Rule Ordering, and Constraint Interaction in OT

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1. From the very start of generative phonology and throughout much of its history, except for a period in the 70's when there was vigorous debate on whether language-specific rule ordering is needed (Koutsoudas, Sanders and Noll 1974), it has been widely assumed that phonological rules are extrinsically ordered (Halle 1962, SPE 1968, Bromberger and Halle 1989).[1] In fact, rule ordering was one of the most powerful tools in phonological analysis in derivational analyses. Furthermore, numerous cases have been reported of dialects or historical stages of a language that contain the same underlying representations and the same rules, but differ simply by virtue of the ordering of the rules (Kiparsky 1971, Halle 1962).

The interaction between /t/-voicing and diphthong raising in Canadian English is one of the most widely cited examples supporting the rule-based nature of phonology. This example has been cited repeatedly in the literature (Joos 1942, Halle 1962, SPE 1968, Chambers 1973, Bromberger and Halle 1989). The situation is summarized in (1). The low vowel nucleus in the [ay] and [aw] diphthongs raises before voiceless consonants, and the intervocalic /t/-/d/ contrast is neutralized in favor of [d] (instead of a flap as in American English). Dialect A distinguishes the words, *writer* and *rider*, while in dialect B they are homophonous. The difference has been explained in terms of the difference in the order of the two rules. It is argued that reversing the order of rule application of Dialect A results in Dialect B. To use the ordering terminology, in Dialect B the rules apply in bleeding order; in dialect A they apply in counterbleeding order.

(1) **Dialect A** (counterbleeding)

| | | | | |
|---|---|---|---|---|
| /rayt/ | /rayd/ | /rayt-ər/ | /rayd-ər/ | UR |
| rʌyt | ____ | rʌytər | ____ | Raising |
| ____ | ____ | rʌydər | ____ | Voicing |

**Dialect B** (bleeding)

| | | | | |
|---|---|---|---|---|
| /rayt/ | /rayd/ | /rayt-ər/ | /rayd-ər/ | UR |
| —— | —— | raydər | —— | Voicing |
| rʌyt | —— | —— | —— | Raising |

An exactly parallel case has been reported for American English, as shown in (2). In this case, the two rules involved are Vowel Shortening before a voiceless consonant and Flapping of /t/ and /d/.

(2) American English Flapping and Vowel Shortening

Dialect 1: Shortening counterbleeds Flapping

| | | |
|---|---|---|
| /pæt+iŋ/ | /pæd+iŋ/ | |
| pæ̆tiŋ | ---------- | Shortening |
| [pæ̆ɾiŋ ] | [pæɾiŋ] | Flapping |

Dialect 2: Flapping bleeds Shortening

| | | |
|---|---|---|
| /pæt +iŋ/ | /pæd+iŋ/ | |
| pæɾiŋ | pæɾiŋ | Flapping |
| ------- | ------- | Shortening |

In Optimality Theory (McCarthy and Prince 1993, Prince and Smolensky 1993), the grammar evaluates candidate outputs in parallel against a hierarchy of ranked, violable constraints. Devoid of rules and rule ordering, a powerful device of operational theories, Optimality Theory has to somehow reflect dialectal variation by relying solely on constraint interaction. Before we provide such an account for English, we need to spell out two additional assumptions about the substantive aspect of well-formedness constraints, in addition to the usual ones.

The first concerns the markedness considerations. According to Kiparsky (1994), constraints cannot specify unmarked feature values, and for every constraint that refers to a phonological category, there is an otherwise identical constraint that refers specifically to the marked member of that category (e.g. Fill-lab, Fill-place, Spread-lab, Spread-place, etc.) In addition, a specific constraint is active only if it precedes the corresponding general constraint by Panini's Theorem (Prince and Smolensky 1993). Since no constraints refer to an unmarked feature, it is impossible to have a constraint on an unmarked feature ranked above the constraint on the corresponding marked feature.

