Targeted Constraints Optimality Theory and Overlapping Violations

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1. Introduction

Wilson (in prep) observes that classic, non-derivational Optimality Theory (OT) predicts an unattested non-local interaction. In contrast, these problematic predictions do not arise in rule-based theory. Wilson proposes an extension of the system introduced in Wilson (2001) as an alternative system. Targeted Constraint OT (TCOT) avoids such predictions while also maintaining advantages of an OT system. In this paper, I observe that, surprisingly, TCOT also allows for an analysis of Acoma accent loss, a pattern involving overlapping violations that is left unexplained by both classic OT and rule based theory.

This paper begins with an introduction to the Acoma data in section 2. This section also shows why neither ordered rules nor classic OT can provide an analysis for the accent assignment when part of a marked sequence is also part of a second instance of the same marked sequence. Section 3 introduces the motivation for and machinery of TCOT. Section 4 is a TCOT account of the Acoma data. Section 5 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. Accent Loss in Acoma

Acoma is a language spoken by the Native Americans group known by the same name. The pueblo of Acoma is located in New Mexico, about sixty miles west of Albuquerque. 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, which documents his work on Acoma.

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[1]: In Acoma, one of 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), except for certain final syllables.

(1) 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'

Two principal circumstances lead to subsequent loss of the high accents assigned by the accent ablaut rule. In the first case, short syllables adjacent to a glottalized sonorant lose their accents. In the second case, a short syllable between obstruents followed by an accented syllable loses its accent. Our discussion focuses on the second case, as it is under this case that relevant examples of overlapping violations arise. In the examples given below, a vowel that has lost its accent is underlined and italicized.

Anderson writes the rule for such changes as follows:

(2) $V \rightarrow$ [-accent] / [+obst] ____ [+obst] C_0 [+ syll, + accent]

Anderson uses the terms *focus* to refer to the segments that satisfy the conditions for application of the rule and *context* to refer to the conditions.

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

a.	k *u* b ə́ n í	'at sunset'
b.	s̉ *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 *a* č á n í	'when I saw him'
e.	s é i n ú u s t' *u* z í m í	'when I put the fire out'

When two consecutive vowels meet the conditions for application of this rule, more than one syllable can lose its accent. This is particularly interesting because one focus of the rule may be part of the context for another instance of the focus 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:

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[1] Anderson uses /ɑ/ 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).

(4) Multiple accent loss when two foci are present. (Miller p84)

a.	k’ a̲ p i̲ š ə́ n í	‘at night’
b.	š’ a̲ p ə̲ g á n í	‘early evening’
c.	s’ i̲ p ə̲ k á a w á n í	‘when I chopped wood’
d.	k’ a̲ c̣ ə̲ 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).)

(5) Derivation if the rule in (2) applies left to right:

k’ (a) p (í) š ə́ n í	two syllables are in the context which conditions accent loss
k’ a̲ p (í) š ə́ n í	(2) applies to the leftmost instance first
k’ a̲ p i̲ š ə́ n í	(2) then applies to the next instance to the right

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.

(6) Multiple accent loss when three foci are present.

a.	k ə̲ ẓ á c̣ ə̲ k á n’ i	‘your cigarettes’
b.	k a̲ g ə́ c̣ ə̲ d í n í	‘when it was in bloom’
c.	s u̲ c̓ í t i̲ s t á a n í	‘when I was thinking’

Again, this pattern can, by itself, be accommodated with directional rule application, but only inconsistently with the account of (5). 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.)

(7) Derivation if the rule in (2) applies right to left:

s (u) c̓ (í) t (í) s t á a n í	three syllables are in the context which conditions accent loss
s (u) c̓ í t i̲ s t á a n í	(2) applies to the rightmost instance first. This destroys a previous context for rule (3); Only one context remains that conditions accent loss.
s u̲ c̓ í t i̲ s t á a n í	(2) then applies to the next instance to the left.

The problem, however, is that the rule in (2) must apply from left to right to account for the pattern in (4) while the same rule must apply in the other direction to account for the pattern in (6). The rules cannot be reformulated to avoid this inconsistency.

