A Co-occurrence Restriction in Maori*

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1. Introduction
The Polynesian language Maori has a number of well-known co-occurrence restrictions on labial segments, listed in (1):

(1) *wu *wo *whu *who

At first glance these seem to be transparently related. Accordingly, it is reasonable to expect that discerning a common underlying motivation for these restrictions would be a straightforward, even trivial, matter. It is somewhat surprising, then, that this assumption is not entirely valid. In fact, this seemingly simple phonological problem will be shown to be the result of a complex interaction of non-obvious constraints. In the process it will be demonstrated that the most parsimonious explanation is provided by a parallelist conception of phonological computation, specifically Optimality Theory. In addition, the grammar’s tendency to representational and computational parsimony will be shown to play an essential part in providing a solution, validating the notion of featural underspecification (Kiparsky 1982, Archangeli 1984, cf Steriade 1995).

Of course, before the co-occurrence restrictions can be discussed in depth, it is necessary to consider a few basic facts of Maori phonology.

The Maori language has a set of phonemes that is similar to many other Polynesian languages. While the vowels are only five in number (i e a o u) the consonant inventory is considerably richer with three voiceless stops (/p t k/), their corresponding nasals (/m n ng/), one rhotic (/r/), the labio-velar glide (/w/), the glottal fricative /h/, and the labial fricative ‘wh’. Of these ‘wh’ exhibits the most variation between dialects. Since this consonant plays a crucial role in the phenomena under discussion a fuller treatment of it will be given below.

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1 Thanks to Wayne Lawrence for providing many significant comments and the original impetus for this paper. Thanks are also due to Harry Leder, George Puttnen, and two anonymous reviewers. All Maori words and their glosses are from Williams (1971).

2 This sound is phonetically realised as a voiced tap (Bauer 1993:533). It will be represented as phonemic /h/ in this analysis.

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2. The Problem
Superficially, it seems that the sequence [w] is a logical constraint on adjacent labial sounds, general a statement as the labial consonant with the labial vowels /o/ and /a/:

(2) pou ‘consumed’
mouki ‘Asplenium bulbiferum’

Evidently, the class of affected sounds is achieved by noting that ‘wh’ and /w/ are [+continuant]. Since all vowels (Clements 1983:7), it seems reasonable to state as a prohibition on adjacent labia:

However, there is even further prohibition would prevent /o/ or /a/ sequence sounds. That this is undesirable is shown specifically, there is a constraint on the configuration ‘CV’.

At this point, the restriction seems Bauer (1993:570) notes one other significant forms where /w/ has been deleted fol configuration VC):

(3) kowera > koera ‘broken (clouds)’
tauwehe > taehe ‘separate’

Despite Bauer’s uncertainty as to whether change, a dialectical variation, or a syncretism, there is still evidence of a systematic prohibition of the /o,u/ w sequences. Coupled with this,韦 forms that show these segment sequences restriction on such sequences with ‘wh’.

To complicate matters further, the restriction in Maori (Williams 1971:xxx) vowels /o/ and /a/, where the sequence is internally. However, Bauer (1993:544) possible vowel-sequences occur in Maori list a number of forms with the /u/ conspicuously few in number, and there is phonologically marked: some are loanw
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2. The Problem
Superficially, it seems that the sequences in (1) are prohibited by a phonological constraint on adjacent labial sounds. However, this is obviously too general a statement as the labial consonants /p/ and /m/ can freely combine with the labial vowels /o/ and /u/:

(2) pou ‘consumed’
   mouki ‘Asplenium bulbiferum’
   puku ‘secretly’
   mure ‘slander’

Evidently, the class of affected sounds must be further refined. This is achieved by noting that ‘wh’ and /w/ are distinguished from /p/ and /m/ by the feature [+continuant]. Since all vowels are also continuants (Halle & Clements 1983:7), it seems reasonable to assume that the restriction is better stated as a prohibition on adjacent labial continuants.

However, there is even further need of refinement here since this prohibition would prevent /ou/ sequences, for both /o/ and /u/ are labial sounds. That this is undesirable is shown by pou and mouki in (2). So, more specifically, there is a constraint on adjacent labial continuants in the configuration ‘CV’.

At this point, the restriction seems easy to characterise. However, Bauer (1993:570) notes one other significant fact. There are a number of forms where /w/ has been deleted following a labial vowel (i.e. in the configuration VC):

(3) kowera > koera ‘broken (clouds)’
   tauwehe > tauhe ‘separate’

Despite Bauer’s uncertainty as to whether the deletion is a diachronic change, a dialectal variation, or a synchronic process, the fact remains that there is still evidence of a systematic prohibition (or at least avoidance) of /w/ sequences. Coupled with this, Williams’ (1971) dictionary lists few forms that show these segment sequences. Surprisingly, there is no restriction on such sequences with ‘wh’.

To complicate matters further, there is yet another co-occurrence restriction in Maori (Williams 1971:xxxiii). This time, it involves the labial vowels /o/ and /u/, where the sequence *uo/ is prohibited morpheme internally. However, Bauer (1993:544) disputes this, claiming that all possible vowel-sequences occur in Maori. Indeed, Williams’ dictionary does list a number of forms with the /uo/ sequence. However, they are conspicuously few in number, and there is good reason to think that they are phonologically marked: some are loanwords, which typically do not follow...
usual phonological rules, and the others did have morpheme boundaries between the /hu/ and /lo/ at some point in the past. From this, it is valid to claim that the sequence */hu/ is prohibited morpheme-internally.

The problem is obviously not as simple as it first seemed. In fact, there are now four restrictions that need to be explained:

(4)  
(i) *w{o,u}  
(ii) *wh{o,u}  
(iii) *{o,u}w  
(iv) *uo

The */uo/ restriction is significant in that it shows that the prohibition on adjacent labial continuants is not limited to CV configurations. In fact, the explanation of this co-occurrence restriction will give significant insight into the workings of the other restrictions.

The other prohibitions suggest that ‘wh’ and /w/ are related since they are prohibited in the same environment — i.e. before labial vowels. However, they must also be formally distinct since only /w/ is prohibited after /u/ and /o/. Of course, any formal distinction between /h/ and /w/ relies on a formal definition of their internal structure (or featural composition). For ‘wh’ this is not as simple a matter as one might think.

2.1 ‘Wh’

‘Wh’ represents the most dialectically variable sound in Maori. While it is difficult to determine the pre-European form of this phoneme, the use of the digraph ‘wh’ instead of ‘f’ suggests that the sound was not labio-dental, but perhaps voiceless and bi-labial. The dialectical reflexes of this sound vary somewhat, but still have features in common, as shown by the following list (summarising Bauer 1993:531,532):

(5)  
(i) [f]  
(ii) [ɾ], a voiceless labio-velar fricative.  
(iii) [h], strongly labialized, with back tongue raising.  
(iv) [w]  
(v) [hw]/[wh]

The common component of all the dialectal reflexes is that it must form at least part of the sound. This same component ([labial]) is common to them all. In addition, the second component (realised in some as /h/ and in others as a voiceless stop) is common to /w/ and /h/. So, it is enough to say that ‘wh’ contains the features [labial], [voiceless], with perhaps another feature making no claim as to precise phonetic identity.

2.2 The Phonemic Conflation Approach

It is intuitively implausible that the restrictions on the use of ‘wh’ as entirely separate phonological prohibitions the estimation of this phoneme, and hence the representation of it can be expressed by a merely descriptive way.

One approach to reducing the number of prohibitions is to suppose that the allophones of a single phoneme then the constraints can be conflated.

The most likely candidates for such an approach are the sounds /w/ and /u/ as they are not prohibited, and it soon becomes evident that these forms are not in fact prohibited. The only environment in which they appear is in Maori:

(6)  
ua ‘backbone’  
ui ra ‘gleam, flash’  
ure ‘red’  
pa:ua ‘basin’  
pawa ‘smoke’  
 kouha = koua

There is a more compelling reason to search for restrictions — parsimony. If it is assumed that the representation and computation, then it should be avoided. Instead, all vowels have a preattached mora (Bauer 1994, Perlmutter 1995).

The feature [+syllabic] does not figure in this approach. Instead, all vowels have a preattached mora.

Although I only have six examples here, there are 33 words beginning with /u/ alone in Bauer (1994) approaches to this type of allophony, all /u/ sequences of the type /uV/.

One reviewer pointed out that despite the clausal transparency it is often difficult to tell whether a /u/ is pronounced as either [u] or [O]. In many cases this is true but in others [u] whereas /u/ is pronounced as either [u] or [O], at least some support for William’s examples.
The common component of all the dialectical reflexes is the use of the lips to form at least part of the sound. This suggests that the phonological feature [labial] is common to them all. In addition, all forms include a voiceless component (realised in some as /h/ and /ɪ/) and all contain a continuant component (only /w/). So, it is enough to idealise the situation and assume that ‘wh’ contains the features [labial], [+continuant] and [-voice]. Because of this, ‘wh’ will be represented as phonemic /ɪ/, with the proviso that this makes no claim as to its precise phonetic realisation.

2.2 The Phonemic Conflation Approach

It is intuitively implausible that the restrictions in (4) are unrelated, existing as entirely separate phonological prohibitions. Because of this, a more fundamental constraint must be involved in the co-occurrence restrictions than can be expressed by a merely descriptive statement or rule such as in (4).

One approach to reducing the number of restrictions is to claim that phonemic identity plays a role; after all, if the elements involved are allophones of a single phoneme then at least two of the co-occurrence restrictions can be conflated.

The most likely candidates for such a phonemic conflation are the glide /w/ and the vowel /h/ as they are featurally identical. However, it is soon evident that these forms are not in complementary distribution as they appear in identical environments:

(6) ua ‘backbone’
    uira ‘gleam, flash’
    uere *Baryspira australis*
    pawa ‘basin’
    pawa ‘smoke’
    koua = koua
    wa: ‘region’
    wiri ‘tremble, shiver’
    were ‘hang, be suspended’
    pa:wa ‘collar-bone’
    koua ‘roe of fish’
    kowaka ‘dry, open gully’

There is a more compelling reason to search for an underlying motivation for these restrictions — parsimony. If it is assumed that the grammar aims for parsimonious representation and computation, then it should maximise the resources it has, thereby conflating rules and processes.


Although we have six examples here, there are many more. For example, there are 33 words beginning with /a/ alone in Williams' dictionary. By conventional approaches to /w/-/h/ allophony, all /a/ sequences should be realised as /w/.

One reviewer pointed out that despite the claim that Maori spelling is phonetically transparent it is often difficult to tell whether a Maori word contains a [w], a [u], or a [o]. In many cases this is true but in others the difference is phonetically evident. Bauer (1993:540) points out that for many speakers /wa/ is pronounced [wn] whereas /ua/ is pronounced as either [uo] or [un]. This phonetic difference offers at least some support for William’s examples.
Similarly, /w/ and /f/ must be phonemically distinct as they also appear in identical environments, as do /l/ and /h/.

(7) wa: ‘area, region’  fa: ‘four’
    wai ‘water’        fai ‘possessing’

(8) uere ‘univeal moluscs’  fere ‘overcome’
    uara ‘desire’      fara ‘be struck’

From this, it is evident that an appeal to allophony is misguided. Any attempt to provide an analysis must instead consider the featural content of the phonemes involved.

