AN ARGUMENT FOR PROCESS-BASED MORPHOLOGY:
SUBTRACTIVE MORPHOLOGY IN TOHONO O'ODHAM
(UTO-AZTECAN)

by

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ABSTRACT

Subtractive morphology (SM) has been an important form of evidence for process-based theories of morphology. The evidence in the literature consists of broad surveys of plausible examples, but lacks either theoretical justification for selected examples or rigorous investigation of SM in the context of grammars of particular languages.

Focusing on Tohono O’odham (TO, Uto-Aztecan), the aim is to determine (i) if the native rules alone can account for SM, (ii) if concatenative theories of morphology can account for all the facts without unmotivated assumptions. This study investigates options that make use of TO phonological and morphophonemic processes, as well as a number of approaches to SM intended to avoid process-based morphology. It concludes that all of these concatenative approaches lead to unnecessary stipulations or predictions of TO that are untrue. Finally, this study provides a process-based analysis of TO subtractive morphology in Antifidelity Theory to address criticisms to process-based morphology.

Keywords: subtractive morphology; Tohono O’odham; truncation; process-based morphology; morphology; antifidelity

Subject terms: Grammar, Comparative and general -- Morphology; Morphology - linguistics --; Uto-Aztecan languages -- Morphology; Tohono O’odham dialect; Tohono O’odham dialect -- Verb; Optimality theory (Linguistics)
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Last, but certainly not least, I thank my parents for encouraging me and being there at each step along the way. Even if nobody else believed in me, and even when I didn’t believe in myself, my parents have always known that I can and will achieve great things.
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1: INTRODUCTION

1.1 Introduction

This thesis is about subtractive morphology and its theoretical implications. Subtractive morphology is a type of morphology that involves phonological deletion to mark a morphological distinction. The data below illustrate subtractive morphology in Uto-Aztecan language Tohono O’odham (TO), where final C or VC deletion marks the perfective in verbs.

(1) Subtractive morphology in Tohono O’odham (Zepeda, 1983, pp. 59-61)
(a) C-final deletion
   hihim \(\rightarrow\) hihi
   imperfective
   perfective
   ‘to laugh’
(b) VC-final deletion
   cipo\text{šiq} \(\rightarrow\) cipoš
   imperfective
   perfective
   ‘to brand’

Subtractive morphology is interesting in the context of the history of morphological theory because it indicates that morphology is about more than the syntax of morphemes. The first chapter, starting in 1.2, lays out this history and reviews a set of proposals that attempt to incorporate segment-deleting morphology in a purely concatenative theory of word formation (Steins, 2000; Stonham, 1994). Concatenative morphology contends that morphological categories are marked through the addition of morphemes and not through phonological processes such as deletion. Subsection 1.2 also reviews theories of non-concatenative morphology that embrace subtractive morphology.
and assign it a theoretical status. The larger issue here is, is subtractive morphology real, and does morphological theory have to contend with morphology that instantiates a mark with phonological deletion. This question is explored, with a positive answer, through a close formal and empirical exploration of subtractive morphology in Tohono O'odham.

To illustrate some of the core problems that any theory of subtractive morphology must contend with, I also survey many known cases of subtractive morphology. In 1.3, I review these cases with a critical eye, attempting to narrow the focus on valid cases of subtractive morphology. Finally, in 1.4, I describe the methods with which I investigate subtractive morphology in Tohono O'odham.

1.2 Theoretical background

In order to understand subtractive morphology in the context of contemporary morphology, it is important to go back to the origins of current morphological theories. Many important assumptions in contemporary morphology have been developed in response to the issues raised in (Chomsky, 1970) and (Halle, 1973). Prior generative models of language did not include a separate morphological component. In (Chomsky, 1965), for example, all productive morphology is a response in the phonological component to a set of morpho-syntactic features on terminal nodes of the syntactic tree. For instance, in the case of German plural formation, the output of the syntax for the ‘Bruder’ node includes morpho-syntactic features such as [2 Number] and [2 Case] reflecting plural number and accusative case (see example 2). A phonological rule, umlaut, is triggered by these features resulting in the plural form ‘Brüder’ (Chomsky, 1965, p. 171).
(2) Example of plural marking in German: (Chomsky, 1965, p. 171)
(a) Output of syntax: \textit{N}\textsubscript{Bruder} [2 Number, 2 Case]
(b) Phonology: Bruder $\rightarrow$ Brüder

(3) Example of nominalization in English: (Chomsky, 1970, p. 187)
(a) Underlying sentence: John is eager to please.
(b) Surface sentence: John's eagerness to please.

Generative morphology emerges with (Chomsky, 1970), which argues for a separate morphological module for derivational morphology. Nominalizations like 'eagerness' from 'eager', as illustrated in (3), are no longer the result of grammatical transformations as in (Chomsky, 1965), but a separate morphological process. In the same vein, (Halle, 1973) outlines a new morphological module for both inflection and derivation and raises important questions regarding morphemes and word structure rules. (Halle, 1973) also lays the groundwork for morpheme based approaches to morphology. In line with (Chomsky, 1970), (Aronoff, 1976) expands a word formation model for word derivation. Furthering these efforts, (Selkirk, 1982) expands the concepts of word formation rules and word structure rules to all areas of productive morphology using context free grammar (4). The morphological model in (Selkirk, 1982), exemplified below, illustrates a syntax of words that emphasizes constituency and establishes the same tools for morphology, context-free rewrite rules, that have been employed in generative frameworks of syntax.

(4) Selkirk word formation rules: plural marking on nouns (Selkirk, 1982, p. 71)
\[
N \rightarrow N^{\text{Ybf}} \quad [\pm \text{plural}]
\]
While the model in (Halle, 1973) assumes a concatenative approach to all morphological processes, other proposals make use of concatenative word formation rules without excluding the possibility of non-concatenative processes. For example, the updated Aspects model in (Chomsky, 1970) suggests generative approaches for derivation, but allows inflection the freedom of being marked through any phonological process. As seen in (2) above, the inflectional categories such as [2 Number] and [2 Case] trigger a phonological process which changes /u/ into /ũ/ (Chomsky, 1965, p. 171). Similarly to the Aspects model, the model of word formation rules in (Aronoff, 1976) only applies to derivational processes, allowing inflectional morphology to make use of any phonological processes.