The Acoma accent loss pattern is also problematic for classic OT. In this paper, "classic" OT refers to the version typically regarded as the starting point for variations on OT. That is, a classic OT system makes use of only two types of constraints, markedness and faithfulness, where markedness constraints only take into account elements in the output and faithfulness constraints take into account elements at two levels, input and output. Only a single optimization occurs and the output of an optimization does not become the input for a second optimization. This characterization appears to be the system generally meant by "plain" or "vanilla" OT (vs. bi-directional OT, multi-stratal OT, TCOT, etc.). Classic OT is drawn from the original Prince and Smolensky (1993) manuscript, but it is only a particular instantiation of their thesis that a surface form is the resolution of conflicting constraints rather than the result of rewrite rules.

In classic OT, GEN is posited to be free to generate any conceivable candidate output for each input, as long as the candidate output consists of licit linguistic elements. This property, called Freedom of Analysis, requires (k'ápíšə́ní, k'a̲pi̲šə́ní), the attested winner, to compete against (k'ápíšə́ní, k'ápi̲šə́ní). Similarly, the attested pairing (síukáˀcání, síuka̲čání) competes against (síukáˀcání, si̲uka̲čání).

What is crucial below is that a particular constraint will prefer one candidate pair to another. Thus, the formulations of the constraints involved are given loosely.

(8) Constraints preferring (k'ápíšə́ní, k'a̲pi̲šə́ní) over (k'ápíšə́ní, k'ápi̲šə́ní).

	FAITHFULNESS constraints preferring (k'ápíšə́ní, k'a̲pi̲šə́ní)	MARKEDNESS constraints preferring (k'ápíšə́ní, k'a̲pi̲šə́ní)
(k'ápíšə́ní, k'a̲pi̲šə́ní) vs. *(k'ápíšə́ní, k'ápi̲šə́ní)		*ACCENT *ACCENT-FIRST *ACCENT, NO-ACCENT *ACCENT, NO-ACCENT, ACCENT

(9) Constraints preferring (síukáˀcání, síuka̲čání) over (síukáˀcání, si̲uka̲čání)

	FAITHFULNESS constraints preferring (síukáˀcání, síuka̲čání)	MARKEDNESS constraints preferring (síukáˀcání, síuka̲čání)
(síukáˀcání, síuka̲čání) vs. *(síukáˀcání, si̲uka̲čání)	FAITH-ACCENT FAITH-LEFT EDGE	*LAPSE *NO-ACCENT, NO-ACCENT, ACCENT

The constraints should be interpreted as follows:

FAITH-ACCENT: accents must surface faithfully.
FAITH-LEFT EDGE: the leftmost accent must surface faithfully (or: the leftmost syllable's accent value must surface faithfully)
*LAPSE: penalize two consecutive unaccented syllables
*ACCENT: penalize accents
*ACCENT-FIRST: the leftmost syllable must not be accented
*ACCENT, NO-ACCENT: penalize a bi-syllabic sequence consisting of an accented syllable followed by an unaccented syllable.
*ACCENT, NO-ACCENT, ACCENT: penalize a tri-syllabic sequences consisting of an accented syllable followed by an unaccented syllable followed by an accented syllable.
*NO-ACCENT, NO-ACCENT, ACCENT: penalize a tri-syllabic sequences consisting of two unaccented syllables followed by an accented syllable.

We have now identified all the constraints that might be involved in evaluating the attested pairs as optimal. Using Prince's fusion technique (Prince 2002), we see that two harmony relations exist which are impossible to accommodate under any ranking. In each row of Table (10), we compare the attested winner against a losing competitor. If the constraint prefers the attested winner, we denote this with a W. If the constraint prefers the desired loser, we denote this with an L. We see below that every constraint that prefers the attested pair (k'ápíšə́ní, k'a̲pi̲šə́ní) in row 1 prefers the desired loser (síukáˀcání, si̲uka̲čání) in row 2. Thus, none of the constraints may be top ranked.