3. Towards a Resolution
So far, it has been established that any explanation of the co-occurrence restrictions involving /l/ and /w/ must account for the following facts:

(9) (i) *{w,f}{o,u}
    (ii) *{o,u}w
    (iii) {o,u}f
    (iv) h{o,u}
    (v) p{o,u}

(i) and (ii) restate the co-occurrence restrictions while (iii) makes the point that there must be some featural difference between /w/ and /l/ that motivates their different treatment with regard to preceding labial vowels. (iv) and (v) show that neither the feature [labial] alone (as in /p/) nor [continuant] alone (as in /h/) is enough to cause a prohibition—the segment must be both [labial] and [+continuant].

However, this assumes that the features [labial] and [+continuant] are actually specified for /l/ and /w/ in the lexicon, or at least in the computational component of the phonology. A lack of such specification has significant implications for an adequate explanation of the problem. In fact, identifying the lack of underlying featural specification—or 'underspecification'—will be an essential step towards providing an economical solution to the co-occurrence restrictions.

3.1 Underspecification
The term 'underspecification' refers to the principle whereby predictable features of a phoneme are not specified in the lexical and computational component of the grammar. Instead, predictable features are inserted by redundancy rules after computation. The version of underspecification adopted here is that of Itô, Mester and Padgett (1995) since this framework is particularly suited to Optimality Theory.

Itô, Mester, & Padgett's framework (also see Itô & Mester 1993). This means that feature F if F is entirely predictable given — i.e. F is not licensed to apply underlyingly the feature [+sonorant] implies the presence is not licensed by sonorants, and cannot segment underlyingly. However, a sonorant that feature is licensed by and associated (below). So, underspecification is the empty inventory that are predictable by implication.

3.1.1 Feature Geometry
Underspecification plays an essential role. However, determining the underspecification of a phoneme is impossible without being sure features exist.

Earlier theories of featural components of unerorder phonological features (e.g. Clements, (1985) are 

Clements challenged by Clements (1985) are 

ordered into dependency where the [distrubbed] is dependent upon the node, and the 

structure [distributed] cannot exist, and without a 

[distributed] could exist in a representation - all those enclosed in square brackets called terminal nodes.

Recently, a consensus has emerged that [±vocoid] and [±vocoid] are not terminal nodes, but are 

[distributed] (Clements & Hume 1995). Because into adjacency violations, nor can they 

be a feature in the tree. 

Clements & Hume (1995) have suggested an organisation. They differ from other proposals feature (geometry) has a structural dis 

 vocoids. The difference rests on the fact that there are three separate nodes: C-Place, Vocalic, and 

a C-Place node, only vocoids have a Vocalic node, and 

V-Place nodes, with C-Place joining [dorsal], and [coronal].

* The reader may also wish to examine 

(Kiparsky 1982, Archangeli 1984 cf Steriadis

* Also see Hohepa (1967:6).
phonemically distinct as they also appear in /f/ and /w/.

: ‘four’
: ‘possessing’
: ‘overcome’
: ‘be struck’

An appeal to allophony is misguided. Any account must instead consider the featural content of /w/.

and that any explanation of the co-occurrence of /w/ must account for the following facts:

3.1.1 Feature Geometry
Underspecification plays an essential role in the Maori restrictions. However, determining the underspecified featural composition of a phoneme is impossible without being explicit about which phonological features exist.

Earlier theories of featural composition treated phonemes as bundles of unordered phonological features (e.g. Chomsky & Halle 1968). This view was challenged by Clements (1985) and Sagay (1986)’s proposals that features are organised into dependency relations. For example, the feature [distributed] is dependent upon the node [coronal], which in turn is dependent upon the place node, and so on; without a [coronal] node, [distributed] cannot exist, and without a place node neither [coronal] nor [distributed] could exist in a representation. Only the outermost points of the tree – all those enclosed in square brackets in (10) – are features. These are called terminal nodes.

Recently, a consensus has emerged that features such as [+sonorant] and [+vocoid] are not terminal nodes, but are encased in the root node (Halle 1995, Clements & Hume 1995). Because of this, these features cannot enter into adjacency violations, nor can they spread independently of any other feature in the tree.

Clements & Hume (1995) have suggested another revision to featural organisation. They differ from other proposals in that their feature tree (or feature geometry) has a structural distinction between consonants and vocoids. The difference rests on the decomposition of the Place node into three separate nodes: C-Place, Vocalic, and V-Place. While all sounds have a C-Place node, only vocoids have a Vocalic and V-Place node. The diagram below shows the structure of a vocoid; a non-vocoid omits the Vocalic and V-Place nodes, with C-Place joining directly to the features [labial], [dorsal], and [coronal].

The reader may also wish to examine other theories of underspecification (Kiparsky 1982, Archangel 1984 cf Steriade 1995).
(10) **Amalgam of Consonant and Vocoid Trees**

-+/-] indicates bivalent features. All others are privative. 
[Clements & Hume (1995:292)]

For the values of individual features see Clements & Hume (1995) and Halle & Clements (1983).

Some of the features are binary while others are privative. Binary features have two values, designated '+' or '-' (e.g. [continuant]). Privative features have only one value and as such are either 'present' or 'not present'. As an example, the place features are all privative, so it makes no sense to say that a sound is [-labial], [+coronal], [-dorsal]. Instead, it is simply [coronal].

### 3.1.2 Maori Phonemes

From the theory of underspecification and the feature tree of Clements and Hume, the Maori phoneme inventory can be featurally decomposed in the following manner:

<table>
<thead>
<tr>
<th>Root</th>
<th>Phoneme</th>
<th>Labial</th>
<th>Coronal</th>
<th>Dorsal</th>
<th>Nasal</th>
<th>+Continuant</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Approx</td>
<td>p</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+Sonorant</td>
<td>t</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Vocoid</td>
<td>k</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>h</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11 Some analyses have suggested that *h* is [+vocoid] (Chomsky & Halle 1968:303, Halle 1995:7, Clements & Hume 1995:271). However, the evidence for this is not overly compelling (Fromkin 1970, Lass 1984), hence its representation here as a consonant. This has no significant implications for the analysis presented herein.

12 Since [anterior] and [distributed] are not co-occurrence restrictions, it is not possible to include them in the phoneme inventory because they cannot be meaningfully specified in underspecified phonological systems. Instead, these features will be treated as the terminal feature (see Clements & Hume 1995:292)
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<table>
<thead>
<tr>
<th>Root</th>
<th>Phoneme</th>
<th>Labial</th>
<th>Coronal</th>
<th>Dorsal</th>
<th>Nasal</th>
<th>+Continuant</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Approx</td>
<td>m</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>+Sonorant</td>
<td>n</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>-Vocoid</td>
<td>η</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>+Approx</td>
<td>i</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+Sonorant</td>
<td>e</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+Vocoid</td>
<td>o</td>
<td>✓</td>
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<tr>
<td></td>
<td>u</td>
<td>✓</td>
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<td></td>
<td>w</td>
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</tbody>
</table>

(11) Underspecified Maori phoneme inventory

The phonemes are not fully specified in the above table as many of their features are predictable by implication, and are therefore not licensed to appear. The following list gives the principal implications:

(i) [α sonorant] → [α voice]
(ii) [t approximant] → [α continuant]
(iii) [+vocoid, labial] → [dorsal] (applies to /w, o, u/)11
(iv) [coronal] → [+anterior], [-distributed]12
(v) [j, w] → [coronal] (applies to /l, n, r, i, e/ since they have no place node)

The vowels are not specified for height features in (10). Although these are phonologically necessary to distinguish /i/ from /e/ and /a/ from /a/, they do not have any bearing on the present analysis as height features do not figure in any restrictions in Maori, with all vowel-combinations possible except */uol/.

This still leaves a distinction to be made between /w/ and /u/. A traditional approach to this would invoke the feature [+syllabic], with /w/ negatively specified for this feature and /u/ positively specified. A more recent idea is that vowels are underlingly associated to a prosodic element called a mora, while glides are mora-less. This way there is no feature difference between /w/ and /u/, yet they are still distinct by virtue of their underlying prosodic affiliations.

A number of interesting facts follow from the characterisation of the

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11 This raises the classic problem of which feature implies the other: [dorsal] or [labial] (traditionally [back] or [round]). However, since [labial] is obviously the one involved in this co-occurrence restriction, it must be overtly specified.
12 Since [anterior] and [distributed] are not contrastive features in Maori, [coronal] will be treated as the terminal feature (see Clements & Hume 1995).
phoneme inventory above. Firstly, apart from the nasals, /h/ is the only sound that requires the specification of two terminal features.\(^{13}\) Such a featurally complex state is typically avoided or at least marked cross-linguistically (Padgett 1995) and will be shown to have a significant role to play in the Maori restrictions. Also, the place features used by vowels and consonants are identical. As such, [labial] is the same for the consonants /p, m, f/ and for the vocoids /w, u, o,/, implying that they are accessible to each other for phonological processes (Hume 1992, Clements & Hume 1995). This also has significant repercussions in accounting for the co-occurrence restrictions.

3.2 Constraints and Feature Sharing

With the featural structure of the phonemes established, it is now possible to discern the workings of the co-occurrence restrictions.

The co-occurrence restrictions in Maori seem to result from the Obligatory Contour Principle (OCP), which prohibits identical elements from being adjacent (Goldsmith 1976, 1990; Myers 1994). The OCP was originally used to account for prohibitions on sequences of identical tones: i.e. *HH, *LL cf LH, HL. The OCP has since been extended to account for a wide variety of phonological phenomena, accounting for the avoidance of adjacent identical phonemes (McCarthy 1979), and at a lower level, the avoidance of adjacent identical features.

From (4) it is evident that the features involved in at least the /f[ou]/ restriction are [labial] and [+continuant]. However, claiming that the OCP only holds for adjacent [labial] and [+continuant] features together and not individually is only restating the description in (4). Instead, let us assume that the OCP holds in its strongest form in Maori with the proviso that this will be revised shortly. In other words, adjacent identical features are prohibited.

(13) OCP: *FiFj.

(i) Fi and Fj are on the same tier.

There is more than one way to avoid an OCP violation. One method is to simply eliminate one of the features. This is arguably what has occurred in the diachronic change from Proto-Eastern Polynesian *f to Tahitian /h/ when followed by a round vowel (Biggs 1978, Harlow 1997):

(14) \[\begin{align*}
  \text{f} & \rightarrow \text{V} \\
  \text{[+cont]} \text{[labial]} & \rightarrow \text{h} \text{[labial]}
\end{align*}\]

To avoid an OCP violation one of the features (e.g. delete), leaving /h/ with only its [-cont] transformation into the glottal fricative.

The other method of avoiding a feature:

(15) SHARE: ‘Given a segment x and a feature Fi and y requires an identity associated to both x and y, as long as:

This is expressed representationally as:

(16) \[\begin{align*}
  X & \rightarrow F \\
  Y & \rightarrow F
\end{align*}\]

This way, instead of there being two features, one is delinked (hence deleted), and the other is licensed - the presence of the [+voice] feature.

Despite the seeming simplicity of the OCP, it does not license the presence of the [+voice] feature. Similarly, /p/ and /o/ both license /p/ or /o/ which implies the presence of /o/ and /p/ to share this feature.