Second, we assume, following McCarthy (1994), that there is a distinction between two relations obtaining between a feature F and a segment S (or between a segment S and a prosodic constituent P). Sponsorship obtains when a feature is associated with the segment in the input, while parsing refers to the association in the output.

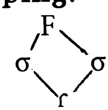
(3) Two relations between a feature F and a segment S
Sponsorship: S sponsors F iff F is associated with S in input.
Parsing: S parses F iff F is associated with S in output.

Now, we attempt an optimality analysis of the American English facts in (4). Flapping ensures a foot-internal ambisyllabic alveolar stop to be realized as a flap.

(4) An OT account of Vowel Shortening and Flapping

Constraint1: **Vowel Shortening:** V̆ C[-voice]

Constraint2: **Flapping:**




Dialect 1 ( patting [pæ̆ɾiŋ ], padding, [pæɾiŋ])

| patting | VS 1 | Flapping |
|---|---|---|
| pætiŋ | * ! | * |
| pæɾiŋ | * ! | |
| pæ̆tiŋ | | * ! |
| → pæ̆ɾiŋ | | |

| padding | VS 1 | Flapping |
|---|---|---|
| pædiŋ | | * ! |
| → pæɾiŋ | | |
| pæ̆diŋ | * ! | * |
| pæ̆diŋ | * ! | |

Dialect 2 (patting [pæɾiŋ], padding [pæɾiŋ])

| patting | VS 2 | Flapping |
|---|---|---|
| pætiŋ | * | * |
| → pæɾiŋ | | |
| pæ̆tiŋ | | * |
| pæ̆ɾiŋ | * | |

(5) two versions of Vowel Shortening

a) f-Sponsor (VS1)

V̆C
|
[-voice] in input

b) f-Parser (VS2)

V̆C
|
[-voice] in output

In Dialect 1, a short vowel results when followed by a consonant that sponsors the feature [-voice] (i.e., an underlyingly voiceless consonant), shown in (5a). It makes no difference whether the underlying [-voice] is parsed in the output or not. The flapping process wipes out the voicing specification on the surface. There is some question as to whether Dialect B in Canadian English and Dialect 2 in American English actually exist (Kaye 1990), but if they do, the dialectal difference can be obtained by activating a slightly different constraint, Vowel Shortening 2 in (5b); i.e. a short vowel occurs only with a [-voice]-parsed consonant. When the sponsoring constraint (VS1) is active, the optimal candidate reflects the underlying distinction (in this case, the voiced /d/ vs. voiceless /t/). On the other hand, when the parsing constraint (VS2) is active, the optimal candidate is true to the surface forms; i.e., the constraint relies on the phonetic voicing of the flap.

The upshot of this short exercise is that there is no direct translation of the powerful argument for extrinsic rule ordering within a phonological theory based on defeasible ranked constraints. The two constraints, VS and Flapping do not interact as rules do. Rather, the variation depends on the nature of the constraints (in this case, the sponsorship vs. the parsing).

**2.** For the past two decades or so, determination of the ordering between rules which potentially interact was an important aspect of phonological analyses. The ordering relationship between rules is stated in terms of the potential effect (both positive and negative) that the application of one rule has on the application of another.

(6) Rule Ordering Terminology (Kiparsky 1968)

1. Feeding: Rule A feeds Rule B if A applies before B and creates places in which B can apply.
2. Bleeding: Rule A bleeds Rule B if A applies before B and prevents B from applying.
3. Counterfeeding(=failure to feed): If Rule A would have fed Rule B but is ordered too late to do so, it counterfeeds B.
4. Counterbleeding (=failure to bleed): If Rule A would have bled Rule B but is ordered too late to do so, it counterbleeds B.

It is clear that there is no direct correlation between rule ordering in the old theory and constraint interaction such as constraint ranking in OT. In the old theory, differences among languages and dialects resulted from languages having different rules, and in some cases different ordering relations among the same rules. Now Optimality Theory articulates a more restricted position where all of the constraints are universally present, and the differences between languages and dialects arise solely from the difference in the rankings of the constraints.