(10) Fusion results

	FAITH-ACCENT	FAITH-LEFT EDGE	*LAPSE	*ACCENT	*ACCENT-FIRST	*ACCENT, NO-ACCENT	*ACCENT, NO-ACCENT, ACCENT	*NO-ACCENT, NO-ACCENT, ACCENT
(k'ápíšə́ní, k'a̲pi̲šə́ní) > (k'ápíšə́ní, k'ápi̲šə́ní)	L	L	L	W	W	W	W	L
(síukáˀcání, síuka̲čání) > (síukáˀcání, si̲uka̲čání)	W	W	W	L	L	L	L	W
Fusion result	L	L	L	L	L	L	L	L

3. Targeted Constraint Optimality Theory

In this section, the TCOT framework (Wilson, in prep), which does allow an analysis of the Acoma pattern, is introduced. Because the framework is as yet unpublished, a significant amount of space is devoted to motivating and describing TCOT.

3.1 A Problem for Optimality Theory

Wilson's concern is that OT also predicts a "farsighted" pattern that is unattested. Purely local processes are predicted to be able to be sensitive to global conditions. As a specific example, Wilson shows how an empirically motivated spreading constraint and a standard OT constraint can give rise to an unattested kind of non-local interaction. He begins with data from Johore Malay (Onn 1980, Walker 1998 [2000]).

(11) Examples of unbounded nasal spreading in Malay (Onn 1980, Walker 1998)

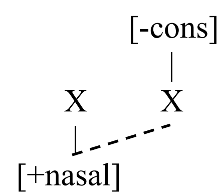
mĩnõm	'to drink'	mãkan	'to eat'	mə̃nãw̃ãn	'to capture'
mãj̃ãŋ	'stalk (palm)'	mə̃ratappi	'to cause to cry'	pəŋãw̃ãsan	'supervision'

Within rule based phonology, the pattern in Malay can be analyzed with the iterative application of spreading rules, such as the feature changing rule in (12a) or the autosegmental rule in (12b) (Anderson 1974, Archangeli and Pulleyblank 1994). These rules affect adjacent elements.

(12) Nasal spreading rules

a. [-consonantal] → [+nasal] / [+nasal] ___

b.



Classic OT generally does not involve iterative applications. Thus, the constraint given by Walker (1998 [2002]) in her analysis of Malay, paraphrased in (13), allows the constraint to evaluates elements of an unbounded distance from the [+nasal] domain.

(13) 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]. A hypothetical input such as /nawakast/ in this system would exhibit non-local blocking of epenthesis. I replicate Wilson's explication here:

(14) "Non-local blocking of vowel epenthesis

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

The second candidate incurs one additional violation of SPREAD-R([+nasal], PrWd), because it contains one more segment (the epenthetic vowel) that lies to the right of the [+nasal] domain. If SPREAD-R([+nasal], PrWd) dominates *CC#, then this one additional violation is sufficient to prevent epenthesis from breaking up the final cluster. Generalizing beyond this particular input, 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)

To avoid the sort of non-local interactions illustrated above, Wilson (in prep) proposes an alternative version of OT, Targeted Constraint OT (TCOT), a derivational framework that extends the theory in Wilson (2001). TCOT is not the first variation 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 associated with a particular markedness constraint.

The first aspect, a modification to evaluation, is done by allowing targeted constraints to carry information about marked patterns as well as the repair that would cause the minimal change as stated in (15). This contrasts with the markedness constraints in classic OT, which can be thought of as statements of marked or unmarked patterns.

(15) 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).

For example, a targeted version of the nasal spreading constraint is given below. A "T:" indicates that the constraint is targeted:

(16) T: SPREAD-R([+nasal], PrWd) (Wilson, in prep)[2]
λ: A [+nasal] segment and an immediately following [-nasal] segment in the same PrWd.
δ: [-nasal] → [+nasal]

The system rewards changes that were specified but penalizes those that are not specified. Wilson takes work on phonological licensing as support for the existence of a minimal change (e.g. Steriade's 2001 P-map). The characterization of repairs as indeed instantiating minimal perceptual distance is tentative, since independent evidence is still pending. While rules stipulate what the change is, targeted constraints and Steriade's P-map make a claim as to the underlying factors.

Let us compare McCarthy's (2003) formulation of Prince and Smolenky's (1993) original proposal of constraint evaluation in OT with Wilson's (in prep) definition of constraint evaluation in TCOT:

(17) Constraint evaluation in OT (McCarthy, 2003)
*λ. Assign one mark for every instance of λ,

where λ is what McCarthy refers to as the locus of violation of the constraint.