In comparison, the two sounds in feature [+continuant]; both require [+cont] since this feature is implied by their [+apical] license its presence. Because of this [+cont] shared by /ou/ in the computational system.

\(^{13}\) This constraint follows from the system whereby a constraint requiring the presence of a feature may require the feature to be licensed. This feature sequence such as xzy may share a feature if only the feature sequence to be broadened to include such a case, but the feature sequence xzy.

\(^{14}\) Despite the fact that a segment may need a feature, this does not imply that it will in fact be output from the [\text{+vow}]) specified.
To avoid an OCP violation one of the [labial] features must delink (thence delete), leaving /h/ with only its [+continuant] feature, effectively transforming it into the glottal fricative /h/.

The other method of avoiding the OCP is to share the offending feature:

\[ \text{SHARE: Given a segment } x \text{ and a segment } y \text{ where } x \text{ requires a feature } F_i \text{ and } y \text{ requires an identical feature } F_j, \text{ then one of } F_i,F_j \text{ is associated to both } x \text{ and } y, \text{ as long as } x \text{ or } y \text{ licenses } F. \]

This is expressed representationally as:

\[ \begin{array}{c}
X & Y \\
F & F \\
\end{array} \rightarrow \begin{array}{c}
X & Y \\
F & F \\
\end{array} \rightarrow \begin{array}{c}
X & Y \\
F \\
\end{array} \]

This way, instead of there being two adjacent identical features, one is delinked (thence deleted), and the other is associated to both segments.

Despite the seeming simplicity of this approach, there are a couple of complexities. ‘Requires F’ in the above definition means that a segment needs the feature F for full specification at the phonetic level. For example, in the sequence /po/, /p/ and /o/ both require [labial] for full phonetic specification. However, just because a segment requires a feature F does not mean that it licenses F. For example, /t/ requires [+voice] for full specification. However, the feature [+voice] is predictable by implication, since all sonorants are voiceless. Because of this, the [+sonorant] /t/ does not license the presence of the [+voice] feature.

Similarly, /p/ and /o/ both license [labial] since there is no feature in the sequence /po/ or /p/ which implies the presence of [labial]. As such, share requires /p/ and /o/ to share this feature.

In comparison, the two sounds in the sequence /ou/ cannot share the feature [+continuant]; both require [+continuant] for full specification, but since this feature is implied by their [+approximant] root feature, neither can license its presence. Because of this [+continuant] cannot be associated to or shared by /ou/ in the computational system.

14 This constraint follows from the system of Ihı, Mester and Padgett (1995:10) whereby a constraint requiring the presence of a feature is ranked below one requiring the feature to be licensed. This formulation does not allow a segment sequence such as xz to share a feature if only x licenses that feature. This may have to be broadened to include such a case, but this is a question beyond the scope of this paper.

15 Despite the fact that a segment may need a feature for full specification, this does not imply that it will in fact be output from the phonological component fully specified.
The final case is where both sounds require a feature, but only one licenses it. For example, all vowels require [+continuant] but none of them license it. However, /l/ does license the presence of [+continuant]. Now, share forces a feature F to spread if an adjacent segment requires F. So, in the sequence /fa/ even though /a/ does not license [+continuant], this feature still spreads from /l/ since /a/ requires it:

\[
\begin{array}{c|c|c}
\text{f} & \text{a} & \rightarrow \\
\text{[+continuant]} & & \text{[+continuant]}
\end{array}
\]

One more matter has to do with direction of feature spreading. Many approaches to phonological processes have proposed that feature spreading—indeed all alterations in phonological representation—occurs from one edge to another in sequence. This directionality has often been seen as a parameter (see Archangeli & Pulleyblank 1994:298ff for discussion). In Maori, feature spreading occurs from left to right. So, in /au/ only /u/ is associated to the feature [continuant] despite the fact that /a/ requires it, simply because [continuant] cannot spread leftwards.

3.2.1 Language-Specific Constraints

Having established that features must share when necessary, the exact constraints that cause the co-occurrence restrictions in Maori can be determined. The restrictions will be shown to result from constraints on the application of feature sharing in certain environments.

For Maori, there are two specific constraints that cause the co-occurrence restrictions. Firstly, the ban on */[o,u]w/[o,u]/ sequences is caused by forcing an OCP violation of adjacent [labial] [+ tense] features:

\[
\text{(18) LABSPR: 'When [labial][+ tense] is in an onset, it may not be shared.'}^{15}
\]

Effectively, this means that /w/ may never spread its [labial][+ tense] feature. The implications of this can be seen in the sequences /wo/ and /wul/. Both /o/ and /u/ bear a [labial][+ tense] specification, and by share in a sequence /wo/ the phoneme /w/ must share its [labial][+ tense] feature with /o/. However, doing so violates LABSPR; alternatively, not doing so violates share since there are two adjacent identical features. This produces a no-win situation, with either share or LABSPR being violated. Ultimately, this means that /w/[o,u]/ may

\[
\text{(17) } f \quad a \rightarrow f \quad a \quad \text{[+continuant]}
\]

never be put from the phonological description of this point see section 4.

In comparison, LABSPR does not place a feature as neither /o/ nor /u/ are in an onset, nor LABSPR may seem overly specific, but this can be expanded to other broader principles.

3.2.2 */[o,u]/

The */[o,u]/ restriction is another matter that is similar to LABSPR, but only one feature:

\[
\text{(19) SPRNS: 'A segment in an onset must not be licensed by only one feature.'}^{17}
\]

This constraint is somewhat convoluted, and the feature in question is derived from general principles. Without the example, it is seen that this will apply to sequences:

\[
\text{(A) }
\begin{array}{c}
\text{L} \\
\text{C}
\end{array}
\]

\[
\text{(B) }
\begin{array}{c}
\text{L} \\
\text{C} \\
\text{f}
\end{array}
\]

\[
\text{(20)'' The */fo/ restriction}
\]

\[
\text{L = [labial], C = [+continuant]}
\]

In the examples above, /l/ licenses both /o/ and /u/ sequences, whereas /o/ licenses only [labial] but not [continuant]. In (A), SPREAD has applied to the features. This configuration is unacceptable under SPRNS, which only allows one shared feature.

In comparison, (B) satisfies SPRNS.

\[\text{Note that 'feature' only refers to terminal contained features [sonorant], [-approximant], [-nasal], [labial] and [+sonorant]. [lumal, /m/, etc. are not labial] feature with the following vowel.}\]

\[\text{15 Configurations of the type such as 19B will be impossible as C is not licensed by /o/. A configuration with interchanged features.}\]

\[\text{17 No other consonant will share two features but other two-featured phemes are the nasals spread since there are no nasal vowels.}\]
There both sounds require a feature, but only one vowels require [+continuant] but none of them license the presence of [+continuant]. Now, spread if an adjacent segment requires F. So, in /a/ does not license [+continuant], this feature requires it:

\[
\begin{array}{c}
\text{f} \\
[+\text{continuant}]
\end{array}
\]

with direction of feature spreading. Many processes have proposed that feature spreading is an operational representation — occurs from one This directionality has often seen as a \cite{Pulleyblank1994} for discussion). It occurs from left to right. So, in /ut/ only /t/ is +continuant despite the fact that /u/ requires it, cannot spread leftwards.

**Constraints**

Features must share when necessary, the exact co-occurrence restrictions in Maori can be will be shown to result from constraints on the in certain environments.

Two specific constraints that cause the co-occurrence of adjacent [labial] features:

\[
[\text{labial}]^{\text{face}} \text{is in an onset, it may not be shared.}{^16}
\]

It may never spread its [labial] feature. The +continuant in the sequences /wo/ and /wul/. Both /o/ and /u/ feature, and by share in a sequence /wo/ the [labial] feature with /o/. However, doing so does not violate Share since there are no /w/. This produces a no-win situation, with either missed. Ultimately, this means that /w{o,u}/ may

Face feature is in the onset, it may not spread since V-face feature that ever occurs in an onset. This censuring of V-face features by the nucleus of the basic analysis for the moment. An ‘onset’ is the part of the consonant.

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never be out-put from the phonological component. For detailed explanation of this point see section 4.

In comparison, LabSpr does not stop /o/ from sharing the [labial] feature as either /o/ nor /u/ are in an onset. At this point, the formulation of LabSpr may seem overly specific, but it will be shown to derive from broader principles.

3.2.2 */f{0,u}/

The */f{0,u}/ restriction is another matter. In this case, a prohibition is operative that is similar to LabSpr, but more general in scope:

(19) **SprOns:** ‘A segment in an onset and an adjacent segment may share only one feature.’

This constraint is somewhat convoluted, but like LabSpr it can be shown to derive from general principles. Without further discussion as to its validity for the moment, it is evident that this will result in a prohibition of */f{0,u}/ sequences:

\[
\begin{array}{c}
\text{(A) } \\
\text{(B) } \\
\text{(C) }
\end{array}
\]

(20) The */fo/ restriction

\[
L = [\text{labial}], C = [+\text{continuant}]
\]

In the examples above, /f/ licenses both [labial] and [+continuant] features whereas /o/ licenses only [labial] but requires both [labial] and [+continuant]. In (A), Spread has applied maximally, resulting in two shared features. This configuration is unacceptable as it causes a violation of SprOns, which only allows one shared feature.\footnote{Note that ‘feature’ only refers to terminal features. It does not refer to the root-contained features [asonorant], [approximant], and [vowel]. If this was not so, the sequences /mo, mu/ would be violations of SprOns since they would share both [labial] and [+sonorant], [mol, mua, etc. are not prohibited since they share only the [labial] feature with the following vowel.}

In comparison, (B) satisfies SprOns, permitting only one feature to

\footnote{No other consonant will share two features with the following vowel. The only other two-featured phonemes are the nasals, and their [nasal] feature will never spread since there are no nasal vowels.}
spread. Even so, now the OCP is violated because there are two adjacent [labial] features.

Finally, in (C) no feature has spread violating SPREAD as well as the OCP. Thus, /fi/ is in a no-win situation when followed by a labial continuant. This effectively prohibits /f{0,u}/ sequences.

This raises an issue with respect to /f{u,0}/ sequences: should these not be prohibited by SPrONS? The reply to this is in the negative as feature spreading is rightwards. So, /u/'s [labial] feature will spread rightwards to join to /fi/, but /fi/’s [+continuant] feature cannot spread leftwards to /fi/. So, /fi/ has only one shared feature, so satisfying SPrONS.

At this point, the two constraints SPrONS and LABSPR have accounted for the co-occurrence restrictions involving /wi/ and /fi/. However, the /uo/ restriction still remains.

3.2.3 /uo/

Superficially, the prohibition on /uo/ sequences seems to be related in some way to the restriction */{0,u}w{0,u}/ as it involves [labial]w*free. This relation will be shown to be more than co-incidental.

Of immediate concern is that the sequence /ou/ is permitted. Like LABSPR, it seems that [labial]w*free must be blocked from spreading in certain configurations, forcing an OCP violation.

The problem is in defining the domain in which [labial]w*free may not share. For */{0,u}w{0,u}/ the domain is between vowels and consonants. However, */uo/ prohibits [labial]w*free from sharing between two vowels. However, a generalisation employing this cannot be valid since the sequence /ou/ is perfectly acceptable, and here [labial]w*free is shared between two vowels.