Like prior theories of morphology, the context free grammar used for English word formation in (Selkirk, 1982) makes use of concatenative rules resembling context free grammar rules, but there is no prohibition against allowing languages other than English to make use of other types of rules. In this context, autosegmental phonology and morphology emerged as a new theory with powerful tools for non-concatenative morphology, such as the analysis of root-and-pattern verb inflections of Arabic, as illustrated by (McCarthy, 1982). An autosegmental framework can also be used for other non-concatenative processes such as subtractive morphology. For example, (Martin, 1988) describes Koasati plural formation as a case of final rhyme deletion where the final rhyme is delinked from the syllable node, as seen below in (5) (p. 231).

(5) Koasati rhyme deletion (Martin, 1988, p. 231):
While many of the early generative models of morphology allow for non-concatenative processes, it is important to ask, for the purpose of restrictiveness, if it is necessary to allow non-concatenative processes. Non-concatenative models of morphology, such as process-based morphology, contend that morphological categories are marked through changes to the phonological structure that are more than simple concatenation of morphemes, allow for a wide range of possible morphological processes, including ones rarely or never encountered (Anderson, 1992; Zwicky, 1988). Therefore, non-concatenative models do not appear to have much predictive value as they cannot account for the lack of certain morphological processes. On the other hand, concatenative models are more restrictive and can explain the absence of certain processes and the presence of others.

Should a concatenative-only framework of morphology offer analyses of subtractive morphology and other non-concatenative processes, the argument for the need to expand concatenative frameworks would be weakened. This is especially true when considering that non-concatenative models do not seem to predict the patterns of morphological processes that are missing from the world languages. With respect to proposed subtractive morphology cases, concatenative approaches have offered a series of alternative analyses (summarized in table 1.1 below) which would remove the need for subtractive morphology. Section 1.3 includes a lengthy discussion of some of the proposed cases of subtractive morphology and the alternative concatenative analyses that exist for each case.
Table 1.1 Alternative concatenative analyses of subtractive morphology

<table>
<thead>
<tr>
<th>Main device</th>
<th>Motivation</th>
<th>Example</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reanalysis of base form/stem</td>
<td>Proposing new underlying structure</td>
<td>French</td>
<td>(Stonham, 1994)</td>
</tr>
<tr>
<td></td>
<td>Reanalyzing the phonological system</td>
<td>Danish</td>
<td>(Stonham, 1994)</td>
</tr>
<tr>
<td></td>
<td>Reverse direction</td>
<td>Tohono O’odham Koasati</td>
<td>(Stonham, 1994) (Martin, 1988)</td>
</tr>
<tr>
<td>Templatic process</td>
<td>Missing segments did not fit the template</td>
<td>Nootka</td>
<td>(Stonham, 1994)</td>
</tr>
<tr>
<td>SM as phonological or phonetic process</td>
<td>Stress patterns or rapid rate of speech causes deletion of segments</td>
<td>Colloquial Hebrew</td>
<td>(Bolozky, 1979)</td>
</tr>
<tr>
<td>SM as a result of phonological constraints</td>
<td>Auxiliary + verb syllable conservativity between imperfective and perfective</td>
<td>Tohono O’odham</td>
<td>(Steins, 2000)</td>
</tr>
<tr>
<td>Deletion is not a process</td>
<td>Forms are few and listed in lexicon; or not a productive process</td>
<td>Icelandic</td>
<td>(Orešnik, 1976)</td>
</tr>
</tbody>
</table>

It is argued that concatenative approaches to the problem of subtractive morphology, like the ones listed in table 1.1 and discussed in section 1.3 below, suffer from several problems. For example, (Anderson, 1992) addresses the issue of a subtractive morph, one device that can be used to analyse subtractive morphology as concatenation, by arguing that it is impossible to parse a complex morpheme in any way that would associate a phonological subpart of it as the subtractive morph (Anderson, 1992, p. 66). (Martin, 1988), on the other hand, addresses the issue of reversing the direction of the morphological process. In Koasati, an alternative to subtractive morphology is to posit a process of singularisation rather than pluralisation. (Martin, 1988) remarks that this would result in an increase in rule complexity by offering thirteen affixes versus one subtractive process (p. 233). As well, the increase in rule complexity would lead to complications to language learnability and may prove no more insightful...
than simply listing the forms. By introducing a process of singularisation, much of the generalizability of the morphology is lost (Martin, 1988).