(18) Constraint evaluation in TCOT (Wilson, in prep)

Let C be any constraint that specifies both a locus λ and a change δ, *x* and *y* be any two representations, and Δ be the change from *x* to *y*.
a. For every λ∈C(*x*), assign one mark to *x*; for every λ∈C(*y*), assign one mark to *y*.
b. For every λ∈C(*x*) that is repaired in the way specified by δ, remove one mark from *y*.
b'. For every λ∈C(*x*) that is repaired in a way not specified by δ, add one mark to *y*.[3]

Informally, (18) indicates that a targeted constraint C_i evaluates a candidate as follows: C_i identifies violations in the input form(s). When evaluating an output candidate, C_i compares each sequence in the output that corresponds to a violation in the input.

Stage 1: If there is still a violation in the output, the form gets +1. (18a)

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[2] This is a very slight deviation from the formulation given in Wilson (in prep). Doing so will make stating how to assign marks based on whether a repair is the one specified by the constraint easier.

[3] For b', Wilson's paper actually reads, "For every λ∈C(*x*) that is repaired in a way not specified by δ, remove one mark from *x*." However, on pg 21, he 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* due to his revision of GEN's role (see (21) - the number of candidates is directly related to the number of violations of the constraint at hand). I use the version in (18) because I will compare more than one *y* against *x* at a time.

(19) Stage 1: Violations incur marks

/nawakast/	T: SPREAD-R([+nasal], PrWd)
a. nawakasət	Violations: 1
b. nãwakast	Violations: 1

Stage 2: If a locus of violation in the input is no longer a violation in the output, we ask, did the form change the way that C_i specified?

Stage 2a: If yes, the form gets –1. (15b)
Stage 2b: If no, the form gets +1. (15b')

(20) Stage 2a: Changes are evaluated

/nawakast/	T: SPREAD-R([+nasal], PrWd)
a. nawakast	Violations: 1 na : not changed: 0 Total: 1
→ b. nãwakast	Violations: 1 na : fixed as in δ: –1 Total: 0

Note that an arrow →, not the usual hand ☞ points to the winner after evaluation against a constraint. This is to indicate that the constraint C_i takes the output(s) after constraints 1 through i-1 have applied as its input. That is, faithfulness constraints evaluate faithfulness to the most recent form in the derivation, not faithfulness to the original underlying form. (Except in the special case when the original underlying form is also the most recent form in the derivation. That is, no change has yet been deemed optimal.)

The second aspect is a major revision to GEN, which is motivated by the proof in Moreton (1996/1999) that unfaithful outputs only occur when markedness constraints are ranked highly enough. Wilson chooses to place the responsibility of candidate generation largely on the markedness constraints. Wilson gives the proposal formally as follows:

(21) Formal proposal for architecture of the system (Wilson, in prep)

> "For each C, there is a constraint-specific function GEN$_C$ (i.e. GEN(λ, δ)) that maps candidates to candidate sets. GEN$_C$ returns the set containing all and only the candidates that can be derived from the original candidate by applying the change δ to zero or more instances of the locus λ. GEN$_{Pros}$ then applies to this set, adding all universally-possible prosodic parses of the candidates created by the constraint. If *x* is the original candidate, then the resulting candidate set is GEN$_{Pros}$(GEN$_C$(*x*)) (i.e. [GEN$_{Pros}$ ○ GEN$_C$](*x*), where '○' is the function composition operator)."

Thus, GEN$_{\text{T:SPREAD-R([+nasal], PrWd)}}$ (nawakast) = {nawakast, nãwakast}. After nãwakast wins the first round of evaluation, evaluation of GEN$_{\text{T:SPREAD-R([+nasal], PrWd)}}$ (nãwakast) = {nãwakast, nãw̃akast} takes place. The targeted constraint continues to generate candidates until a faithful pairing wins.

Rather than presenting a series of small tableaux and listing *n*-tuples for the candidates, it will be useful to represent the derivation in one chart as below. Steps are indexed by *k* (position of the constraint in hierarchy) and *m* (iteration of a given constraint). *m* is omitted if there is only one iteration for a constraint.