This problem can be avoided by rejecting the linear characterisation of domains, appealing instead to prosodic structure. In this case it is syllabic structure that is significant. So, there must be a structural distinction between /ou/ and /uo/. Following previous work on syllable structure in Maori, the difference can be represented as in (21) (de Lacy 1995, 1996a,b; Barbour 1996): 20

(21)  /uo/: R σ o /uo/: R R o

Here, ‘σ’ represents the syllable node, while ‘R’ is the rime – a sub-syllabic constituent containing the vocalic members of a syllable. Whereas /ou/ is contained in a single syllable, /ai/ and /ai/ words, a diphthong in Maori is a sequence of two or more complex sounds (for discussion see Bickmore 1995). The restriction can be stated as follows:

(22)  LABSPR*: [labial]w*free may not spread.

3.2.4 Implications

So far, two constraints have been identified /{0,u}/ and the /uo/ prohibition: LABSPR*. This specification can simplify this even further.

There are a variety of processes affecting the underspecified place of articulation in the passive suffix (Blevins 1996b) and consonant dissimilation (Kaisse 1994). This is of some significance: since [coronal] feature, it need not be specified to avoid redundancies. The Place node will be automatically assigned.

So, /fi/ can be specified underlyingly as [coronal].

This can be expressed representationally as

(23)  Place → Place
              [coronal]

This results in a simplification of the features

(24)  /ai/ = No Place node,
              /e i/ = Place node, No features,
              /o u/ = Place node, [labial] feature.

20 Simply, if there are two adjacent vowels of the same syllable if /ai/ is equally or more sonorous than the scale /ai/ > /e, /e > /ai/ (Or et al., 1997).
21 Syllabification in Polynesian languages is left-to-right (pref.).
22 Epenthesis in loanwords is a more complex matter (pref.).
CP is violated because there are two adjacent features has spread violating SPREAD as well as the situation when followed by a labial continuant.

(6, u, l) sequences.

with respect to /u, o/ sequences: should these /u, o/ be labialized? The reply to this is in the negative as feature /u, o/ labial will spread rightwards to /v, /l/ feature cannot spread leftwards to /u, o/. So, there are no satisfying SPRONS.

Two constraints SPRONS and LABSPR have no sequence restrictions involving /w/ and /l/. However, ins.

/u, o/ sequences seems to be related in some way to [labial][p, t, k]. This seems more than co- incidental.

is that the sequence /u, o/ is permitted. Like [p, t, k], they must be blocked from spreading in certain contexts.

The domain in which [labial][p, t, k] may not spread is between vowels and consonants. [labial][p, t, k] is shared between the domain in which [labial][p, t, k] may not spread is between vowels and consonants. [labial][p, t, k] is shared between two vowels. Employing this cannot be valid since the [labial] feature is shared between vowels.

So, there must be a structural distinction between previous work on syllable structure in Polynesian languages, see de Lacy (1995, 1996a, b).

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contained in a single syllable, /u/ and /o/ are in separate syllables. In other words, a diphthong in Maori is a sequence of two vowels where the second is less sonorous than the first. So, there are no 'rising' diphthongs in Maori (for discussion see Bickmore 1995 in the context of Tahitian). Thus, the /l/ restriction can be stated as follows:

\[(22) \quad \text{LABSPR:} \quad \text{[labial][p, t, k] may not spread over a syllable boundary.}\]

3.2.4 Implications

So far, two constraints have been identified that account for the /u, o/ and the /l/ prohibition: LABSPR and LabSPR. Returning to underspecification can simplify this even further.

Returning to underspecification can simplify this even further.

There are a variety of processes in Maori that point to [coronal] as being the underspecified place of articulation in Maori. These include epenthesis in the passive suffix (Blevins 1994, Sanders 1991, de Lacy 1996b) and consonant dissimilation (Kawasaki 1988). The implications of this are of some significance: since [coronal] is the default place of articulation feature, it need not be specified underlingly, but filled in at the end of the derivational process. This means that any vowel with an empty Place node will be automatically assigned the feature [coronal].

So, /v, o/ can be specified underlingly as having a C-Place node but no associated [coronal] feature since it will be supplied later. In fact, /v, o/ cannot license the presence of [coronal] underlingly because it is supplied by a redundancy rule. Similarly, /v/ and /o/ have a V-Place node and no features. This can be expressed representationally by the following redundancy rule:

\[(23) \quad \text{Place} \rightarrow \text{Place} \rightarrow \text{[coronal]}\]

This results in a simplification of the featural composition of the vowels:

\[(24) \quad /a/ = \text{No Place node.} /e, i/ = \text{Place node, No features.} /o, u/ = \text{Place node, [labial] feature.}\]

21 Simply, if there are two adjacent vowels α and β, then \(α \approx β\) and \(β \approx α\) if α is equally or more sonorous than β. Sonority is calculated according to the scale \(r < l < m < n\) (Dell & Elmedlaoui 1985). In the case of /aii/, it is syllabified as /aii/ (not /ai, i/) since long vowels take precedence over diphthongs. In /aei/ there are two possible combinations: /ae, ei/ and /a, ei/. The former is chosen since syllabification is from left to right in Maori.

22 Epenthesis in loanwords is a more complex issue. See Kearns (1990) and Kitto (in prep.).

23 This is in contrast to /u/ which does not have a C-Place node at all.
This means that the only vowels with terminal features are /u/ and /o/, and that the only terminal feature for vowels is [labial].

Now, the */uo/ and */(o,u)w{0,u}/ constraints state that [labial]^{place} can not spread in certain constituents. This can now be generalised to say that no V-Place feature may spread (in certain domains). This generalisation is possible since [labial] is the only V-Place feature specified underlyingly. Even so, this still leaves two constraints:

(25) LABSriv: A V-Place feature may not share over an onset boundary.

LABSriv$: A V-Place feature may not share over a syllable boundary.

These two constraints can now be conflated into one by adopting a traditional model of the syllable which distinguishes between onset and rime (Halle & Vergnaud 1980):

(26) \[ \begin{array}{c}
\sigma \\
R \\
O \\
\text{[labial]} \\
\end{array} \quad \begin{array}{c}
\sigma \\
R \\
O \\
\text{[labial]} \\
\end{array} \quad \begin{array}{c}
\sigma \\
R \\
O \\
\text{[labial]} \\
\end{array} \]

Here, the only situation in which [labial]^{place} can share is when the two sharing segments are in the same sub-syllabic constituent – i.e. the rime. So, LABSriv and LABSriv$ can be conflated into one constraint:

(27) V-SPR: V-Place features may not be shared over a sub-syllabic constituent boundary.

However, this leaves one issue unresolved. For example, in /pos/, /p/ and /o/ both share [labial] features to avoid an OCP/SHARE violation. This is also true for /{f,m}{o,u}/. As it stands, V-SPR seems to prohibit such sharing. To avoid this, the term 'V-Place feature' needs to be refined. This is resolved by comparing /pos/ and /wos/:

(28) \[ \begin{array}{c}
p \\
C-Place \\
\text{[labial]} \\
\end{array} \quad \begin{array}{c}
w \\
C-Place \\
\text{[labial]} \\
\end{array} \]

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There is an obvious difference in the two types of this distinction V-SPR can be revised, and

(29) \[ \begin{array}{c}
\alpha_1 \\
\text{V-Place} \\
\delta \\
\end{array} \quad \begin{array}{c}
\alpha_2 \\
\text{V-Place} \\
\end{array} \]

\(\delta\) is the terminal feature [labial]. The V-Place features are assigned to two different prosodic nodes (\(\alpha_1\), \(\alpha_2\)) and may not spread into syllabic constituents.

Of course, this configuration does not apply to any other CV sequences (\(C \neq /w/\)) since this is one V-Place node. In effect, the configuration applies to /pos/ and /wos/ sequences; it does not apply to /pos/. (Note that it was ascribed to Sprons (repeated here):

(30) Sprons: A segment in an onset may never share one feature.

As it stands, Sprons is overly specific and it stands that this constraint derives from more general.

Ino, Mester & Padgett (1995) propose that the CV sequences in which a CV is No-NC-Link which prohibits features for \(C\) and a following oral consonant. In the case for */f{o,u}/ seems to be No-NC-Link. However, this has not been shown as the only sharing features in the configuration CVC.

However, using No-NC-Link over their following V's may never share a feature. There are many cases when this occurs [labial], /f/ and /a/ share [+continuant] and allow it to be violated minimally within this out-put. However, traditionally no distinction differing degrees of constraint violations if it violates one or several constraints. For recent approaches to phonological theory, allowing a distinction to be made between the most successful approaches to this issue (McCarthy & Prince 1993, Prince &
levels with terminal features are /u/ and /o/, and for vowels is [labial].

V{[o,u]}w{[o,u]}/ constraints state that [labial]\textsuperscript{\text{V-Place}}
constituents. This can now be generalised to say . . . 
only V-Place feature specified underlyingly.

two constraints:

1. feature may not share over an onset boundary.
2. feature may not share over a syllable boundary.

be conflated into one by adopting a tradition which distinguishes between onset and rime

\[
\begin{array}{c}
\sigma \\
R \\
\sigma \\
R \\
\sigma \\
R \\
\sigma
\end{array}
\]

which [labial]\textsuperscript{\text{V-Place}} can share is when the two
sub-syllabic constituent - i.e. the rime. So, conflated into one constraint:

features may not be shared over a sub-syllabic

unresolved. For example, in /pol, /f/ and /lo/
avoid an OCP/SHARE violation. This is also

ends, V-SPR seems to prohibit such sharing. To

feature' needs to be refined. This is resolved by

\begin{array}{c}
\text{cf} \\
\text{V-Place} \\
[\text{labial}]
\end{array}
\]

A Co-occurrence Restriction in Maori

There is an obvious difference in the two configurations here. By employing
this distinction V-SPR can be revised, and expressed representationally:

\[(29) \quad \text{V-SHARE:} \quad * \quad \alpha_1 \quad \alpha_2 \quad \text{Prosodic tier} \]

\[
\begin{array}{c}
\text{V-Place} \\
\delta \quad \text{V-Place tier} \\
\text{terminal feature}
\end{array}
\]

\(\delta\) is the terminal feature [labial]. The V-Place nodes must (ultimately) attach
to two different prosodic nodes \((\alpha_1, \alpha_2)\), hence being in separate sub-
syllabic constituents.

Of course, this configuration does not occur in a /po/ sequence or in
any other CV sequences \((C \neq /w/)\) since there is only one C-Place node and
one V-Place node. In effect, the configuration only applies to //o{u}/w{[o,u]}//
and /u/o/ sequences; it does not apply to other CV or VC sequences.

3.2.5 Linking

Up to this point, the restrictions involving /w/ have been the focus of
attention, resulting in the constraint V-SHARE which prohibits both /uo/ and
//o{u}/w{[o,u]}// sequences. This still leaves the //f{o,u}// prohibition which
was ascribed to SPRONS (repeated here for convenience):

\[(30) \quad \text{SPRONS: A segment in an onset and an adjacent segment may only share
one feature.}\]

As it stands, SPRONS is overly specific and convoluted. It is possible to show
that this constraint derives from more general principles.