1.3 Survey of known examples

While many cases of subtractive morphology have been identified and analysed (see table 1.2 below), there is some evidence that calls in question the validity of these examples as subtractive morphology. For some of the processes listed, compelling arguments exist to suggest that these are not examples of subtractive morphology, while for other processes arguments exist or can be made to suggest that the processes are not productive (table 1.1). I discuss some of these cases in order to motivate my choice in investigating Tohono O’odham as a valid case of subtractive morphology.
<table>
<thead>
<tr>
<th><strong>Table 1.2 Some examples of subtractive morphology</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Danish Imperative:</strong> (Anderson, 1992), (Horwood, 2000), (Martin, 1988), (Zwicky, 1988)</td>
</tr>
<tr>
<td>Danish imperative is formed through the deletion of the final schwa /ə/ from the infinitive form.</td>
</tr>
<tr>
<td>$X_{\text{inf}}$ $\rightarrow$ $X_{\text{imp}}$</td>
</tr>
<tr>
<td>$X_{\text{inf}}$ $\rightarrow$ $X_{\text{imp}}$</td>
</tr>
<tr>
<td>Koasati verb plural is formed through the deletion of the final VC or V, with the exception of a few cases where only the final C is truncated.</td>
</tr>
<tr>
<td>$XV_{\text{sg}}$ $\rightarrow$ $X_{\text{pl}}$</td>
</tr>
<tr>
<td>$XV_{\text{sg}}$ $\rightarrow$ $X_{\text{pl}}$</td>
</tr>
<tr>
<td>$XV_{\text{sg}}$ $\rightarrow$ $X_{\text{pl}}$</td>
</tr>
<tr>
<td>$XV_{\text{sg}}$ $\rightarrow$ $X_{\text{pl}}$</td>
</tr>
<tr>
<td><strong>Hebrew Imperative:</strong> (Bat-El, 2002), (Bolozy, 1979)</td>
</tr>
<tr>
<td>Colloquial Hebrew imperative is formed from the deletion of final VC or V of the prefix of the future 2nd person form. In some cases, the entire CV prefix is truncated.</td>
</tr>
<tr>
<td>$CV_{\text{fut.2nd}}X_{\text{fut.2nd}}$ $\rightarrow$ $C_{\text{fut.2nd}}X_{\text{imp}}$</td>
</tr>
<tr>
<td>$CV_{\text{fut.2nd}}X_{\text{fut.2nd}}$ $\rightarrow$ $C_{\text{fut.2nd}}X_{\text{imp}}$</td>
</tr>
<tr>
<td>$CV_{\text{fut.2nd}}X_{\text{fut.2nd}}$ $\rightarrow$ $C_{\text{fut.2nd}}X_{\text{imp}}$</td>
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<td>$CV_{\text{fut.2nd}}X_{\text{fut.2nd}}$ $\rightarrow$ $C_{\text{fut.2nd}}X_{\text{imp}}$</td>
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<td>$CV_{\text{fut.2nd}}X_{\text{fut.2nd}}$ $\rightarrow$ $C_{\text{fut.2nd}}X_{\text{imp}}$</td>
</tr>
<tr>
<td>$CV_{\text{fut.2nd}}X_{\text{fut.2nd}}$ $\rightarrow$ $C_{\text{fut.2nd}}X_{\text{imp}}$</td>
</tr>
<tr>
<td><strong>Lomongo Vocatives:</strong> (Horwood, 2000), (Weeda, 1992)</td>
</tr>
<tr>
<td>Lomongo vocatives are formed through the deletion of final C(C)V of a name.</td>
</tr>
<tr>
<td>$XV_{\text{1:voc.}}$ $\rightarrow$ $X_{\text{1:voc.}}$</td>
</tr>
<tr>
<td><strong>Tohono Perfective:</strong> (Bat-El, 2002), (Hill &amp; Zepeda, 1992), (Horwood, 2000), (Mathiot, 1973), (Saxton, 1982, 1996), (Steins, 2000), (Stonham, 1994), (Zepeda, 1983)</td>
</tr>
<tr>
<td>Tohono perfective is formed through the deletion of the final segment, most often final consonant but in very few cases final vowel. In some cases the final VC is truncated.</td>
</tr>
<tr>
<td>$XC_{\text{imp}}$ $\rightarrow$ $X_{\text{perf}}$</td>
</tr>
<tr>
<td>$XC_{\text{imp}}$ $\rightarrow$ $X_{\text{perf}}$</td>
</tr>
<tr>
<td>$XC_{\text{imp}}$ $\rightarrow$ $X_{\text{perf}}$</td>
</tr>
<tr>
<td>Icelandic action nouns are formed through the deletion of the final /a/ of the infinitive.</td>
</tr>
<tr>
<td>$XC_{\text{inf}}$ $\rightarrow$ $XC_{\text{N}}$</td>
</tr>
<tr>
<td>$XC_{\text{inf}}$ $\rightarrow$ $XC_{\text{N}}$</td>
</tr>
</tbody>
</table>
In French, the masculine adjectives differ from feminine adjectives in that they lack the final consonant that appears in feminine forms. For example, the adjective for ‘good’ has the masculine form bon /bɔ/ and the feminine form bonne /bɔn/. Even though it may appear that the masculine is formed from the feminine through deletion, (Stonham, 1994) discusses an alternative analysis that does not make use of deletion, cf. (Tranel, 1981). The analysis proposes a new underlying structure of French adjectives which contains a schwa-like vowel marking the feminine. It is this vowel that protects the final consonant against deletion in feminine forms and, since this vowel is not present in the masculine forms, the final consonant is not protected against deletion as seen in (7) below.

(6) Deletion rule:
C \rightarrow \emptyset/ _# #CX

(7) Adjectives in French:

<table>
<thead>
<tr>
<th>Root:</th>
<th>Feminine</th>
<th>Masculine</th>
</tr>
</thead>
<tbody>
<tr>
<td>/bon mer/</td>
<td>/bɔn pɛʁ/</td>
<td></td>
</tr>
<tr>
<td>Feminine Suffix:</td>
<td>/bon o mer/</td>
<td>-</td>
</tr>
<tr>
<td>Deletion rule:</td>
<td>-</td>
<td>/bɔ pɛʁ/</td>
</tr>
<tr>
<td>Schwa-deletion:</td>
<td>/bon mer/</td>
<td>-</td>
</tr>
</tbody>
</table>

The analysis is further supported by the fact that the final consonant does appear in masculine forms when they are followed by a vowel-initial noun, as seen in ‘un bon home’ [œ̃ bɔn o̞m] (Stonham, 1994, pp. 64-65). Since the deletion rule in (6) only applies at the border between a word ending in a consonant and a word beginning with a consonant, the final consonant of the masculine adjective followed by a vowel-initial noun does not undergo deletion and appears in the surface form (as seen in (8)).
Adjectives in French (Stonham, 1994, pp. 64-65):

Masculine Feminine Masculine
un bon père une bonne mere un bon home
[œ bɔ̃ per] [yn bon mer] [œ bon ɔm]

Nootka hypocoristic names/terms are characterized by missing final segments from the names and terms and the addition of the suffix /is/. Cases of deletion such as the Nootka hypocoristic names/terms have been reanalyzed as melody based templatic processes. Using an autosegmental framework, (Stonham, 1994) presents an analysis of Nootka hypocoristic names/terms consisting of a melody based templatic process as exemplified in (9) below (pp. 74-90). As described in (Stonham, 1994), the hypocoristic names/terms are also characterized by the same number of syllables and similar segment layout despite the very different root names/terms. Applying the template to Nootka names/terms results in the removal of excess segments that do not fit the template. The templatic processes in Nootka are based on an autosegmental framework similar to that discussed in (McCarthy, 1982).