In derivational theories, the sequential order of rules was supported by the observation that a rule may require information which is supplied by another rule. For instance, in the typical feeding relation, information supplied by the first rule is essential to the application of the second rule. One way of interpreting this in OT is to assume that the information relevant in activating constraints is already present underlyingly and that the two constraints independently exert their power, thus yielding an output that satisfies both of the constraints. This conceptual difference between these two types of theories yields quite different predictions. For instance, well-known cases of neutralization and assimilation have been accounted for in terms of a feeding relationship between the processes, as exemplified by the Korean example in (7).

(7) Korean Neutralization and Assimilation

Feeding Order (Neutralization precedes Assimilation):
/kas+pota/ → katpota → [kappota] 'rather than green mustard'
/kot+pota/ → [koppota] 'rather than soon'

Hyphothetical Counter-feeding Order (Assimilation first):
/kas+pota/ → [katpota] (Only Neutralizaton applies.)
/kot+pota/ → [koppota] (Assimilation of underlying dentals only)

The fricative [s] neutralizes to the dental stop [t] in coda position, and undergoes assimilation when a marked consonant such as a labial or a velar follows. Derivational theories generate two equally plausible grammars depending on the order of the rules, but the fact is that feeding order is the only order that surfaces in language after language. For example, in the Sanskrit examples in (8), neutralization of larygeal features appears to apply before assimilation such as palatalization and lateralization.

(8) Sanskrit Neutralization and Assimilation

/tad ca/ → tat ca → [tacca] 'and this'
/tad lebhe/ → tat lebhe → [tallebhe] 'I obtain this'

In contrast, an optimality account provides only the single possibility in which both Neutralization and Assimilation apply, namely the result of a feeding order. I assume that assimilation is enforced by a constraint which prohibits multiple specification of a feature.

(9) Korean Neutralization and Assimilation

Neutralization          Assimilation

$$\begin{array}{c} *\ C]_{\sigma} \\ | \\ [+\text{cont}] \end{array} \qquad\qquad \begin{array}{c} C \quad C \\ \diagdown\ \diagup \\ \text{Place} \end{array}$$

| /kas+pota/ | Neutralization | Assimilation |
|---|---|---|
| kaspota | * ! | |
| katpota | | * ! |
| → kappota | | |

In this account, the processes of Neutralization and Assimilation are handled by two independent constraints, and there is no obvious way to obtain the 'counterfeeding effect'. One might wonder if it is possible to have the Assimilation constraint sensitive to the underlying distinction between the dental stop /t/ and the fricative /s/, limiting the scope of Assimilation only to a segment that sponsors the features of the dental stop. However, this is in violation of Kiparsky's markedness frame in which constraints cannot specify unmarked feature values alone. [2] There is no way to refer to dental stops to the exclusion of the coronal fricative or other marked consonants.

3. McCarthy (1994) presents two processes in the Najdi dialect of Bedouin Arabic. In non-final unstressed open syllables, short /i/ deletes (Syncope) and short /a/ is changed to [i] (Raising) but the [i]'s from /a/ do not delete.

In a derivational account, the most obvious thing to do would be to order Syncope before Vowel Raising so that the output of VR does not have a chance to undergo the first rule, a typical counterfeeding order.

(10) Arabic chain shift (McCarthy 1994)

| Counterfeeding order | | Feeding order | |
|---|---|---|---|
| i → Ø | Syncope | a → i | Vowel Raising |
| a → i | Vowel Raising | i → Ø | Syncope |
| (* a → i → Ø) | | (a → i → Ø) | |

Kiparsky (1994) provides a slightly revised version of McCarthy's analysis. The crucial modification involves markedness considerations. In both account, some constraints shown in (11) are crucially sponsoring constraints. We have seen earlier that when the output is sensitive to underlying distinctions, sponsoring constraints are required.

