmonic candidate is the one in which δ is applied to both loci of violation..

(23) T:*CLASH chooses [k'apĩšóní]:

k'ápíšóní#	*EXT LAPSE-ACCENT	T:*CLASH	FAITH-ACCENT	*LAPSE-ACCENT
k'ápíšóní#		k'ápí : violation +1 píšó: violation +1 Total = 2 (!)		
k'ápĩšóní#		k'ápĩ : not fixed as in δ : +1 pĩšó: fixed as in δ : -1 Total = 0 (!)	*	
k'apíšóní#		k'apí : fixed as in δ : -1 píšó: violation +1 Total = 0 (!)	*	
→ k'apĩšóní		k'apĩ : fixed as in δ : -1 pĩšó: fixed as in δ : -1 Total = -2	**	*

(24) Steps 0–2,2 for the derivation of (k'ápišóní, k'ap̣išóní)

Step	Input	Candidate set	Output	Comments
0	k'ápišóní		k'ápišóní	
1	k'ápišóní	{k'ápišóní}	k'ápišóní	No change
2, 1	k'ápišóní	GEN _T :*CLASH(k'ápišóní) = {k'ápišóní, k'ápišóní, k'ap̣išóní, k'ap̣išóní}	k'ap̣išóní	Loss of accent on both loci of violation
2, 2	k'ap̣išóní	GEN _T :*CLASH(k'ap̣išóní) = {k'ap̣išóní}	k'ap̣išóní	No change

Faithfulness constraints do not have an associated GEN_C, so FAITH-ACCENT does not generate any candidates. Non-targeted markedness constraints do not have an associated GEN_C either, so *LAPSE-ACCENT also does not generate any candidates. For concreteness, we arbitrarily assign the third position in the hierarchy to FAITH-ACCENT and the fourth position to *LAPSE-ACCENT.

(25) Derivation chart for (k'ápišóní, k'ap̣išóní)

Step	Input	Candidate set	Output	Comments
0	k'ápišóní		k'ápišóní	
1	k'ápišóní	{k'ápišóní}	k'ápišóní	No change
2, 1	k'ápišóní	GEN _T :*CLASH(k'ápišóní) = {k'ápišóní, k'ápišóní, k'ap̣išóní, k'ap̣išóní}	k'ap̣išóní	Loss of accent on both loci of violation
2, 2	k'ap̣išóní	GEN _T :*CLASH(k'ap̣išóní) = {k'ap̣išóní}	k'ap̣išóní	No change
3	k'ap̣išóní	k'ap̣išóní	k'ap̣išóní	No change
4	k'ap̣išóní	k'ap̣išóní	k'ap̣išóní	No change

Having seen how TCOT can provide an account of the pattern in (15), let us turn to the pattern in (17). We will use [súci'tístáani], (17c), as our example of the case of three overlapping λ's. We follow Anderson in assuming the form that results after accent ablaut has assigned a high accent to every syllable is /súci'tístáani/. At step 1, it is evaluated against *EXTLAPSE-ACCENT. As before, *EXTLAPSE-ACCENT, generates no candidates. Again, the most harmonic candidate is the only candidate, the faithful form. Since the input is the same as the output, we move to step 2.

(26) Steps 0-1 for the derivation of [*sucítistáani*]

Step	Input	Candidate set	Output	Comments
0	sucítistáani		sucítistáani	
1	sucítistáani	{ sucítistáani }	sucítistáani	No change

There are three violations of T:*CLASH. At step 2,1 GENT:*CLASH produces eight candidates; each locus of violation may remain as is or have delta applied. *EXTLAPSE-ACCENT eliminates the candidate where delta applies to all three loci from the competition. Thus, T:*CLASH chooses the three candidates where delta applies to two loci as most harmonic: *sucítistáani*, *sucítistáani*, and *sucítistáani*. These are the candidates where accent loss occurs on the second and third syllable, the first and third syllable, and the first and second syllable, respectively. Thus, they all violate FAITH-ACCENT equally. When the three are subsequently evaluated by *LAPSE-ACCENT, *sucítistáani#* and *#sucítistáani* are eliminated. This leaves *sucítistáani*, the candidate one where δ is applied to the first and third loci of violation and the middle syllable is unchanged, as the most harmonic candidate. Since the input to step 2,1 and the output to 2,1 are different, GENT:*CLASH remains active. When the remaining candidate, *sucítistáani*, is given as the input to GENT:*CLASH at step 2,2, there is no locus of violation, so the output is the faithful candidate.