Hypocoristic Template in Nootka (Stonham, 1994, p. 84):

tu:xmis → to:x?is
In the case of Danish imperative case morphology, introduced in table 1.2, it is argued that the imperative is a case of subtractive morphology as it is formed from the infinitive through the deletion of the final /a/ (Anderson, 1992). Due to the phonology of the language, the only way to account for the form of the imperative is to assume that the imperative is formed from the infinitive through deletion. However, (Stonham, 1994) argues that the phonology of Danish has been misunderstood and a new interpretation of the phonology can account for the form of the imperative. As a result, there is no need for subtractive morphology and the imperative is formed from the root of the verb through conversion.

One of the phonological processes of Danish, stød (10), inserts a glottal stop /ʔ/ after a long segment and shortens the segment. It is this process that suggests that the imperative is formed from the infinitive form rather than the root of the verb (Anderson, 1992).

(10) Rule of stød:
\[ X \rightarrow \tilde{\text{ʔ}} \ X_\text{−} \quad \text{where} \quad X=\{V, C\} \]

Imperative forms in Danish all contain the glottal stop /ʔ/, the result of the rule of stød. However, in order for the rule of stød to apply, the input form to the rule must contain a long vowel or geminate consonant. The infinitive forms contain a final vowel /a/, which triggers vowel lengthening (11), and, as a result, the infinitive forms contain long vowels. However, the root forms of verbs in Danish do not contain long vowels word finally. It is argued that if the imperative (e.g. /bæʔd/) was formed from the root of the verbs, the rule of stød could not be triggered and therefore the resulting form would
not contain a glottal stop (e.g. /bæd/). As such, the imperative forms must be formed from the infinitive form, as seen in (12a).

(11) Vowel lengthening:
\[ V \rightarrow V:_/C\# \]

(12) Subtractive morphology in Danish (Stonham, 1994, p. 66):
(a) Formation of imperative form with subtractive morphology:
   I. Base: /bæd/
   II. Infinitive: /bæda/
   III. Vowel lengthening: /bæ:da/
   IV. Imperative: /bæ:d/
   V. Stød: /bæ?d/

(b) Formation of imperative form with new definition of stød:
   I. Base: /bæd/
   II. Imperative: /bæd/
   III. Stød: /bæ?d/

Alternatively, (Stonham, 1994) proposes a reanalysis of the phonological system of Danish, in particular the rule of stød, which would obviate the need for subtractive morphology. The rather convincing counter-argument from (Stonham, 1994) argues that the rule of stød is actually a result of a constraint in the language requiring all verb forms of the language to be minimally bimoraic (pp. 67-68). Under this interpretation, the insertion of a glottal stop /?/ would occur after the formation of the imperative from the verb root (see (12b)). This brings into question the need for subtractive morphology, as assumed by the analysis in (12a).

In Koasati, the plural of a particular inflectional class of verbs is formed through the deletion of final VC or V: from the singular form (as seen in (13) and table 1.2)
An alternative analysis of a reversed direction, from plural to singular (singularisation), results in a process marked with 13 affixes (Martin, 1988).

(13) Koasati pluralisation versus singularisation (Martin, 1988):

\[
\text{pitaf-fi-n}_{\text{singular}} \rightarrow \text{pit-li-n}_{\text{plural}} \quad \text{‘to slice up the middle’} \\
\text{pit-fi-n}_{\text{plural}} \rightarrow \text{pitaf-fi-n}_{\text{singular}} \quad \text{‘to slice up the middle’}
\]

Colloquial Hebrew is cited as a case of subtractive morphology with an extensive analysis of the various issues in (Bat-El, 2002). As subtractive morphology, the imperative is formed from the 2\textsuperscript{nd} person future form of the verb through the deletion of segments from the 2\textsuperscript{nd} person future prefix (see table 1.2). A method for circumventing the need for subtractive morphology in Colloquial Hebrew is to argue that the deletion is a phonetic process and therefore not morphology at all. (Bolozky, 1979) presents an analysis where the imperative is a result of stress constraints in the language. According to this analysis, the future form (2\textsuperscript{nd} person) is often used as a polite version of the imperative (e.g. tekabel ‘please receive!’) and it is also used as a direct command but in a shortened version (e.g. tkabel ‘receive!’). However, the imperative used as a direct command occurs always sentence initially creating a sentence with two stresses together. Colloquial Hebrew favours alternating stress in surface forms and therefore the stress clash is avoided by the deletion of the prefix vowel (Bolozky, 1979, p. 22). Further support for this alternative analysis is provided by the fact that future forms do sometimes, though rarely, appear in a short form with future use, but always in circumstances where the long form would create a stress clash (Bolozky, 1979, p. 23).

Several researchers (Kawahara, 2001; Kiparsky, 1984; Kurisu, 2001, 2002) try to account for the action noun construction in Icelandic (see table 1.2) as a case of subtractive morphology. Some of the action nouns in Icelandic are formed through the
deletion of the final /a/ from the infinitive form of the verb. An argument against subtractive morphology in Icelandic can be made by arguing that the case of subtractive morphology is not productive. Such an argument can be made based on the fact that the few examples of verbs undergoing nominalization do not appear in current dictionaries of this language and seem to be extracted from old literature rather than current speech. (Oresnik, 1976) contains both a discussion of the historical development of action nouns and an extensive list of examples of Icelandic action noun formation which exhibit deletion. These examples are extracted from old texts and an overview of two English-Icelandic dictionaries and grammars, (Einarsson, 1949) and (Jónsson, 1927), does not reveal any examples of action nouns that have undergone deletion. Also, these dictionaries do not contain the truncated forms cited in (Orešnik, 1976). The case of Icelandic nominalization brings to light the necessity to ensure that cases of subtractive morphology are productive morphological processes.