(11)
Parse-V (A [low]-**sponsoring** vowel must be parsed.)
|
low

Parse-V (A [place]-**sponsoring** vowel must be parsed.)
|
place

(12) Kiparsky's improvement on Arabic chain shift

*V ] σ , Parse V >> Parse-place >> Parse V
| | |
place low place

| | *V]σ / \| / place | Parse V / \| / low | Parse-pl | Parse V / \| / place |
|---|---|---|---|---|
| V / \| / low | * ! | | | |
| → a → i V / \| / <low> | | | * | |

| | | | | |
|---|---|---|---|---|
| <V><br>\|<br>low | | * ! | | * |
| V<br>\|<br>hi | * ! | | | |
| V<br>\|<br><hi> | | | * ! | |
| → i → Ø <V><br>\|<br>hi | | | | * |

As illustrated by the first three candidates in (12), Parse-V-low is ranked higher than its corresponding general constraint Parse-V-place, and the vowel segment of the marked vowel [a] needs to be parsed, though its terminal feature [low] does not surface in the output due to the Neutralization constraint, which prohibits any place features in the weak position. The unmarked vowel, /i/, however, does not surface due to the lower ranked Parse-V-place because there is no Parse-V-high constraint.

In Arabic the unmarked vowel /i/ deletes, and the marked vowel /a/ changes to the unmarked vowel /i/, the state of affairs generated by the counterfeeding order between Syncope and Raising. The feeding order would predict a situation where both marked and unmarked vowels delete, as found in Yokuts, Icelandic and Piro. An optimality account can derive such a situation just as easily, by reranking of the same constraints, in particular by reversing the ranking between Parse-V-ploace and Parse-pl (Kiparsky 1994). Parse-V-low is dominated and thus has no effect.

We have observed in Korean that the only order possible between neutralization and assimilation is the feeding relation while in the vowel syncope and raising case of Arabic, both orders are typologically possible. In derivational theories, there seems to be no principled way to account for such contrasts. In OT, however, the explanation follows naturally from the very nature of the constraints themselves. Reranking the general constraint (Parse-pl) higher than the specific constraint referring to the marked feature [low] results in the difference between Arabic and Icelandic, for instance.

4. Now, we will look at another intriguing case in which the derivational theory relying on rule ordering clearly makes predictions distinct from Optimality Theory. We have seen in our discussion of Korean neutralization and assimilation that a derivational account is capable of generating two grammars with two different orderings, while an optimality account in no way allows two possibilities. An analogous case is found in Klamath where two processes of deglottalization have been analyzed as exhibiting a bleeding relationship in the literature. Just as natural an account can be put forward where the two rules are in a feeding order, but an optimality account excludes such a possibility on principled grounds.

Klamath, an Amerindian language spoken in south-western Oregon has both glottalized obstruents and glottalized sonorants, in addition to voiceless (aspirated) sonorants. Deglottalization of stops occurs in preconsonantal position, except before the voiced nonglottalized sonorants (m, n, w, y, l), as exemplified by (13). [3] Sonorants, however, deglottalize before any obstruents, as well as glottalized and aspirated sonorants (Barker 1964, Kisseberth 1972, Kean 1973, Lightner 1976). [4]

(13) Klamath Deglottalization

| | | |
|---|---|---|
| a. | p'et'-a | 'a hole becomes larger' |
| | p'e-pt'-a | '(distributive) holes tear out' |
| | wLet'-wal | 'lies spread eagled on top of' |
| | wLet-pg-a | 'is lying flat on the back' |
| b. | nčoq'-a | 'is deaf' |
| | nčoq-n'apg-a | 'is almost deaf' |
| c. | nt'op'-a | 'rots' |
| | nt'op-Wi:y-a | 'almost rotted' |
| d. | nt'op'-ye:g-a | 'starts to rot' |
| e. | n'o-k'a | 'little head' |
| | n'o-n-k'a | '(distributive) are breathless' |
| | ?-iwy'aq | 'put in plural objects' |

| | |
|---|---|
| ?i-?o:yg-a | '(distributive) put plural objects into' |

f.