Itô, Mester & Paeggett (1995) postulate a set of Linkage constraints
that prohibit certain segment sequences from sharing features. One example
is No-NC-Link which prohibits feature-sharing between a nasal consonant
and a following oral consonant. In the case of Maori, the constraint at work
for //f{o,u}// seems to be No-CV-Link. This prevents consonants and vowels
sharing features in the configuration CV.

However, using No-CV-LINK overpredicts: this means that C's and
their following V's may \textit{never} share a feature. This is plainly undesirable as
there are many cases when this occurs in Maori (e.g. /lm/ and /lo/ share
[labial], /fl/ and /la/ share [+continuant]). A way to retain No-CV-LINK is to
allow it to be violated minimally without preventing the form from being
out-put. However, traditionally no distinction has been made between
differing \textit{degrees} of constraint violation in phonological theory: a form fails
if it violates one \textit{or} several constraints.

More recent approaches to phonology have abandoned this view,
allowing a distinction to be made between degrees of violation. One of the
most successful approaches to this has been Optimality Theory (OT)
(McCarthy & Prince 1993, Prince & Smolensky 1993). The following
sections introduce the basic tenets of OT, and offer an OT solution to the Maori co-occurrence problems in this framework.

4 Optimality Theory

Following traditional approaches to phonology, standard formulations of Optimality Theory recognize a repository for lexical items called the ‘lexicon’ (cf. Hammond 1995). If a lexical item is to be output, it enters into a phonological component termed GEN. GEN generates a large number of possible output candidates from this input. From here, the output candidates enter a component called CON. In CON, the most optimal candidate is selected from all the possible outputs. This optimal candidate is then passed on to the phonetic component.

This raises a number of issues. Most importantly, there is the question of how optimality is calculated. In answer to this, CON consists of a set of universal constraints. These constraints are of two types – gradient and non-gradient. A gradient constraint can be violated more than once by an output candidate. For example, the constraint ALIGN(\(V_i\), L, Wd, L) means ‘align the left edge of a vowel with the left edge of a word’. So, the output candidate /CV/ violates this constraint once and /CCV/ twice. In comparison, non-gradient constraints can only be violated once. If the ALIGN constraint above was non-gradient, both /CV/ and /CCV/ would incur only one violation.

To determine the optimal candidate of a set of possible candidates, it is only necessary to determine which candidate violates the least number of constraints.\(^2^3\) As an example, consider the constraints ONSET, which requires every syllable to have an onset, and NO-CODA, which prohibits codas. A few possible outputs are given below, with their corresponding violations:\(^2^4\)

<table>
<thead>
<tr>
<th></th>
<th>ONSET</th>
<th>NO-CODA</th>
</tr>
</thead>
<tbody>
<tr>
<td>/at/</td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>/tat/</td>
<td></td>
<td>*!</td>
</tr>
<tr>
<td><strong>&quot;ta</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table shows that /at/ violates ONSET while /tat/ violates NO-CODA. Of the three candidates, /at/ violates the least optimal form (marked by “!”). Violations of less optimal candidates are marked by ‘!’. There is an added complication when constraints are ranked with respect to each other. At the same level, if two candidates are optimal as they both violate one constraint with the same weight, then higher constraint will be less optimal than the following constraint. If the constraint, it is less optimal than a candidate having the following constraint. In illustration, consider the following constraint, which consists of ONSET, and the constraint ALIGN that vowel to be at the left edge of a word:

(32) ONSET | ALIGN(V,W)
---|---
* | *

Although both candidates cause only one violation, since it violates a lower-ranked constraint.

As a note on the form of the constraints indicates that the leftmost constraint is the most significant. A dotted line as in (32) indicates unranked.

Of significant interest is the fact that the ONSET constraint, it is still the optimal output, because it is satisfied by the candidate to satisfy all constraints. Instead of the optimal candidate causes the fewest constraints for all other candidates.

The OT framework places many constraints on each other that co-occurrence restrictions so far. It will approach significantly reduces the number of constraints to account for this problem while still accounting for minor cross-linguistic differences.

4.1 Linkage

As mentioned above, the nature and importance in an OT-oriented explanation. Paquette’s (1995) NO-XY-LINK family of constraints, as a broad applicability. In effect, any element that has a NO-PLACE-VPLACE-LINK prevents a C-place node with a V-place node.
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three candidates, /ta/ violates the least constraints, and hence is the most optimal form (marked by "*"). Violations that were crucial in failing a candidate are marked by '!'.

There is an added complication to this system: constraints can be ranked with respect to each other. At the moment, /at/ and /tat/ are equally optimal as they both violate one constraint. However, if onset is ranked higher than NO-CODA, /at/ will be less optimal than /tat/ since it violates a more significant constraint. So, if a candidate violates a highly ranked constraint, it is less optimal than a candidate that violates a lower ranked constraint. In illustration, consider the following constraint tableau. This consists of ONSET, and the constraint ALIGN(V, L, Word, L) which requires a vowel to be at the left edge of a word. Crucially, ONSET is ranked above ALIGN:

\[
\begin{array}{c|c|c}
\text{ONSET} & \text{ALIGN(V, Wd)} \\
\hline
\text{ta} & *! \\
\text{at} & * \\
\end{array}
\]

Although both candidates cause only one violation, /ta/ is the most optimal since it violates a lower-ranked constraint than /at/.

As a note on the form of the table, a solid line separating two constraints indicates that the leftmost constraint is ranked more highly than the rightmost. A dotted line as in (31) indicates that the constraints are unranked.

Of significant interest is the fact that although /ta/ violates a constraint, it is still the optimal output. Thus, it is not necessary for a candidate to satisfy all constraints. Instead, a relative approach is taken: the optimal candidate causes the fewest constraint violations in comparison to all other candidates.

The OT framework places much significance on the formulation and ranking of constraints. Because of this, the following few sections are devoted to refining the constraints that have been proposed for the Maori co-occurrence restrictions so far. It will be shown an Optimality Theoretic approach significantly reduces the number of theoretical devices necessary to account for this problem while still offering the flexibility necessary to account for minor cross-linguistic differences.

4.1 Linkage

As mentioned above, the nature and form of constraints is of prime importance in an OT-oriented explanation. In this regard, Ito, Mester & Padgett's (1995) NO-X-Y-LINK family of constraints are of some use, and have a broad applicability. In effect, any elements can be x and y. For example, NO-CPLACE-VPLACE-LINK prevents a C-Place node from sharing a feature with a V-place node.
It has already been shown that the following configuration is prohibited:

\[ (33) \]

\[ \star \quad \alpha \quad \alpha \quad \text{prosodic tier} \]

\[ \quad \text{V-Place} \quad \text{V-Place} \quad \text{tier I} \]

\[ \quad \delta \quad \text{terminal feature} \]

This prohibition is really an amalgam of two constraints. The first is on the linking of V-Place elements: NO-VPLACE-LINK. The second is on the linking of two sub-syllabic constituents: NO-SUB$\S$-LINK. /w\{o,u\}/, /\{o,u\}w/ and /au/ violate both of these constraints as they share the feature [labial] between two V-Place nodes and between two different sub-syllabic constituents (i.e. onset and rime for /\{o,u\}w\{o,u\}/, and rime and rime for /au/). In comparison, /ou/ only violates NO-VPLACE-LINK as [labial] is shared between two V-Place nodes. This difference in violation is extremely significant, even more so when the /\{o,u\}/ prohibition is considered.

4.2 */f/o(u)/ Revisited

Using only the two constraints NO-VPLACE-LINK and NO-SUB$\S$-LINK it is possible to account for the /f/o(u)/ restrictions. Firstly, it is noticeable that the sequences /fu/ and /fo/ both cause two violations of NO-SUB$\S$-LINK as /fu/ and the following labial vowel share two features: [labial] and [+continuant].

In comparison, /pu/ violates NO-SUB$\S$-LINK only once since /p/ and /u/ only share the single feature [labial]. In fact, no other CV or VC combinations cause two violations.8

At this point, it is conspicuous that all the co-occurrence restriction combinations incur two constraint violations while every other possible combination incurs only one (e.g. /pol/) or even none (e.g. /tul/).

A method of prohibiting a sequence in an Optimality Theoretic framework is to arrange the constraints so that the input is never the optimal output. So, for the input /fu/, if the output candidate /fu/ is more optimal than the output candidate /fu/, /fu/ can never be output. From this, it is only necessary to show how it is that the input /f,o(u)/, /\{o,u\}w\{o,u\}/ and /au/ can never be output intact. To do so requires a brief excursion into correspondence.

4.3 Correspondence

While, a number of constraints have already been established, two more are necessary to provide a workable Optimality account of the co-occurrence restrictions: IDENT(F0) and MAXIO (Non-Identity) require a relation of correspondence to a given output candidate.

MAXIO stipulates that every element has a correspondingly corresponding element in the output. This is necessary if an input being output as something totally different from the set /tapa/ and in /kimi/, causing multiple outputs.

IDENT(F0) is somewhat more specific, requiring a set of features in the input, there must be output. For example, IDENT(\{labial\}) requires that in the input there must be a corresponding input such as /p/ and an output /m/, IDENT(\{labial\}) and /m/ both have a [labial] feature. IDENT(\{labial\}) would be violated since /\{o,u\}/.

In Maori, both MAXIO and IDENT will only refer to C-Place features, hence minimizing for every C-Place configuration in the input, C-Place configuration in the output.77

At this point a simplification occurs: So far both Spread and the OCP essentially composites of each other; spread and OCP is violated. More specifically, two elements can cause an OCP violation and a spread violation, both subsumed by spread the OCP can be eliminated.

4.4 The Constraint System

So far, the following constraints have been established: NO-VPLACE-LINK, IDENT(C-Place), MAXIO, and the crucial aspects of an OT constraint system: it stands /fu/ can avoid violation of no simply not sharing its features. To formally rank all other constraints.

In addition, MAXIO is ranked below all other constraints.77

The reasons that will become evident. The final ranking:

---

8 In /of.../ and /uf.../ there is only one violation since /u,of/ and /uf/ share only [labial]. They do not share [+continuant] as features only spread rightward.