Although arguments against some cases of subtractive morphology have been successful, other cases of subtractive morphology may very well be valid. Koasati pluralisation is a process that applies to a particular inflectional class of verbs with many examples (Kimball, 1983, 1985, 1991). These facts suggest that Koasati pluralisation is at least a productive process which is an important requirement for a valid case of subtractive morphology, as illustrated by the Icelandic case. However, while deletion is used to mark the plural on a particular class of verbs, affixation is also used to mark the plural on most verbs in Koasati. Contrastively, most of the verbs in Tohono O’odham are marked for the perfective through deletion with few examples of suppletion and zero
morphology or conversion (Steele, 2008). This difference makes the argument for the productivity of the subtractive morphology a lot stronger in Tohono O’odham.

Several attempts are made to account for the details of perfective formation in Tohono O’odham within concatenative theories of morphology, both in (Stonham, 1994) and (Steins, 2000). I discuss these approaches to Tohono O’odham perfectives along with other possible alternatives in chapter 3.

1.4 Methods

In order to argue for the existence of subtractive morphology, I have to make a negative argument that there is no concatenative analysis that accounts for all the facts of Tohono O’odham perfectives. This argument must be supported by extensive research into the various alternative concatenative analyses and the different theoretical frameworks which may support a concatenative analysis.

My approach for the negative argument is two pronged. First, I investigate the phonology and morphology of Tohono O’odham. Given all the facts of the phonological and morphological structure of Tohono O’odham, I attempt to account for all the facts of perfective formation using these independently motivated phonological and morphophonemic processes of the language.

Second, I investigate the alternative concatenative analyses already proposed for Tohono O’odham, as well as other analyses proposed for other cases of subtractive morphology. Using the theoretical tools presented in these analyses, I attempt to investigate if a valid concatenative analysis of Tohono O’odham perfective exists. I
evaluate concatenative analyses in terms of their ability to account for all the facts and whether they are independently motivated.

Third, I investigate non-concatenative analyses as a point of contrast to concatenative analyses in order to establish the merits of a non-concatenative analysis over a concatenative one. Also, I present an Antifidelity Optimality Theory analysis in order to address some criticisms against process-based morphology and provide a basis for exploring, in future work, the predictions that arise from such an analysis of subtractive morphology.
2: SUBTRACTIVE MORPHOLOGY IN TOHONO O’ODHAM

Chapter 2 presents the facts of Tohono O’odham morphology and phonology as well as the specific details of subtractive morphology in Tohono O’odham. These facts are used in section 2.5 to investigate whether the language particular morphology and phonology of Tohono O’odham, “the native processes”, are sufficient to explain the facts of subtractive morphology on their own. In order exemplify the various issues that an analysis of Tohono O’odham perfective would need to account for, I lay out the different patterns of deletion alongside exceptions and rare cases. In the same section 2.1, I also describe the interaction between the perfective and the phonological processes of Tohono O’odham. To understand the interaction between the perfective and the various verb categories and morphological processes in Tohono O’odham, I present, in section 2.2, an outline of the verb morphology in Tohono O’odham based on (Mathiot, 1973) and (Mason, 1950). This outline includes the morphological template, morphological processes, morphological categories and phonological processes triggered by morphology (morphophonemics). In section 2.3, I lay out a phonological sketch of Tohono O’odham based on several resources (Fitzgerald, 1997; Mason, 1950; Mathiot, 1973; Saxton, 1982, 1996; Zepeda, 1983). In section 2.4, I present other facts about the syntax of Tohono O’odham, which are significant for the chapter 3 discussion on concatenative analyses of Tohono O’odham perfective (Zepeda, 1983). The morphological and phonological sketches serve as a basis for section 2.5 where I investigate possible analyses of
perfective formation using only the existing morphological and phonological processes of the language.

2.1 Perfective in Tohono O’odham

The perfective forms in Tohono O’odham are formed through the deletion of final segments from the imperfective forms. Most verbs in Tohono O’odham undergo deletion of the final consonant as seen in (1). The examples are taken from various resources and the transcriptions are unified using IPA conventions in order to facilitate ease of analysis (Mason, 1950; Mathiot, 1973; Saxton, 1982; Zepeda, 1983).

(1) XC \rightarrow X
   hihim \rightarrow hihi  'to laugh'
   hihim \rightarrow hihi  'to walk (pl)'
   hi:ŋk \rightarrow hi:ŋ  'to bark'
   huhu?i.q \rightarrow huhu?i  'to chase'
   goloŋ \rightarrow golo  'to rake'
   ?o?ohaŋ \rightarrow ?o?oha  'to write'

However, when deletion of the final consonant would result in a verb ending in a coronal consonant plus high vowel, the perfective is formed through the deletion of the final VC as seen in (2).

(2) XVC \rightarrow X
   cipošiŋ \rightarrow cipos  'to brand'
   gigošiŋ \rightarrow gigoš  'to feed'
   širioŋ \rightarrow šir  'to straighten'

Not all verbs fit the C or VC deletion patterns. For a few verbs ending in Ci, the perfective is formed through the deletion of the final Ci, independently of whether the C
is coronal, as seen in (3). For other verbs ending in VCV (aŋi, oŋi, V?V, VhV), the perfective is formed through the deletion of the final VCV as seen in (4). Verbs ending in vowels that do not fit the Ci or VCV deletion patterns do not undergo deletion (5). Some verbs, though, form the perfective through suppletion (6).