Targeted Constraint Optimality Theory and Overlapping Violations

(27) T:*CLASH chooses [súçítístáaní]:

súçítístáaní	*EXT-LAPSE-ACCENT	T:*CLASH	FAITH-ACCENT	*LAPSE-ACCENT
súçítístáaní		súçí: violation +1 çítí: violation +1 tístáa: violation +1 Total = +3 (!)		
súçítístáaní		súçí: violation +1 çítí: not fixed as in δ : +1 tístáa: fixed as in δ : -1 Total = +1 (!)	*	
súçítístáaní		súçí: not fixed as in δ : +1 çítí: fixed as in δ : -1 tístáa: violation +1 Total = +1 (!)	*	
súçítístáaní		súçí: not fixed as in δ : +1 çítí: fixed as in δ : -1 tístáa: fixed as in δ : -1 Total = -1	**	*!
súçítístáaní		súçí: fixed as in δ : -1 çítí: violation +1 tístáa: violation +1 Total = +1 (!)	*	
→ súçítístáaní		súçí: fixed as in δ : -1 çítí: not fixed as in δ : +1 tístáa: fixed as in δ : -1 Total = -1	**	
súçítístáaní		súçí: fixed as in δ : -1 çítí: fixed as in δ : -1 tístáa: violation +1 Total = -1	**	*!
súçítístáaní	*!	súçí: fixed as in δ : -1 çítí: fixed as in δ : -1 tístáa: fixed as in δ : -1 Total = -3	***	

As above, neither FAITH-ACCENT nor *LAPSE-ACCENT generates any new candidates. As the only candidate, the faithful form will be the most harmonic candidate at step 3 and step 4. Since the input is the same as the output, we are finished.

(28) Derivation chart for (sú[́]cítí[́]stá[́]aní, sú[́]cítí[́]stá[́]aní)

Step	Input	Candidate set	Output	Comments
0	sú [́] cítí [́] stá [́] aní		sú [́] cítí [́] stá [́] aní	
1	sú [́] cítí [́] stá [́] aní	sú [́] cítí [́] stá [́] aní	sú [́] cítí [́] stá [́] aní	No change
2, 1	sú [́] cítí [́] stá [́] aní	GEN _T :*CLASH(sú [́] cítí [́] stá [́] aní) = { sú [́] cítí [́] stá [́] aní, sú [́] cítí [́] stá [́] aní, sú [́] cítí [́] stá [́] aní, sú [́] cítí [́] stá [́] aní, sú [́] cítí [́] stá [́] aní, sú [́] cítí [́] stá [́] aní, sú [́] cítí [́] stá [́] aní, sú [́] cítí [́] stá [́] aní }	sú [́] cítí [́] stá [́] aní	Loss of accent on first and third syllables
2, 2	sú [́] cítí [́] stá [́] aní	GEN _T :*CLASH(sú [́] cítí [́] stá [́] aní) = { sú [́] cítí [́] stá [́] aní }	sú [́] cítí [́] stá [́] aní	No change
3	sú [́] cítí [́] stá [́] aní	{ sú [́] cítí [́] stá [́] aní }	sú [́] cítí [́] stá [́] aní	No change
4	sú [́] cítí [́] stá [́] aní	{ sú [́] cítí [́] stá [́] aní }	sú [́] cítí [́] stá [́] aní	No change

5.2 Constraint Re-rankings

By virtue of retaining the OT architecture, TCOT also inherits the attribute of predicting typologies. We have already seen that the ranking in (21) simulates Anderson's proposed rule application process. The three other types of rule application discussed by Anderson, simultaneous, left-to-right, and right-to-left, can be simulated by re-ranking the constraints used in (21). When T:*CLASH is ranked above both *EXTLAPSE and *LAPSE, the winning candidates are those that remove the accents from all λ , the same outcome predicted by simultaneous rule application and left-to-right application. If instead T:*CLASH is ranked below both *EXTLAPSE and *LAPSE, the ranking predicts the same patterns as right-to-left rule application, so long as we take T:*CLASH to continue penalizing any λ 's in the candidates throughout the derivation.

While we may not find another language identical to Acoma except in its accent loss pattern, what is important is that these other patterns of repair for overlapping violations are attested. Anderson uses multiple instances of Mandarin third tone sandhi ([tone 3] \rightarrow [tone 2] / ___ [tone 3]) as an example of a pattern often attributed to left-to-right rule application (3-3-3-3# becomes 2-2-2-3#). Stress assignment has also been proposed to have a directionality parameter (Lieberman and Prince 1977, Prince 1983) and the strong tendency towards rhythmic alternation could be recast as the result of a directionally applying rule. For example, the stress system of Warao assigns main stress to the penultimate syllable and secondary stress to all even-numbered syllables counting back from the main stress (Kager 1999). A naïve account of Warao might include a rule ([σ] \rightarrow [$\acute{\sigma}$] / ___ [σ]) that, when applied from right to left, would yield the pattern ($\sigma\sigma\sigma \rightarrow \sigma\acute{\sigma}\sigma$).