(22) Derivation chart for (nawakast, nãw̃ãkast)

Step	Input	Candidate set	Output	Comments
0	nawakast		nawakast	
1, 1	nawakast	GEN$_{\text{T:SPREAD-R([+nasal], PrWd)}}$ (nawakast) = {nawakast, nãwakast}	nãwakast	a is nasalized
1, 2	nãwakast	GEN$_{\text{T:SPREAD-R([+nasal], PrWd)}}$ (nãwakast) = {nãwakast, nãw̃akast}	nãw̃akast	w is nasalized
1, 3	nãw̃akast	GEN$_{\text{T:SPREAD-R([+nasal], PrWd)}}$ (nãw̃akast) = {nãw̃akast, nãw̃ãkast}	nãw̃ãkast	a is nasalized
1, 4	nãw̃ãkast	GEN$_{\text{T:SPREAD-R([+nasal], PrWd)}}$ (nãw̃ãkast) = {nãw̃ãkast}	nãw̃ãkast	No change

Additionally, I would now like to make explicit an assumptions 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 Ci 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.

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

Let H = [C_1 >> C_2 . . . >> 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 [GEN$_{\text{Pros}}$ ○ 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 $m > 0$, $out_{k,m}$ = H-max([GEN$_{\text{Pros}}$ ○ 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*.

4. A TCOT Analysis for Acoma Accent Loss

As yet, we have not identified any specific empirical differences between the rule based framework and TCOT. Wilson's (in prep) modifications align an OT framework with rule-based theory with respect to certain patterns that are not attested. The main point below, however, is to show where TCOT and rule based theory differ in their empirical predictions. Though TCOT was not proposed to address overlapping violations, in this section, we see how the TCOT framework correctly predicts the pattern in Acoma.

The constraints used in this analysis are borrowed from the stress literature. *LAPSE-ACCENT is similar to FT-BIN: feet are binary under moraic or syllabic analysis (Prince and Smolensky 1993). *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 (Liberman 1975). In the analysis given here, only the constraint T:*CLASH is crucially a targeted constraint. The other two markedness constraints need not be targeted.[4] For ease of explication, the discussion below assumes *EXTLAPSE-ACCENT and *LAPSE-ACCENT are untargeted marked constraints of the usual kind.[5, 6]

(24) 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

This formulation of T:*CLASH penalizes a very specific pattern. 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 the rule used in section 2, that of Anderson (1974), makes comparison maximally straightforward. 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. Lastly, 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.

The following ranking yields the desired result:

*EXTLAPSE-ACCENT >> T:*CLASH >> FAITH-ACCENT, *LAPSE-ACCENT

The derivation of (4a), [k'apiš̌ə́ní], will be our example of the case of two overlapping λ's. We begin with the form that results after accent ablaut has assigned a

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

[5] All the constraints used in the TCOT analysis have analogues in the fusion results table in (10) except for *EXTLAPSEACCENT. Note that this is because *EXTLAPSEACCENT does not distinguish between the attested pair and the desired loser in (10). Thus, the addition of this constraint in a classic OT system will not yield the desired result.

[6] This analysis owes significantly to direct suggestions by C. Wilson (p.c.).

high accent to every syllable, which we follow Miller in taking to be /k’ápíšə́ní/. At 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 move to step 2.

(25) Steps 0-1 for the derivation of [k’apišə́ní]

Step	Input	Candidate set	Output	Comments
0	k’ápíšə́ní		k’ápíšə́ní	
1	k’ápíšə́ní	{k’ápíšə́ní}	k’ápíšə́ní	No change

There are two violations of T:*Clash. At step 2, Gen$_{\text{T:*Clash}}$ produces four candidates, the completely faithful candidate, the candidate where delta is applied to both λ’s, and two candidates where delta is only applied to one lambda. Tableau (26) shows that in the most harmonic candidate, delta is applied to both loci of violation.

(26) T:*Clash chooses [k’apišə́ní]:

k’ápíšə́ní	*ExtLapse-accent	T:*Clash	Faith-Accent	*Lapse-accent
k’**á**p**í**šə́ní		Violations: 2 Total = 2		
k’**á**p**i**šə́ní		Violations: 0 k’**á**pí : not fixed as in δ: +1 p**í**šə́ : fixed as in δ: –1 Total = 0	*	
k’**a**p**í**šə́ní		Violations: 1 k’**á**pí : fixed as in δ: -1 Total = 0	*	
→ k’**a**p**i**šə́ní		Violations: 0 k’**á**pí : fixed as in δ: -1 p**í**šə́: fixed as in δ: -1 Total = -2	**	*