77 More technically, take 'C-Place' to be a set of features. Consider C-Place node (e.g. {C-Place, [labial], (C-place):relations involving C-Place as the dominating node in the output. This is significant because, here, the input both /p/ and /u/ have the same [labial], hence they are sharing [labial], hence there is one less violation in the input. Even so this does not violate /ip/C-Place, [labial]) and /uf/C-Place, V-Place, respectively.
shown that the following configuration is

\[
\begin{align*}
\alpha & \quad \text{prosodic tier} \\
V-\text{Place} & \quad \text{tier I} \\
\delta & \quad \text{terminal feature}
\end{align*}
\]

The amalgam of two constraints. The first is on the
\[\text{NO-VPLACE-LINK}\text{. The second is on the linking}\]
\[\text{NO-SUBS-LINK, /w(o,u)/, /}(o,u)w/\text{, and }/u0/\text{ as they share the feature [labial] between two different sub-syllabic constituents (i.e. /}(o,u)/\text{, and rime and rime for /u0/). In}\]
\[\text{NO-VPLACE-LINK as [labial] is shared between}\]
\[\text{vowel is extremely significant, due to the \text{prohibition is considered}.}\]

\[\text{NO-VPLACE-LINK and NO-SUBS-LINK it is}\]
\[\text{incompatible with the /}(o,u)/\text{ restriction. Firstly, it is noticeable that}\]
\[\text{there are no violations of NO-SUBS-LINK as they share the feature [labial] and}\]
\[\text{the vowel is compatible with the /}(o,u)/\text{ restriction.}\]

\[\text{NO-SUBS-LINK only once since /p/ and /u/ are both [labial]. In fact, no other CV or VV}
\]
\[\text{occur,}\]

\[\text{redundant since all the co-occurrence restrictions are violated in every possible}\]
\[\text{sequence in an Optimality Theoretic analysis of the input so that the output candidate}\]
\[\text{is never the optimal one}.\]

\[\text{The output candidate /u/ is more optimal than /v/ can never be out-put from it. From this, it is only possible for the input /}(o,u)/\text{, /}(o,u)w/\text{, and /u0/}\
\]
\[\text{To do so requires a brief excursus into}\]

\[\text{A Co-occurrence Restriction in Maori}\]

\[\text{restrictions: IDENT(FPO) and MAIO (McCarthy \& Prince 1995). These}\]
\[\text{require a relation of correspondence to exist between the input form and a}\]
\[\text{given output candidate.}\]

\[\text{MAIO stipulates that every element in the input must have a}\]
\[\text{corresponding element in the output. This constraint is necessary to prohibit}\]
\[\text{an input being output as something totally unrelated, such as the input /tap/}
\]
\[\text{being output as /kimi/}.\]
\[\text{Of course, there are no corresponding phonemes in the set /tap/ and in /kimi/, causing multiple violations of MAIO.}\]

\[\text{IDENT(FPO) is somewhat more specific, requiring that for some feature or set of features}\]
\[\text{in the input, there must be a corresponding feature in the output. For example, IDENT([labial]) requires that for every [labial] feature in the}\]
\[\text{input there must be a corresponding [labial] in the output. So, with an}\]
\[\text{input such as /p/ and an output /l/, IDENT([labial]) is not violated since /p/}
\]
\[\text{and /l/ both have a [labial] feature. However, if the output was /l/, IDENT([labial]) would be violated since /l/ has no [labial] feature.}\]

\[\text{In Maori, both MAIO and IDENT(F) will be used. However, IDENT(F)}\
\[\text{will only refer to C-Place features, hence IDENT(C-Place). This requires that}\]
\[\text{for every C-Place configuration in the input, there must be a corresponding}\]
\[\text{C-Place configuration in the output.}\]

\[\text{At this point a simplification can also be made in the constraint}\]
\[\text{system: So far both Spread and the OCP have been used, but they are}\]
\[\text{essentially composites of each other; spread is violated in every case that the}\]
\[\text{OCP is violated. More specifically, two adjacent identical features will}\]
\[\text{cause an OCP violation and a spread violation. Since the OCP's role is}\]
\[\text{subsumed by spread the OCP can be eliminated from the constraint ranking.}\]

\[\text{4.4 The Constraint System}\]

\[\text{So far, the following constraints have been invoked: NO-VPLACE-LINK, NO-SUBS-LINK, IDENT(C-Place), MAIO, and SPREAD. As noted above, one of the}\]
\[\text{crucial aspects of an OT constraint system is the constraint-ranking. Now, as}\]
\[\text{it stands /tu/ can avoid violation of NO-VPLACE-LINK and NO-SUBS-LINK by simply not sharing its features. To force feature sharing, \text{SHARE}\]
\[\text{must be ranked above all other constraints.}\]

\[\text{In addition, MAIO is ranked below all the other constraints for}\]
\[\text{reasons that will become evident. This gives the following constraint}\]

\[\text{ranking:}\]

\[\text{More technically, take \text{C-Place} to be a set of dominance relations involving the}\]
\[\text{C-Place node (e.g. /C-Place, [labial], [C-place, [coronal]]). Hence for every set of}\]
\[\text{relations involving C-Place as the dominating argument, there is a corresponding set of the relations in the output. This is significant when considering sequences like /p/}\]
\[\text{Here, in the input both /p/ and /u/ have the feature [labial]. However, in the output}\]
\[\text{they are sharing [labial], hence there is one less [labial] feature in the output as there}\]
\[\text{was in the input. Even so, this does not violate IDENT(C-Place) since the relations}\]
\[\text{/p/, /C-Place, [labial] and /u/, /C-Place, V-Place, [labial] still exist in the output.}\]
(34) **SPREAD >> no-VPLACE-LINK, no-SUB$-LINK, IDENT(C-Place) >> MAX(IO)**

All that remains is to show that these constraints are enough to prohibit all the co-occurrence restrictions while permitting licit forms. This is best demonstrated by considering the tableaux in the following section.

4.4.1 Tableaux

The tableaux have the following characteristics: the constraints are arranged in columns. If a dotted line separates two constraints, they are equally ranked. However, if there is a solid line, the leftmost constraint is ranked higher than the rightmost. A crucial violation of a constraint – i.e., a violation that eliminates a candidate – is marked with an exclamation mark ‘!’.

Constraints that are irrelevant in determining the optimal output are darkly shaded. The most optimal candidate is marked with a pointer “*”. In some cases there is more than one optimal candidate, hence more than one pointer. Finally, an ‘X’ indicates that a candidate violates that constraint.

In the candidate representations below, the small ‘l’ represents the feature [labial] and ‘c’ represents [+continuant].

The first tableau shows the restriction on /f(u,o)/ sequences.

<table>
<thead>
<tr>
<th>/fu/</th>
<th>Spread</th>
<th>No-Vplace-Link</th>
<th>No-Sub$-Link</th>
<th>IDENT(C-Place)</th>
<th>Max(IO)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>f u</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>Spread is violated since [labial] is not spread.</td>
</tr>
<tr>
<td>u h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>By using /h/ instead of /f/ a C-Place feature is lost.</td>
</tr>
<tr>
<td>u p</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Although [+continuant] is eliminated it is not a C-Place feature.</td>
</tr>
<tr>
<td>u t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(35) Tableau for the /f(u,o)/ restriction

Here, it is only necessary to demonstrate that /f(u,o)/ is more optimal than /f[u,o]/. This means that |f[u,o] in the above table, /pl/, /muh/, /hu/, and /hu/ can be discarded since /fu/, hence /fu/ will never be output. Consequently, /fu/ will never be output. Consequently, /fu/ will never be output.

(36) Tableau for /i(o,u)l/

The reader may be surprised to note that a point that is /fu/ is /fu/. However, if Gen is taken to generically result in candidates that seem bizarrely like the above tableau, I am not suggesting that /pu/ is a licit case. In this fragment of the Maori constraint, there are other constraints that would mark them as licit, but it is not the case that nothing but /fu/ is optimal in terms of markedness (a point to this, see McCarthy & Prince (1995)).
A Co-occurrence Restriction in Maori

Here, it is only necessary to demonstrate that there is some sequence that is more optimal than /f{u,o}/. This means that /f{u,o}/ will never be output. In the above table, /pu/, /mu/, /tu/, and /iu/ are more optimal candidates than /fu/, hence /fu/ will never be output. Compare this with /f{o,u}f/:

<table>
<thead>
<tr>
<th>/fu/</th>
<th>Spread</th>
<th>No-V-place-Link</th>
<th>No-SubS-Link</th>
<th>Ident (C-Place)</th>
<th>Max(IO)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>u f</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>[+continuant] does not spread leftwards.</td>
</tr>
<tr>
<td>u h</td>
<td>L</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>By using /h/ instead of /f/ a C-Place feature is lost.</td>
</tr>
<tr>
<td>u p</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>Although [+continuant] is eliminated it is not a C-Place feature.</td>
</tr>
<tr>
<td>u t</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>/t/ is not /f/, violating MAXIO.</td>
</tr>
<tr>
<td>u</td>
<td>l</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>Elimination of /f/ violates both IDENT and MAXIO.</td>
</tr>
<tr>
<td>u o</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i p</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>u i</td>
<td>L</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(36) Tableau for /f{o,u}f/.

The reader may be surprised to note that a possible candidate output from the input /fu/ is /tu/. However, if GEN is taken to generate all possible outputs from an input it will result in candidates that seem bizarrely divorced from the underlying form. By the above tableau, I am not suggesting that /pu/ and /tu/ are equally as optimal in this case. In this fragment of the Maori constraint hierarchy they are, but in reality there are other constraints that would mark them as non-optimal. We could ask, then, why it is not the case that nothing but /fu/, for example, can be produced, presuming that /fu/ is optimal in terms of markedness (a point made by Chomsky 1995). For a reply to this, see McCarthy & Prince (1995).
Unlike /{u,o}/, the input /{o,u}/ will always be out-put intact because there is no candidate that satisfies the constraints better. Every possible sequence violates at least one constraint in the constraint hierarchy. The most significant constraint in this respect is IDENT(C-Place) as any non-labial segment causes a violation. MAXIO is also significant as it makes a sometimes crucial distinction between the input and the output.

The following tableaux show that the sequences /{u,o}w/ and /w{u,o}/ can never be output.

<table>
<thead>
<tr>
<th>/uw/</th>
<th>Spread</th>
<th>No-Vplace-Link</th>
<th>No-Sub$-$Link</th>
<th>Ident (C-Place)</th>
<th>Max(IO)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>u</td>
<td>x</td>
<td>x!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>w</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>u</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>w</td>
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<tr>
<td>u</td>
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<tr>
<td>w</td>
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<tr>
<td>i</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

(37) Tableau for /uw/

<table>
<thead>
<tr>
<th>/uw/</th>
<th>Spread</th>
<th>No-Vplace-Link</th>
<th>No-Sub$-$Link</th>
<th>Ident (C-Place)</th>
<th>Max(IO)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>u</td>
<td>x</td>
<td>x!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>w</td>
<td></td>
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<td>u</td>
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<td>w</td>
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<td>i</td>
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<tr>
<td>u</td>
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<tr>
<td>i</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

(38) Tableau for /w{u,o}/

Similarly, /uo/ incurs two violations, the same as /wu/.

<table>
<thead>
<tr>
<th>/uo/</th>
<th>Spread</th>
<th>No-Vplace-Link</th>
<th>No-Sub$-$Link</th>
<th>Ident (C-Place)</th>
<th>Max(IO)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>u</td>
<td>x</td>
<td>x!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>u</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>o</td>
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<tr>
<td>u</td>
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<tr>
<td>o</td>
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<td></td>
</tr>
</tbody>
</table>

(39) Tableau for */uo/

Again, there is a more optimal output for /uo/ to compare this with /ou/, which incurs no violations, such as /tu/ and /hi/ possible form will violate at least MAXIO.