6. Rules, OT, and TCOT

Constraints on linguistic surface forms are a hallmark of OT, but the use of constraints emerged prior to Prince and Smolensky (1993/2004) in response to two key weaknesses of the rewrite systems of classic generative phonology, rule conspiracies and the duplication problem. The conspiracies problem was noted as early as Kisseberth (1970), who drew attention to similarities in the results of structural changes even though the framework required that different rules be proposed for different structural conditions. Though the rules were functionally related, the rule-based framework had no means for formally stating this common output goal. Similarly, the duplication problem is also a kind of failure to formally recognize a common output goal. For example, Kenstowicz and Kisseberth (1977) observed that output goals of rules governing morphology are mirrored by the structure of morphemes. More generally, the inventory of underlying forms (whether morphemes or phonemes) appears to be subject to the same conditions that the rules are enforcing. The lack of formal association suggests the same work is being done twice: once by the inventory and again by the rules.

The strategy of pre-OT works was to introduce output constraints (e.g. the OCP, Goldsmith 1976; No-Clash, Liberman 1975) that could block or trigger rule application. This in turn introduced the question of what principles governed the interaction of rules and constraints. Work such as Paradis (1988) and Myers (1991) proposed ways to address rule-constraint interaction. Mixed models, however, were suspect to a number of objections. First, the work done by rules and constraints sometimes overlapped. Rules “state configurations to be ‘repaired’ by a structural change, hence they are interpretable as ‘rule-specific negative constraints’” (Kager 1993, p56). This creates a different duplication problem in that “output targets are stated in both the rules and the constraints” (ibid, p57). Furthermore, the interactions posited were often quite complicated. In addition to stipulations already necessary in the rule based framework (the order of the rules and the structural conditions of the rules), mixed models also needed to stipulate the interactions of rules and constraints, including whether or not and when a constraint might be temporarily violated.

The problem of finding principles for rules and constraint interaction dissolved with the rise of classic OT, because classic OT posited that there were no rules. The framework uses only interacting constraints. Wilson’s TCOT framework, with its rule-like targeted constraints, can be viewed as a formalized answer to the pre-OT question of how constraints and rules might be combined into one system.

As with many frameworks, as OT work continued, it became apparent that the classic model required modification. The hypothesis that constraints referred only to underlying and surface forms led to the claim that no intermediate representations exist. Under this corollary, a body of data became problem cases for classic OT, most notably, cases of opacity. In contrast, the ease with which ordered rules accounted for certain cases of opacity, has been taken as support for a rule-based system as well as for intermediate representations.

Wilson's (2001) original version of TCOT provided a solution to a number of cases of opacity. A related problem, however, remain unsolved. To simulate patterns previously attributed to iterative rule application, constraints were formulated that evaluated in a non-local manner. Wilson's (in prep) observation that this led to unattested patterns motivated a modification of his original proposal. The Acoma accent pattern shows that the significant revisions to constraint evaluation and candidate generation in TCOT also correctly predict the resolution of a different puzzle, that of overlapping violations. The revisions, however, have also resulted in quite complicated machinery.

Furthermore, the Acoma example suggests that TCOT may be computationally less restrictive than ordered rules, raising the concern as to whether TCOT is in fact too powerful. In fact, if an ordered rule analysis is available, it can be recast straightforwardly as a TCOT analysis: the focus of the rule becomes the locus of violation; the focus in context becomes λ ; and the change is recast as δ . Any directional specification could be carried over. The availability of a recast analysis, however, is asymmetric. If a directional TCOT analysis is available, an ordered rule analysis is not necessarily also available. Wilson has begun to investigate how to implement TCOT in a finite state system, but it remains to be seen whether the generative complexity of TCOT exceeds that of the rule based framework or of classic OT. With certain restrictions, both of these frameworks allow only finite state mappings (Frank and Satta, 1990). Although TCOT appears to be very powerful, it may be the case that the mappings it allows still remains within the class of finite state mappings.

Wilson argues, however, that TCOT is more restricted than a rule-based system not by its inherent formal properties but in the targeted constraints' marriage to perceptual distance. Neither rules nor classic OT makes explicit contact with perception. Nevertheless, this distinction is unsatisfying. Both alternatives could incorporate a notion of perceptually based minimal change.