(27) Steps 0-2,2 for the derivation of [k’apišə́ní]

Step	Input	Candidate set	Output	Comments
0	k’ápíšə́ní		k’ápíšə́ní	
1	k’ápíšə́ní	{k’ápíšə́ní}	k’ápíšə́ní	No change
2, 1	k’ápíšə́ní	Gen$_{\text{T:*Clash}}$(k’ápíšə́ní) = {k’ápíšə́ní, k’ápišə́ní, k’apíšə́ní, k’apišə́ní}	k’apišə́ní	Loss of accent on both loci of violation
2, 2	k’apišə́ní	Gen$_{\text{T:*Clash}}$(k’apišə́ní) = {k’apišə́ní}	k’apišə́ní	No change

Faithfulness constraints do not have an associated GEN$_{\text{C}}$, so FAITH-ACCENT does not generate any candidates. Non-targeted markedness constraints do not have an associated GEN$_{\text{C}}$ 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.

(28) Derivation chart for (k’ápíšə́ní, k’apišə́ní)

Step	Input	Candidate set	Output	Comments
0	k’ápíšə́ní		k’ápíšə́ní	
1	k’ápíšə́ní	{k’ápíšə́ní}	k’ápíšə́ní	No change
2, 1	k’ápíšə́ní	GEN$_{\text{T:*CLASH}}$(k’ápíšə́ní) = {k’ápíšə́ní, k’ápišə́ní, k’apíšə́ní, k’apišə́ní}	k’apišə́ní	Loss of accent on both loci of violation
2, 2	k’apišə́ní	GEN$_{\text{T:*CLASH}}$(k’apišə́ní) = {k’apišə́ní}	k’apišə́ní	No change
3	k’apišə́ní	{k’apišə́ní}	k’apišə́ní	No change
4	k’apišə́ní	{k’apišə́ní}	k’apišə́ní	No change

Having seen how TCOT can provide an account of the pattern in (4), let us turn to the pattern in (6). We will use [su̱c̓íti̱stáaní], (6c), 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 /súc̓ítístáaní/. 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.

(29) Steps 0-1 for the derivation of [su̱c̓íti̱stáaní]

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

There are three violations of T:*CLASH. At step 2, GEN$_{\text{T:*CLASH}}$ produces eight candidates; each locus of violation may remain as is or have delta applied. T:*CLASH evaluates three of these candidates as most harmonic: súc̓itistáaní, suc̓ítistáaní, and suc̓itístáaní. 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, súc̓itistáaní and suc̓itístáaní are eliminated. This leaves suc̓ítistáaní, the candidate one where delta is applied to the first and third loci of violation and the middle syllable is unchanged, as the most harmonic candidate.

(30) T:*CLASH chooses [s***u*****cí**t***i***stáaní]:

s**úcítí**stáaní	*EXT-LAPSE-ACCENT	T:*CLASH	FAITH-ACCENT	*LAPSE-ACCENT
s**úcítí**stáaní		s**ú**cí: violation +1 **cí**tí: violation +1 **tí**stáa: violation +1 Total = +3 (!)		
s**úcí**t***i***stáaní		s**ú**cí: violation +1 **cí**tí: not fixed as in δ: +1 **tí**stáa: fixed as in δ: -1 Total = +1 (!)	*	
s**ú**c***i*****tí**stáaní		s**ú**cí: not fixed as in δ: +1 **cí**tí: fixed as in δ: –1 **tí**stáa: violation +1 Total = +1 (!)	*	
s**ú**c***i***t***i***stáaní		s**ú**cí: not fixed as in δ: +1 **cí**tí: fixed as in δ: –1 **tí**stáa: fixed as in δ: -1 Total = -1	**	*!
s***u*****cítí**stáaní		s**ú**cí: fixed as in δ: -1 **cí**tí: violation +1 **tí**stáa: violation +1 Total = +1 (!)	*	
→ s***u*****cí**t***i***stáaní		s**ú**cí: fixed as in δ: -1 **cí**tí: not fixed as in δ: +1 **tí**stáa: fixed as in δ: -1 Total = -1	**	
s***u***c***i*****tí**stáaní		s**ú**cí: fixed as in δ: -1 **cí**tí: fixed as in δ: –1 **tí**stáa: violation +1 Total = -1	**	*!
s***u***c***i***t***i***stáaní	*!	s**ú**cí: fixed as in δ: -1 **cí**tí: fixed as in δ: –1 **tí**stáa: fixed as in δ:-1 Total = -3	***	