<table>
<thead>
<tr>
<th>/ou/</th>
<th>Spread</th>
<th>No-Vplace-Link</th>
<th>No-Sub$-$Link</th>
<th>Ident (C-Place)</th>
<th>Max(IO)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>u</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o</td>
<td></td>
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<tr>
<td>u</td>
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<td>u</td>
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<tr>
<td>o</td>
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<td></td>
</tr>
</tbody>
</table>

(40) Tableau for /ou/
A Co-occurrence Restriction in Maori

Similarly, /uo/ incurs two violations, thereby never being optimal:

<table>
<thead>
<tr>
<th>/uo/</th>
<th>Spread</th>
<th>No-Vplace-Link</th>
<th>No-Subs-Link</th>
<th>Ident (C-Place)</th>
<th>Max(IO)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>u o</td>
<td>x</td>
<td>x</td>
<td>x!</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(39) Tableau for */uo/

Again, there is a more optimal output for every input of /uo/. It is interesting to compare this with /ou/, which incurs only one violation, and is more optimal than any other combination:

<table>
<thead>
<tr>
<th>/ou/</th>
<th>Spread</th>
<th>No-Vplace-Link</th>
<th>No-Subs-Link</th>
<th>Ident (C-Place)</th>
<th>Max(IO)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

(40) Tableau for /ou/

The final two tableaux give examples of other consonant sequences to show that the constraints do not incorrectly prohibit licit forms. When a form incurs no violations, such as /tu/ and /ti/, it will be optimal since every other possible form will violate at least MaxIO.
A Co-occurrence Restriction in Maori

different in the case of */f[0,u]/ and */v[0,u]/. From this point of view, this can help explain various co-occurrence restrictions in related languages.

Related co-occurrence restrictions in Maori are a member, every language has */f[0,u]/ at least before round vowels (Harley 1992). This change has occurred in several of the languages. These changes have been motivated by several factors, including the co-occurrence restriction */f[0,u]/. However, this does not seem to be the case in Tongan, which has */f[0,u]/ sequences, as well as sequences with consonants restriction on adjacent labial continuants.

The other significant phoneme is /i/ as in all five languages: [w], [ra], [wa], and [i/. In some cases, the occurrence restriction involving this phone is shown in many of the relevant dictionaries. The language sequences are the only ones in which the most extensive set of words with these phones are few. The outliers Nukuoro, Kanak, and West Futuna have very few /vul/ sequences. /vo/ sequences are not as rare, but obviously the /vo/ forms, but few /vul/ sequences, are similar patterns.

This raises the question of whether the Maori are the same as the restrictions that similar constraints are in the principal difference between EP and non-Maori. In restriction on */f[0,u]/ sequences while they are the case in the same way, these cases the sources are very good (the cited constraint for simplification is indeed the motivating force).

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5. Historical Development and Related Restrictions

The above section claims that the co-occurrence restrictions in Maori are the result of the interaction of general constraints of correspondence and linkage. Significantly, the motivations behind the restrictions are slightly

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**Tableau for /tu/**

<table>
<thead>
<tr>
<th>/tu/</th>
<th>Spread</th>
<th>No-Vplace-Link</th>
<th>No-Subs-Link</th>
<th>Ident (C-Place)</th>
<th>Max(IO)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>/tu/</td>
<td></td>
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<td>n u</td>
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<td>x</td>
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<td>u t</td>
<td></td>
<td></td>
<td></td>
<td>x x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although [+continuant] is eliminated it is not a C-Place feature.

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**Tableau for /ti/**

<table>
<thead>
<tr>
<th>/ti/</th>
<th>Spread</th>
<th>No-Vplace-Link</th>
<th>No-Subs-Link</th>
<th>Ident (C-Place)</th>
<th>Max(IO)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>/ti/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n i</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td>/ti/ only has a [nasal] feature, as [coronal] is filled in by default.</td>
</tr>
</tbody>
</table>

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All reconstructed proto-phonemes in this paper are discussed here — the focus will be on Polynesian languages related to Maori have similar restrictions with minor variations. It will be shown in the next section that these minor variations can be dealt with by using minor alterations to the constraint system proposed, thereby further validating the approach in this paper.

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**References**

1. Sources for the languages cited here are listed at the end of this section.
2. Of course, these cases are limited by the constraints of the cited sources. The cited case information, and so cannot be cited here.
3. This is assuming that the change of *f to */f/ is caused by a specific language-internal principle that the constraints of the internal configuration of the different systems has also been avoided in this group of simplification is indeed the motivating force in the approach.


### A Co-occurrence Restriction in Maori

different in the case of */f{o,u}/ and */o,u*/w{o,u}/. From a diachronic point of view, this can help explain various phonemic changes and similar restrictions in related languages.

Related co-occurrence restrictions occur in many Polynesian languages.\(^\text{30}\) It is notable that in the Eastern Polynesian (EP) group, of which Maori is a member, every language has altered Proto-Polynesian */t/ to */h/ or */r/ at least before round vowels (Harlow 1997, Biggs 1978). A similar change has occurred in several of the Outlier languages (Clark 1976). If these changes have been motivated by some language-internal pressure then the co-occurrence restriction */[f{o,u}]/ would be a likely candidate. However, this does not seem to be the case outside Eastern Polynesia. Tongan has many */f{o,u}*/ sequences, as does Samoan, Tokelauan, Wallis and Futuna, Tikopia, and West Futuna.\(^\text{31}\) As such, it is not evident that a restriction on adjacent labial continuants was in force before Proto-EP.

The other significant phoneme is Proto-Polynesian */w/. This is realised as *[v]* in all but five languages: *[w]* in Maori, Morti, Ka-pi-nga-mara-ni, and Hawai'ian, and *[β]* in Renellese. There is also evidence of a co-occurrence restriction involving this phoneme in many non-EP languages as many of the relevant dictionaries show an extreme paucity of */vu*/ sequences. There are considerably more forms with */vo/*, but even this sequence seems to be disfavoured in most languages. Of all these, Tongan has the most extensive set of words with */v{o,u}/*/ sequences, but even then they are few. The outliers Nukuoro, Kapingamarangi, Luangui, Tikopia, and West Futuna have very few */vo/* sequences, as do Wallis and Futuna. */vo/* sequences are not as rare, but obviously avoided. Samoan has a number of */vo/* forms, but few */vu/* sequences, and the related Tokelau language has similar patterns.\(^\text{32}\)

This raises the question of whether the co-occurrence restrictions in Maori are the same as the restrictions that hold in these other languages. The principal difference between EP and non-EP languages is that there is no restriction on */f{o,u}/*/ sequences while there is a restriction on */v{o,u}/*/ sequences.\(^\text{33}\) In these cases, the restrictions cannot be broadly formulated as

\(^\text{30}\) All reconstructed proto-phonemes in this section are taken from Clark (1976, 1992). The possible pre-Polynesian antecedents of the restrictions will not be discussed here — the focus will be on Polynesia.

\(^\text{31}\) Sources for */w/* languages are listed in ‘References Part II’.

\(^\text{32}\) Of course, these claims are limited by the quality of the dictionaries used. In some cases the sources are very good (the cited cases), while in others there is inadequate information, and so cannot be cited here.

\(^\text{33}\) This is assuming that the change of */t/ to */h/ or */p/ in several of the Outliers is not caused by a specific language-internal principle, but perhaps by a desire to simplify the segment internal configuration of their phonemes. Notably, */s*/(+continuant), [coronall]) has also been avoided in this group of languages, suggesting that featural simplification is indeed the motivating force here.
applying to adjacent labial continuants. However, if a solution to this follows the suggestions in this paper it is significant that the most avoided sequence /va/ is featurally unique in comparison with other CV sequences. Notably, /va/ must be specified as [+continuant, labial, +voice], thus sharing three features with /va/ as /va/ is also a voiced labial continuant, violating no-
sub-$\text{-link}$ thrice. From this, it could be that these languages aim to avoid extensive feature sharing between segments: /va/ is acceptable because it shares only two features, but /avo/ and /avo/’s sharing of three is a computational effort best avoided. From here, the feature-sharing restriction seems to have intensified even more in EP languages, allowing only one feature to be shared.

As noted above, many EP languages have altered the PEP phoneme *f to /h/ (Easter Island, Hawaiian, Pehrhn) or /l/ (Mangareva, the Austral Group, Cook Islands Maori). The others (i.e. Marquesic, Tahitian, Tuamotuan, Manihiki, Mori) have variable reflexes of *f, most preserving it as /l/ except before round vowels when it is realised as /h/ (esp. Tahitian, see Harlow 1997). Given that there seems to have been some pressure for languages to alter their phonemes, the /l{u,o}/ restriction in Maori was probably active at some stage during the development of Proto-EP to its daughter languages. Supposing that this original restriction militated against elements that shared more than one feature, the elements with more than one featural specification were then /l/ and /h/, both specified for [labial] and [+continuant], with /h/ having an additional [+voice] specification. This restriction is still active in Tahitian’s restriction on /l{u,o}/ and /h{u,o}/ sequences.  

The alternative was to simply eliminate featurally-complex phonemes altogether. The easiest way to alter the multi-featured /l/ was to delink a featural set. This was either the Place set, which resulted in the placeless continuant /h/, or the Oral Articulator node, resulting in a placeless stop /h/:

\[(43)\]

\[
\begin{array}{c}
\text{Oral Articulator} \\
\quad \rightarrow \quad \text{Oral Articulator}
\end{array}
\]

\[
\begin{array}{c}
\text{Place} \\
\quad \rightarrow \quad \text{Place}
\end{array}
\]

\[
\begin{array}{c}
\text{[labial]} \\
\quad \rightarrow \quad \text{[labial]}
\end{array}
\]

The other option, largely avoided, was the /f/ alone, resulting in /p/. As for as the PPN reflexes of *w, it is distinctive in having /w/, other EP languages to have proven difficult to simplify further. Delinking this would result in a highly unfaithful continuant (/f/).  

If the Oral Cavity group in a voiced glottal stop (an articulatory feature), lend itself to change. The other option was to drop the [+vocoid, +sonorant, +approximant], resulting in /m/, /n/, /r/.  

A final option was to delink the [+continuant] resulting in /p/. However, this is a complex.

5.1 Theoretical Considerations

The preceding discussion has shown that some of the related languages should be explained. However, different languages exhibit different constraints. For example, Pehrhn, for example, do not have the *uo/* restriction. This small exception is expressed by a small alteration in the constraint set: the lack of a *uo/ restriction requires a set of rules that used for Maori. In fact, accounting for

\[34\] Exceptions for this language do exist; however they are very few in number (Jaussen 1993, Davies 1851).

\[35\] See Chomsky & Halle (1968) for a discussion.

\[36\] It is quite possible, even expected, that other languages may. However, these are the only two for which data has been found.
A Co-occurrence Restriction in Maori

```

[+continuant]

Oral Articulator

Place

[labial]
```

The other option, largely avoided, was to delink the feature [+continuant] alone, resulting in /p/.

As far as the PPN reflexes of *w, Maori, Hawai‘ian and Moriori are distinctive in having /w/, other EP languages have /v/. Unlike /l/, /v/ seems to have proven difficult to simplify featurally. If the C-Place node was delinked this would result in a highly marked sound – a voiced glottal continuant (*/f/). If the Oral Cavity group was delinked, this would result in a voiced glottal stop (an articulatory impossibility). Hence, /v/ did not lend itself to change. The other option was to convert its root features to [+vocoid, +sonorant, +approximant], resulting in /w/ (Maori, Hawai‘ian, Moriori).

A final option was to delink the [+voice] and [+continuant] features, resulting in /p/. However, this is a complex operation, and so was avoided.