| | |
|---|---|
| k-bol'-a | 'hits in the stomach' |
| w-bol-lg-a | 'falls on the stomach' |
| gaw'al | 'finds' |
| gawl-i:ya | 'finds for someone' |

The data involving three consonant clusters in (14) illustrate that the rules have to apply in a bleeding relationship, where Sonorant Deglottalization precedes Obstruent Deglottalization. Both of the sequences /q'l'/ and /l'g/ are potential targets of Deglottalization. The fact is that the medial sonorant /l/ deglottalizes while the first obstruent /q'/ does not. The standard assumption in a derivational analysis is that Sonorant Deglottalization precedes Stop Deglottalization. In other words, SonD bleeds StopD. If StopD were to apply first, its output [ql'] could be an input to SonD, producing [qlg], as shown in (15).

(14) Klamath Deglottalization (bleeding order)

/nčoq'-l'-g-a/ 'ears are stopped up'
[nčoq'-l-g-a]

| | | | |
|---|---|---|---|
| /q'l'/ | /l' g/ | /-q'-l'-g-/ | UR |
| ___ | lg | q' l g | Sonorant Deglottalization |
| ql' | ___ | ___ | Obstruent Deglottalization |
| [ql'] | [lg] | **[q'lg]** | |

(15) Klamath Deglottalization (feeding order)

| | | | |
|---|---|---|---|
| /q'l'/ | /l' g/ | /-q'-l'-g-/ | UR |
| ql' | ___ | q l' g | Obstruent Deglottalization |
| ___ | lg | qlg | Sonorant Deglottalization |
| [ql'] | [lg] | **[qlg]** | |

In an OT account, the different behavior of glottalized obstruents and glottalized sonorants is reflected in the family of Deglottalization constraints. Note that the most general deglottalization (*C'C) plays an important role.

(16 ) Relevant Constraints in Klamath

***Obs' Son', *Obs' Obs, *Son' Cons >> Parse >> *Cons'Cons** (Cons' denotes a laryngeal (glottalized) consonant. )

a. Glottalized obstruents followed by an obstruent

| UR | | *O'S' | *O'O | *S'C | Parse | *C'C |
|---|---|---|---|---|---|---|
| /q'g/ | | | | | | |
| | q'g | | * ! | | * | * |
| → | qg | | | | * | |
| /q'g'/ | | | | | | |
| | q'g' | | * ! | | | * |
| | q'g | | * ! | | * | * |
| → | qg' | | | | * | |
| | qg | | | | * * ! | |

b. Glottalized obstruents followed by a sonorant

| UR | | *O'S' | *O'O | *S'C | Parse | *C'C |
|---|---|---|---|---|---|---|
| /q'l/ | | | | | | |
| → | q'l | | | | | * |
| | ql | | | | * ! | |
| /q'l'/ | | | | | | |
| | q'l' | * ! | | | | * |
| | q'l | | | | * | * ! |
| → | ql' | | | | * | |
| | ql | | | | * * ! | |

c. Glottalized Sonorants followed by an obstruent

| UR | | *O'S' | *O'O | *S'C | Parse | *C'C |
|---|---|---|---|---|---|---|
| /l'g/ | | | | | | |
| | l'g | | | * ! | | * |
| → | lg | | | | * | |
| /l'g'/ | | | | | | |
| | l'g' | | | * ! | | * |
| | l'g | | | * ! | * | * |
| → | lg' | | | | * | |
| | lg | | | | * * ! | |

d. Glottalized sonorants followed by a sonorant.

| UR | | *O'S' | *O'O | *S'C | Parse | *C'C |
|---|---|---|---|---|---|---|
| /l'l/ | | | | | | |
| | l'l | | | * ! | | * |
| → | l l | | | | * | |
| /l'l'/ | | | | | | |
| | l'l' | | | * ! | | * |
| | l'l | | | * ! | * | * |
| → | l l' | | | | * | |
| | l l | | | | * * ! | |