(31) Steps 0-2,2 for the derivation of [su̲ˀcíti̲stáaní]

Step	Input	Candidate set	Output	Comments
0	súˀcítístáaní		súˀcítístáaní	
1	súˀcítístáaní	{súˀcítístáaní}	súˀcítístáaní	No change
2, 1	súˀcítístáaní	GEN$_{T:*CLASH}$(súˀcítístáaní) = {súˀcítístáaní, súˀcítistáaní súˀcitístáaní, súˀcitistáaní suˀcítístáaní, suˀcítistáaní suˀcitístáaní, suˀcitistáaní}	suˀcítistáaní	Loss of accent on first and third syllables
2, 2	suˀcítistáaní	GEN$_{T:*CLASH}$(suˀcítistáaní) ={suˀcítistáaní}	suˀcítistáaní	No change

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. Since the input is the same as the output, we are finished.

Step	Input	Candidate set	Output	Comments
0	súˀcítístáaní		súˀcítístáaní	
1	súˀcítístáaní	{súˀcítístáaní}	súˀcítístáaní	No change
2, 1	súˀcítístáaní	GEN$_{T:*CLASH}$(súˀcítístáaní) = {súˀcítístáaní, súˀcítistáaní súˀcitístáaní, súˀcitistáaní suˀcítístáaní, suˀcítistáaní suˀcitístáaní, suˀcitistáaní}	suˀcítistáaní	Loss of accent on first and third syllables
2, 2	suˀcítistáaní	GEN$_{T:*CLASH}$(suˀcítistáaní) ={suˀcítistáaní}	suˀcítistáaní	No change
3	suˀcítistáaní	{suˀcítistáaní}	suˀcítistáaní	No change
4	suˀcítistáaní	{suˀcítistáaní}	suˀcítistáaní	No change

5. 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's (1993) seminal manuscript 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. Thus, a collection of rules seemingly conspired to all produce the same output goal.

Though the rules were functionally related, the rule-based framework had no means for formally stating this common output goal. In contrast, in an OT framework, each constraint pressures the system to conform to one particular output goal without reference to the specific repair. In a system with interacting constraints, more than one means of satisfying an output goal is expected.

Similarly, the duplication problem is also a failure to formally recognize similarity. 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 1998 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, then, 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. Attempts to deal with opacity often could not maintain an account free of some sort of intermediate representation, but reference to intermediate representation is seen as not being a "real" solution. In contrast, ordered rules did not have a problem with these cases since the framework allowed reference to intermediate representations.

Wilson's (2001) original version of TCOT provided a solution to the 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 lambda; and the change is recast as delta. 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.

TCOT, however, is restricted not by its inherent formal properties but in the targeted constraints' marriage to perceptual distance. Neither rules nor classic OT makes contact with perception.

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.

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References

Anderson, Stephen. (1974). *The Organization of Phonology*. New York: Academic Press.

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.

Johnson, C. Douglas. (1972) *Formal aspects of phonological description*. The Hague: Mouton.

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.
Liberman, Mark. (1975) The intonational system of English. PhD dissertation, MIT.
McCarthy, John. (2003) Categorical and Gradient Constraints. Handout of a talk given at SWOT 8, University of Arizona at Tuscon.
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.
Paradis, Carole. (1988) On Constraints and Repair Strategies. *The Linguistic Review* 6: 71-97.
Prince, Alan. (2002) Entailed Ranking Arguments. ROA-500.
Prince, Alan, and Paul Smolensky. (1993). *Optimality Theory: Constraint Interaction in Generative Grammar*. Report no. RuCCS-TR-2. New Brunswick: Rutgers University Center for Cognitive Science. To appear from Blackwell.
Steriade, Donca. (2001) The Phonology of Perceptibility Effects: the P-map and its Consequences for Constraint Organization. Unpublished manuscript, MIT.
Walker, Rachel. (1998) 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. Sommerville, MA: Cascadilla Press.
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.

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