5.1 Theoretical Considerations

The preceding discussion has shown that many languages related to Maori have similar restrictions, with minor variations. This is significant from a theoretical point of view for a number of reasons. Firstly, the restrictions in the related languages should be explainable in the same terms as Maori. However, different languages exhibit different combinations of restrictions. Many, for example, do not have the */u/ restriction (i.e. all except Maori, Pehrhy, and Easter Island). This small difference should ideally be expressed by a small alteration in the constraint system. If this is possible, it lends support to the approach in this paper.

Firstly, consider the */u/ restriction. While a number of languages have the */f/ and */v/ restrictions only Easter Island and Pehrhy have the */u/ restriction (du Feu 1996 and Yasuda 1968 resp.). Of course, the lack of a */u/ restriction requires a slightly different explanation from that used for Maori. In fact, accounting for this requires only one constraint

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33 See Chomsky & Halle (1968) for a discussion of phonological markedness.

34 It is quite possible, even expected, that other languages prohibit this sequence. However, these are the only two for which definite statements to this effect were found.
alteration: instead of using \text{NO-SUB$\$-LINK}, the constraint is made slightly more specific, to \text{NO-ONSET-RIME-LINK}. This constraint prohibits feature sharing between an element in a syllable onset, and one in a syllable rime (the rime need not follow the onset). This is not violated by /hu/ since the [labial] feature is not shared between an onset and a rime, but between two rimes. In fact, the only forms that do violate \text{NO-ONSET-RIME-LINK} are */f\{o,u\}l/ and */\{o,u\}\text{w}\{o,u\}l/.

It seems that some other languages (perhaps most) do not have the /\{o,u\}\text{w}/ restriction. Again, this only requires a minor alteration to the constraint system. \text{NO-ONSET-RIME-LINK} is again used, but with one further restriction: the onset and rime must be in the same syllable. This means that /\{o,u\}\text{w}/ sequences will not violate this constraint, since the rime and onset are in different syllables.

Another variation relates to Maori itself. It seems that there is (or was) a rule optionally prohibiting /\{o,u\}\text{t}/ sequences (Bauer 1993:564). In such sequences, the /\text{t}/ would become /\text{h}/:

\begin{quote}
(44) uwha \sim uha `female' \quad uwhi \sim uhi \textit{dioscorea}
owha \sim oha `greet'
\end{quote}

At issue here is the prohibition of /\{o,u\}\text{t}/ sequences, so I will not attempt to explain how the output with /\text{h}/ came to be the most optimal form.

Preventing the /\{o,u\}\text{t}/ output again requires only a minor alteration to the Maori explanation. All that is needed here is for this sequence to incur two violations. An easy way of achieving this is to force it to share its two features [labial] and [+continuant] with the preceding vowel. To achieve this, all that is needed is for the directional restriction on feature spreading to be relaxed, so as to allow bi-directional spreading. This will result in the following configuration:

\begin{quote}
(45) \begin{tikzpicture}
    \node (f) at (0,0) {f};
    \node (u) at (0,-1) {u};
    \node (labial) at (-0.5,-0.5) {labial};
    \node (continuant) at (0.5,-0.5) {continuant};
    \draw (f) -- (u);
    \draw (u) -- (labial);
    \draw (u) -- (continuant);
\end{tikzpicture}
\end{quote}

This violates \text{NO-SUB$\$-LINK} twice. Of course, a form such as /up/ will only cause one violation of the relevant constraints (i.e. not including \text{MAXIO}), and so be more optimal /af/ and /of/. Thus, /\{o,u\}\text{t}/ will never be out-put given bi-directional feature spreading.

As such, it is evident that the minor differences in co-occurrence restrictions in related languages can be accounted for by minor alterations to the constraint system, further validating the approach in this paper.

6. Related Issues
6.1 Scope
A question which has not been addressed by occurrence restrictions hold. In the case of /\{o,u\}/ within the morpheme as a number of forms vs morheme boundary.\footnote{Again there is a question as to whether these are active or not. If they are not, then this could mean that when these boundaries were recognised, the restrictions are still inactive in the language.}

The evidence is less clear for the forms such as hauwai `damp' which strike `damp, moisture' and wai `water', indicate they apply over a morpheme boundary. On the other morpheme, `saliva' (cf hau `damp' and wai `spit') and huare, both avoiding the /\{o,u\}\text{w}/ restriction seems to hold over a morpheme boundary.

For the other co-occurrence restrictions, the domain must be morpheme-internal as the sequences. Since there no syllables that the consonant must be part of the same syllable, they must also be part of the same morpheme. In sum, the domain for these morpheme.

6.2 Productivity
A final note must be made on the productivity. Bauer (1993) notes that native speakers of Maori and products of this constraint. It could be the speaker that the sequences are extremely and therefore marked but not necessarily. The existence of loanwords and the dialects does not imply that there is no productivity of this constraint. As such, the question of productivity could be a massive influx of words with /\{w,f\}\{o,u\}/ these sequences changed over time as they be adequate evidence that the prohibition. It is unlikely that such a situation will ever take place.

7. Conclusion
This paper has shown that the relations between co-occurrence restrictions are neither obvious nor trivial.
A Co-occurrence Restriction in Maori

6. Related Issues

6.1 Scope
A question which has not been addressed is the domain in which the co-occurrence restrictions hold. In the case of */lu/ the restriction only applies within the morpheme as a number of forms exist with this sequence over a morpheme boundary.17

The evidence is less clear for the */[o,u]w/ sequence. There are forms such as hauwai 'damp' which seems to be a compound from hau 'damp, moisture' and wai 'water', indicating that the distinction does not apply over a morpheme boundary. On the other hand, the word hauware 'saliva' (cf hau 'damp' and wai 'spittle') has the alternative forms hauware and huware, both avoiding the /[o,u]w/ sequence. This time, however, the restriction seems to hold over a morpheme boundary.

For the other co-occurrence restrictions involving /l/ and /w/, the domain must be morpheme-internal as they involve consonant-vowel sequences. Since there are no syllables that end in a consonant in Maori the consonant must be part of the same syllable as the vowel, which means that they must also be part of the same morpheme (there are no morphemes /w/- or /l/-). In sum, the domain for these processes is necessarily the morpheme.

6.2 Productivity
A final note must be made on the productivity of the processes in question. Bauer (1993) notes that native speakers felt that loanwords with /[w,f][o,u]/ sequences were awkward. This in itself is not proof of the productivity of this constraint. It could be merely recognition on the part of the speaker that the sequences are extremely rare, even non-existent, in the language and therefore marked but not necessarily prohibited. On the other hand, the existence of loanwords with the offending sequences in some dialects does not imply that there is no prohibition in force; Itô and Mester (1995) note that loanwords are often not subject to many phonological rules. As such, the question of productivity could only be answered by observing a massive influx of words with /[w,f][o,u]/ sequences into EP languages. If these sequences changed over time as they became internalised this would be adequate evidence that the prohibition is active. However, it is extremely unlikely that such a situation will ever take place.

7. Conclusion
This paper has shown that the relations between the Maori co-occurrence restrictions are neither obvious nor trivial. In fact, it is only by addressing

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17 Again there is a question as to whether these are synchronic morpheme boundaries or not. If they are not, then this could mean that the restrictions applied at a time when these boundaries were recognised, but does not necessarily mean that the restrictions are still inactive in the language.
other issues in the language's phonology that the non-obvious nature of the co-occurrence prohibitions can be discerned.

A number of issues significant to the study of Polynesian phonology have also been discussed, particularly featural underspecification. For the study of phonology, this paper has shown that processes that promote parsimonious representation and computation play a pervasive role in the phenomena under consideration. Parsimony is promoted on all levels, most obviously at the featural level for underspecification, but also with respect to representation. Indeed, the constraint requiring feature spreading increases economy of representation by eliminating unnecessary features. In addition, this paper has affirmed the validity of hotspot, Mester & Padgett's (1995) theory of underspecification, and the parallel approach to phonological computation provided by Optimality Theory.

In sum, the co-occurrence restrictions in Maori are examples of how seemingly simple phonological phenomena can in fact be caused by the complex interaction of non-obvious constraints, and have implications for phonology in general.

NOTE: It was suggested that the Maori restrictions on */w(u.o)/ should be related to the Mandarin restriction on */u/, requiring [wu]. I do not see these as comparable from a number of points of view. Firstly, the Mandarin [wu] does not consist of two separate phonemes, but one: [w] is made up of material from the /u/. In comparison, Maori recognises the two distinct phonemes /w/ and /u/. In addition, the patterns of restrictions in Maori are far more complex than in Mandarin, also including */(u.o)/, */(o,u)/. One would expect any explanation of the Maori */wu/ restriction to at least relate to the other restrictions involving the features [labial] and [+continuant]. Because of these differences, I suggest that the Mandarin situation is not as analogous to Maori as it first seems.

Another suggestion in accounting for the Maori */wu/ restriction is that it is phonetically difficult to produce. In recent concepts of functionalist phonology (Hayes 1996) this phonetic difficulty would give rise to a rule simply stating that /wu/ sequences are prohibited. While appealing to a phonetic motivation is a priori plausible, it is difficult to see how similar reasoning extends to the */fu/ restriction, and to the restrictions involving /w/. Also, I see no easy way that this sort of explanation can give a motivation for the consonant dissimilations. Because of this, I prefer to offer a phonologically-motivated approach involving abstract features. This better relates the */wu/ prohibition to the other restrictions.

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16 Thanks to Phillip Hamilton for raising this point. Also see Hayes (1989:300) for some discussion on */wu/ prohibitions.

References

Part I


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The non-obvious nature of the Maori restrictions on */w(uo)/ should be noted on */u/ requiring [wu], I do not see these as phonological phenomena. Firstly, the Mandarin [wu] parameters phonemes, but one: [w] is made up of a number of points of view. Firstly, the Mandarin [wu] parameterization of the Maori */wu/ restriction in Maori as it first seems. In recent concepts of function (1986) this phonetic difficulty would rise to /u/ sequences are prohibited. While appealing to */ru/ plausible, it is difficult to see how similar /u/ restriction, and to the restrictions involving raising this point. Also see Hayes (1989:300) for further raising this point. Also see Hayes (1989:300) for further discussions.

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A Co-occurrence Restriction in Maori


Part II
Kia and ki te Complementarity: Unaccusative Analysis*

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0. Introduction

Previous analyses of the syntax of subordinate clauses have focused on the view that the selection of kia versus ki te is determined by the verb of the embedded clause (volitionality/agentivity of the embedded subject) (Higginbotham 1994). Whilst we accept these interpretations of kia and ki te, the purpose of the present paper is to show how these may be accounted for through the use of complementation between unaccusative and non-unaccusative constructions.

Section 1 provides a basic description of kia and ki te clauses. Section 2 outlines the various unaccusative constructions which will be relevant in Section 3. Section 3 sets out the analysis of kia/ki te complements and offers a formal account of the conditions for the presence of unaccusativity in the determination of the agent.

1. Finite versus nonfinite asymmetries

In this introductory section, §1.1 gives the basic distinction between finite complements. Section 1.2 outlines the application of these constructions to the agent structure in Maori. Section 1.3 presents the agent structure and the characteristics.

1.1. Kia and ki te complements

Included in the semantic representation is a specification of its predicate-argument role.

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