(3) XCi \[\rightarrow X\]  
  co?mi \[\rightarrow co?\] 'to sew'  

(4) XVCV \[\rightarrow X\]  
  kowoni \[\rightarrow ko?w\] 'to rattle'  

(5) XV \[\rightarrow XV\]  
  daŋa \[\rightarrow daŋa\] 'to arrive'  

(6) Suppletion:  
  ko?a \[\rightarrow hu:\] 'to eat'  

Deletion interacts with phonological rules in the case of monosyllabic stems due to a constraint on all verb forms to be at least bimoraic (Fitzgerald, 1997). The result of this interaction is either vowel lengthening (7) or diphthongization (8).

(7) CVC \[\rightarrow CV:\]  
  miŋ \[\rightarrow mi:\] 'to run'  

(8) CVC \[\rightarrow CVi\]  
  paŋ \[\rightarrow pai\] 'to make fire'  

The majority of verbs cannot undergo suffixation in addition to deletion and therefore cannot be marked for moods other than the indicative, which involves lack of suffixation. However, a few verbs do get marked through suffixation for the correlative or immediate moods in addition to deletion as seen in (9) (Mathiot, 1973, pp. 68, 85-86).
This shows that, in some cases, the deleted segments are actually not word final. In the indicative mood, the result of deletion is a monomoraic word and therefore diphthongization is triggered resulting in the insertion of /-i/ at the end. Due to the presence of suffixes in the correlative and immediative, the resulting form is not monomoraic and diphthongization is not triggered.

(9) Rare cases where suffixation co-occurs with deletion:

bihi → bii (indicative)
→ bi-k (correlative)
→ bi-ka?i (immediate) 'to get something'

2.2 Morphology

2.2.1 Morphological frame

To understand the positions of the various affixes used to mark morphological categories and their relationship with the perfective, I provide a morphological frame adapted from (Mathiot, 1973) (see Figure 1 below). This frame illustrates the positions and possible combinations of affixes for verbs. The different affixes and the categories they express are discussed and referred to in the sections below.

Within this morphological frame, the theme refers to the verb root together with any derivational affixes and epenthetic vowels (such as /a/ or /i/), as well as the result of stem deletion or reduplication (Mathiot, 1973, pp. 66-70).
2.2.2 Morphological processes

In order to determine if native morphological processes can account for perfective formation without the aid of subtractive morphology, I identify the core morphological processes of Tohono O’odham verb morphology.

Affixation is one of the main morphological processes used to mark verb categories. Suffixation is used to mark certain number categories, including most aspect and mood categories, voice, alienability categories and locationals (figure 1). Prefixation is used to mark person categories and intensity categories (figure 1). An example of suffixation is the suffix /p/ used to mark the semelfactive number, which represents single action not bound by location. An example of prefixation is the prefix /m/ used to mark second person singular.

Reduplication is another morphological process used to mark verb morphology in Tohono O’odham. Reduplication is used to mark number categories, except nonlocalized aspectual number, which refers to the number of times an action is performed regardless of location. An example of reduplication is the imperfective plural subject form /hihim/ formed from the imperfective singular subject /him/ (‘to walk’).
As illustrated in section 2.1, deletion is claimed to be another morphological process and is used to mark the perfective on most Tohono O'odham verbs. Suppletion is yet another morphological process used not only to mark the perfective, but other verb categories as well. For example, the habitual form of /hab juní/ 'to do something in a certain way' is /hab vua/. Zero morphology, or conversion, is another morphological process used to mark the perfective, as in the case of the verb /daq̄a/ 'to arrive' where the imperfective and perfective forms are both /daq̄a/.

Lastly, some categories such as the imperative are marked using particles. For example, the particle /gi/ is used for the imperative in conjunction with a special form of the verb theme.

2.2.3 Morphological categories

In this section, I sketch the details of the different morphological categories marked on verbs for two reasons. First, a sketch of verb morphology in Tohono O'odham provides relevant context for an analysis of the perfective. Second, in order to investigate whether or not the perfective can be accounted for with independently motivated processes, it is necessary to have an understanding of the morphological template and the way that different affixes identified in the template mark morphological categories. The primary reference in this section is (Mathiot, 1973).

2.2.3.1 Number categories

Tohono O'odham has two different types of aspectual number, referring to the number of actions, and three categories of entitative number (one extended, two immediate), referring to the number of entities performing the action, and one category of
imperative number, referring to the number of entities the imperative refers to. The extended category and the immediate categories are mutually exclusive, while all other combinations are permitted. Aspectual number can combine with both extended and imperative number (Mathiot, 1973, pp. 48-49).

Example (Mathiot, 1973, p. 49):

\[ \text{QaQags;p-o!} \quad \text{(unitive aspectual, multiple extended, plural imperative)} \]

'You (pl) put your hands on it!

The two types of aspectual number categories are localized, which refers to the number of times an action is performed as well as the number of places where the action is performed, and nonlocalized, which refers to the number of times an action is performed without concern to place (Mathiot, 1973, pp. 49-50). The localized number can be unitive (single action performed in a single place), repetitive (several identical actions in a single place) and distributive (several identical actions in several places). The aspectual number is marked by reduplication for localized number. The nonlocalized number can be semelfactive (single action), marked by a lack of suffixation or the suffixes /-p/ and /-n/, or reiterative (several identical actions), marked by the suffixes /-ç/ (or /-ça/) and /-kì/ (or /-i/).

The entitative number categories are extended number, which refers to the number of entities to which a given action extends without these entities being involved as subjects or objects of the action, and immediate number, which refers to the number of entities directly involved in the action (Mathiot, 1973, pp. 50-52). The extended number can be single, referring to a single entity, or multiple, referring to several entities and marked with reduplication. The immediate number refers to both subject number and
object number, which can be singular or plural with the plural marked through either reduplication or suppletion.