TCOT also implies at least one empirical generalization that can be investigated. By specifying the minimal change, TCOT loses a considerable advantage that classic OT had over ordered rules, an account for conspiracies. Targeted constraints each specify a particular change, and it is not clear how to formally relate the changes that pressure outputs towards the same structural property. TCOT either must relate the changes perceptually or else predicts that conspiracies are actually much less pervasive than predicted by classic OT and less radical OT variations.

While it is true that the relative conceptual and computational intricacy of mixed models in comparison to OT is undesirable, the advantages of such a system deserve consideration as well. Indeed, TCOT is more complex than both the rule based framework and classic OT, but it is formalized enough that we can begin to ask specific questions about the consequences of the additional complexity. The answers with respect to this particular mixed model will aid us in asking whether or not the additional complexity of mixed models in general is justified.

References

- Anderson, Stephen. 1974. *The Organization of Phonology*. New York: Academic Press.
- Archangeli, Diana, and Douglas Pulleyblank. 1994. *Grounded Phonology*. Cambridge, MA: MIT Press
- Bakovic, Eric. 2006. Phonological opacity and counterfactual derivation. Talk given at the GLOW Workshop on Approaches to Phonological Opacity, Barcelona.
- Frank, Robert and Giorgio Satta. 1990. Optimality Theory and the generative complexity of constraint violability. *Computational Linguistics*, 24(2):307-315.
- Goldsmith, John. 1976. Autosegmental Phonology. PhD dissertation, MIT. [Published 1979, New York: Garland.]
- Gordon, Matthew. 2002. A factorial typology of quantity insensitive stress, *Natural Language and Linguistic Theory* 20, 491-552.
- Kager, René. 1999. *Optimality Theory*. Cambridge: Cambridge University Press.
- Kenstowicz, Michael, and Charles Kisseberth. 1977. *Topics in phonological theory*. New York: Academic Press.
- Kisseberth, Charles. 1970. On the functional unity of phonological rules. *Linguistic Inquiry* 1:291-306.
- Lieberman, Mark. 1975. The intonational system of English. PhD dissertation, MIT.
- Lieberman, Mark, and Alan Prince. 1977. On Stress and Linguistic Rhythm. *Linguistic Inquiry* 8:249-336.
- McCarthy, John. 1998. Sympathy and phonological opacity. Ms., University of Massachusetts, Amherst. ROA-252, <http://ruccs.rutgers.edu/roa.html>
- Miller, Wick. 1965. *Acoma grammar and texts*. (University of California Publications in Linguistics Number 40.) Berkeley: University of California Press.
- Moreton, Elliott. (2004). Non-computable functions in Optimality Theory. In John McCarthy (ed.), *Optimality Theory in Phonology*, pp.141-164. Written in 1996.
- Myers, Scott. 1991. Persistent Rules. *Linguistic Inquiry*. 22:315-344.
- Onn, Farid. 1980. *Aspects of Malay Phonology and Morphology*. PhD dissertation. University of Massachusetts, Amherst
- Paradis, Carole. 1988. On Constraints and Repair Strategies. *The Linguistic Review* 6: 71-97.
- Prince, Alan. 1983. Relating to the Grid. *Linguistic Inquiry* 14.1, 19-100.
- Prince, Alan and Paul Smolensky. 1993/2004. Optimality Theory: Constraint interaction in Generative Grammar. Technical report, Rutgers University and University of Colorado at Boulder, 1993. ROA-537, <http://ruccs.rutgers.edu/roa.html>. Revised version published by Blackwell, 2004.
- Steriade, Donca. 2001. The Phonology of Perceptibility Effects: the P-map and its Consequences for Constraint Organization. Unpublished manuscript, MIT.
- Walker, Rachel. 1998/2000. Nasalization, Neutral Segments, and Opacity Effects. PhD dissertation, University of California, Santa Cruz. Published 2000, New York: Garland
- Walker, Rachel. (2000) Long-distance Consonantal Identity Effects. In Proceedings of the 19th West Coast Conference on Formal Linguistics, eds Roger Billerey and Brook Lillehaugen. 532-545. Somerville, MA: Cascadilla Press.

Chen-Main

- Wilson, Colin. 2001. Consonant Cluster Neutralisation and Targeted Constraints. *Phonology* 18:147-197.
- Wilson, Colin. (in prep). Analyzing unbounded spreading with constraints: marks, targets, and derivations. Ms. University of California, Los Angeles.

Department of Cognitive Science
Johns Hopkins University
3400 N. Charles St.
Baltimore, MD 21218

joan@cogsci.jhu.edu