There is the general constraint, *Cons' Cons, which dictates that preconsonantal glottalized consonants are ill-formed. There is a family of more specific deglotttalization constraints, *Obs' Son', *Obs' Obs, and *Son' Cons. Parse has to be ranked higher than *Cons'Cons because glottalized obstruents are not deglottalized before a plain sonorant, but the family of specific constraints needs dominate Parse to have any deglottalization effect. As can be seen in the tableaux (16), Obs deglottalization and Son deglottalization are not crucially ranked. Finally, as illustrated in (17), the choice of [q'lg] over [qlg] is determined by the crucial ranking between the Glottal Constraints and Parse. The second candidate is chosen due to the faithfulness condition. The bleeding order between ObsD and SonD is not reflected in any way in the OT account.

(17) Obs'-Son'-Cons

| | | *O'S' | *O'O | *S'C | Parse | *C'C |
|---|---|---|---|---|---|---|
| /q'l'g/ | | | | | | |
| | q'l'g | * ! | | * | | * * |
| → | q'l g | | | | * | * |
| | q l'g | | | * ! | * | * |
| | qlg | | | | * * ! | |

It appears at first glance that the same effect of the feeding relation between two rules in (15) could be obtained by reranking *C'C and Parse, as in (18).

(18) *C'C >> Parse yields [qlg]

| | | *O'S' | *O'O | *S'C | *C'C | Parse |
|---|---|---|---|---|---|---|
| /q'l'g/ | | | | | | |
| | q'l'g | * ! | | * | * * | |
| | q'l g | | | | * ! | * |
| | q l'g | | | * ! | * | * |
| → | qlg | | | | | * |

However, this ranking is not consistent with the other facts. When glottal obstruents are followed by a sonorant (both glottalized and plain), the ranking of *CC >> Parse yields non-optimal forms as in (19).

(19) *C'C >> Parse cannot be true in Klamath

| | | *O'S' | *O'O | *S'C | *C'C | Parse |
|---|---|---|---|---|---|---|
| /q'l/ | | | | | | |
| | q'l | | | | * ! | |
| → | ql | | | | | * |

As shown in (19), /q'l/ surfaces as [q'l] (no changes) but the ranking of *Cons' Cons >> Parse produces [ql]. This ranking has the same effect as subordinating the three obstruent/sonorant specific constraints by *C'C. However, the fact is that the obstruent target is different from the sonorant target. In other words, the specific constraints are active and must precede the general *C'C constraint, mediated by Parse.

A simple ordering statement between the two rules would easily generate two grammars while an optimality account excludes on principled grounds the effect of the 'feeding' relation between Obs deglottalization and Son deglottalization.

**6.** One of the most powerful arguments for the sequential application of rules has been the fact that differences in closely related dialects are most efficiently explained in terms of rule ordering. However, meta relations such as rule ordering statements are not part of OT, and differences in ranking of constraints is the only source of variation across languages within this theory. It has argued that OT has not only the same descriptive coverage in dealing with dialectal varition as derivational theories, but it also offers more restricted accounts for Korean and Klamath.

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NOTES

[1] According to Koutsoudas, Sanders and Noll (1974), all ordering is predictable, given appropriate universal principles. Their position of nonordering has been believed to be falsified by cases where closely related dialects differ only in ordering.
[2] One cannot simply appeal to the naturalness of 'feeding rules' since there are many cases of bleeding rules, and language change and dialectal variation have been assumed to involve changes in rule ordering.
[3] According to Kisseberth(1972), Stop Deglottalization and Sonorant Deglottalization were not differentiated, but Kean (1973) and Lightner (1976) argue that stops and sonorants deglottalize in distinct environments and the two rules cannot be collapsed into one.
[4] The /s/ does not seem to trigger deglottalization in some cases (e.g. [mol's] 'pus').