The imperative number refers to the number of entities to which an imperative is addressed and can be singular or plural with the plural marked by the suffix */-o/ (or */-io/ or */-vo/) while the singular is marked by a lack of suffix (Mathiot, 1973, pp. 52-53). The mood marker for the imperative is often dropped when the plural imperative marker is present.

2.2.3.2 Person categories

Person categories are associated with personal number, reflexivity and definiteness or humanness. Verbal object personals (person, number, reflexivity, definiteness, and humanness expressed as one marker) are used for both direct and indirect objects in the case of ditransitive verbs. The direct object personals are limited to Ø and */ha-/ (definite markers) in those cases, while the indirect object personals can be any of the prefixes, except for the indefinite prefixes (Mathiot, 1973, p. Table IX). The prefixes */?-i-//*-ha-/, */?-a-/- and */-cu-/- can function as either prefixes or particles (Mathiot, 1973, pp. 56-57).

The person category refers to the relationship between object entities and actions, similar to personal pronoun objects in English. Person can be first, second or third combined with reflexive and non-reflexive for non-first person, definite and indefinite for the third person as well as human and nonhuman for the third person indefinite (Mathiot, 1973, pp. 53-54). Person categories are marked with prefixes; for first person singular */-n-/ and plural */-a-/-, for reflexive */?-i-/, for second person singular */-m-/ and plural */?-im-/,
for third person, definite plural /-ha-/, indefinite human /ha-/ or /-ta-/ and indefinite nonhuman /-cu-/.

Reflexivity refers to whether the referent of the person category is identical with the subject of the clause, but can also mean reciprocal action or passive (Mathiot, 1973, pp. 54-55). Reflexivity can be reflexive, where the referent is identical with the subject, marked by the prefix /-ʔi-/, or nonreflexive, where the referent is not identical with the subject, marked by the second and first person prefixes.

Definiteness refers to whether the referent of the person category has been defined, with regards to the third person (Mathiot, 1973, p. 55). Definiteness can be definite, meaning the referent has been defined, marked by the suffix /-ha-/ in the plural, or indefinite, meaning the referent has not been defined, marked by the prefixes /ha-/ or /-ta-/ for human and prefix /-cu-/ for nonhuman.

Humanness refers to whether or not the referent of the person category is a human being, with regards to the third person indefinite (Mathiot, 1973, p. 55). Humanness can be human, meaning the referent is human, marked by the prefixes /ha-/ and /-ta-/; or nonhuman, meaning the referent is not human or non-Papago, marked by the prefix /-cu-/

2.2.3.3 Aspect categories

Descriptive aspect categories
The descriptive aspect categories are resumptivity and extensionality. The two categories must combine with mood categories and they can combine with each other as
well. Some forms are not inflected for either of the descriptive aspect categories and are called neutral to the descriptive aspect (Mathiot, 1973, p. 57).

Resumptivity refers to whether a given action can be resumed after an interruption and can be either interruptive or completive (Mathiot, 1973, pp. 57-58). Interruptive refers to actions that can be resumed or occur in interrupted portions, while completive refers to actions that are definitively terminated. The interruptive is marked by the suffix /-him(-)/, definite alternant, or the suffix /-hi-/, indefinite alternant, before the durative marker. The completive is marked by the suffix /-o-/ before the immediate marker, /-oho-/ when a word beginning with /g/ occurs after the verb, and /-ok/ otherwise.

Extensionality refers to the duration of the action and can be durative, meaning the action has extension, or immediate, meaning the action immediately precedes another action (Mathiot, 1973, pp. 59-60). The durative is marked with the suffix /-qa-/ before the imperative marker and /-q-/ otherwise, and the immediate is marked with the suffix /-ka?i-/.

Gradational aspect categories

The two mutually exclusive gradational aspect categories are ranking and successionality. The gradational aspect categories must combine with the category of mood and can combine with either one or both of the categories of descriptive aspect. (Mathiot, 1973, p. 60)

Ranking refers to whether the action takes place for the first time or as a unique occurrence (Mathiot, 1973, p. 60). Ranking applies only to a limited number of verbs and can be primofactive, i.e. action taking place for the first time or as a unique
occurrence, or habituative, i.e. action being habitual or one of a series. Habituation is marked through suppletion of the theme.

Successionality refers to whether several actors perform the same action one after the other in successive repetition (Mathiot, 1973, pp. 60-61). Successionality can be successive, action performed in successive repetition, or nonsuccessive, action not performed in successive repetition. The successive is marked with a suffix /-ʔajj/ (or /-aʔj/, or /-q/).

2.2.3.4 Mood categories

Mood categories in Tohono O’odham mark verbs with respect to whether the sentence is a command or not, and whether there is a relationship (and of what type) between the action of the verb and another action. Imperative and indicative moods reflect a lack of relationship with another action, while concursive and correlative moods reflect a relationship between the verb action and another action. The imperative marks commands, while the indicative marks any statements that are not commands. The concursive marks the simultaneity of the verb action and another action, while the correlative marks a priority ranking between the two actions.

The indicative is used to mark that a statement is not a command and it does not describe a connection between actions (Mathiot, 1973, pp. 61-63, 68). The indicative mood can be definite, when the person discussed was previously mentioned, or indefinite, when the person was not previously mentioned. The definite appears to be marked by deletion, while the indefinite is not marked. (Mathiot, 1973) uses the terms definite for perfective and indefinite for imperfective, labels used in other sources such as (Saxton,
1982) and (Zepeda, 1983). The perfective (or definite) is the focus of the discussion surrounding subtractive morphology.

The imperative is used to mark that a statement is a command and it does not describe a connection between actions (Mathiot, 1973, pp. 61-62). The imperative is marked with the suffix /-p/, which can be dropped before the imperative plural marker, or the particle /g/, which co-occurs with the hortative alternate of the verb theme (marked by the suffixes /?i/ or /?a/).

The concursive is used to mark that a statement is not a command and the action of the verb is occurring simultaneously with another action (Mathiot, 1973, pp. 61-62). The concursive is marked by the suffix /-c/ when the theme ends in a consonant and by the suffix /-kc/ when the theme ends in a vowel.

The correlative is used to mark that a statement is not a command and the action of the verb is in a priority relationship with another action (Mathiot, 1973, pp. 61-62). The correlative is marked by the suffix /-hV/ (V is identical or similar to the vowel preceding the correlative suffix) when a word beginning with /g/ immediately follows the verb, or the suffixes /-ck/ or /-k/ when the theme ends in a vowel. The correlative suffix is one of the two inflectional suffixes that can sometimes co-occur with deletion as seen in section 2.1 (9).

2.2.3.5 “Voice” (Active vs. Stative)

Voice categories refer to whether the reference of the verb is an action (active voice) or a state (stative voice). The stative voice is marked by the suffix /-f/ if the verb ends in /k/ or /ka/ or if indefinite auxiliaries or modals occur with the verb (Mathiot,
1973, pp. 63-64). Otherwise, the stative voice is marked by the suffix /-ka-/ before the
durative or interruptive markers and by the suffix /-k/ with verbs uninflected for
descriptive aspect or when definite auxiliaries or modals occur with the verb. The active
voice is marked by a lack of suffixation.

2.2.3.6 Alienability categories

This category applies to denominal stative verbs, and it refers to whether or not
there is an ownership relation between the entities (Mathiot, 1973, pp. 41-42). There are
two types of alienability, alienable, where an ownership relation does exist, and
inalienable status, where an ownership relation does not exist. Alienable status is marked
by the suffix /-ga-/ while inalienable status is marked by the absence of the alienable
status marker.

2.2.3.7 Intensity categories

This category applies to stative verbs and refers to whether the reference is made
with some intensity (Mathiot, 1973, pp. 43, 65). There are two types of intensity,
intensive, meaning there is some intensity, and nonintensive, meaning the reference was
not made with intensity. The intensive is marked by the prefixes /g-/ and /m-/ depending
on the verb.

2.2.3.8 Incorporated locationals

Incorporated locationals are postpositions that appear after the verb. Some of
them are /-ʔamaʔi/ or /-ʔam/ “down at, on the back of, in the back of”, /-ʔabaʔi/ or /-ʔab/
“up at, upon, in the front of, against”, /-ʔaʔaʔi/ or /-ʔaʔ/ “on the side, by the side, on”,
/-ʔamjiq/ “from” and /ʔa:m/ “above, on top of”. The incorporated locations attach to the
verb through a linker /-k-/.

They combine only with verbs in the indicative mood, inflected for the durative or interruptive aspect (Mathiot, 1973, pp. 65-66).

**2.2.4 Morphophonemics**

Below in section 2.5, I survey the morphophonemic processes enumerated in the Tohono O’odham literature in order to determine if they can account for the perfective either on their own, or in conjunction with other morphological or phonological rules.

Morphophonemics refer to phonological processes triggered by morphological processes. The epenthesis of /a/ occurs between consonants at the right edge of words either in derived words or compounds (11). The deletion of /h/ similarly occurs between voiceless consonants or after /s/ at the right edge of the first word in a compound (12). The initial consonant of certain morphemes, such as /ha/ ‘NEG’ and /hahawa/ ‘then’ (13), is deleted if the previous word ends in a consonant or /i/, but this applies only to these morphemes without any phonological conditioning.

(11) Epenthesis of /a/ (Fitzgerald, 1997, p. 153): Vowel /a/ is inserted between a consonant-final verb stem and a consonant-initial suffix, and it is always unstressed. This vowel has no semantic content. As well, the vowel /a/ is inserted between a consonant-final word and a consonant-initial word in a compound.

\[ \emptyset \rightarrow a/ C_1 [\text{Verb/Wd.}] [C_2 \ldots ] [\text{Suffix/Wd.}] \]

Example: /mi\dj/ “running” + /ku\dj/ “instrument” \( \rightarrow /mi\djaku\dj/ “trail” \)

(12) /h/ deletion (Mason, 1950, p. 9): /h/ often deletes after /s/ and between voiceless segments at the border between words in compounds.

\[ h \rightarrow \emptyset / C_1 [\text{voice}] [\text{Word.}] [C_2 [\text{voice}] \ldots ] [\text{Word}] \]

\[ h \rightarrow \emptyset / s/ [\text{Word.}] [\ldots ] [\text{Word}] \]
(13) **Delete initial C in the morphemes below** (Saxton, 1982):
Condition: if following a word ending in C or /i/.

\[
C \rightarrow \emptyset / (C, /i/) \text{word [word#} ~
\]

### 2.3 Phonology

In this section, I lay out a phonological sketch of Tohono O’odham, including segment inventory, allophonic variation, syllable structure, phonological processes and prosody. In order to establish if phonological rules and/or morphological rules can account for the facts of the perfective formation, I must first look at all existing phonological processes, including phonological neutralizations and allophonic rules. Syllable structure and prosody may have some bearing on the correct analysis of the perfective so they are outlined as well.

#### 2.3.1 Segment inventory - phonemes

In this section, I present the segment inventory of Tohono O’odham based on several sources, (Fitzgerald, 1997, p. 42; Mason, 1950, pp. 7-8; Saxton, 1982, pp. 100-101). In order to establish the segment inventory, IPA conventions are used and to match the descriptions and examples described in the various sources (Fitzgerald, 1997, p. 42; Mason, 1950, pp. 7-8; Saxton, 1982, pp. 100-101). I use IPA symbols in order for generalizations to be readily observable.
The velar nasal /ŋ/ is only found in borrowed words, while the retroflex /ɾ/ is in fact a palatal retroflexed flap according to (Saxton, 1982) (p. 101). According to (Mason, 1950), the retroflex /ɾ/ is between /l/ and /r/ acoustically and Tohono O’dodham has the bilabial fricative /β/ and the alveolar affricates /ɾf/, /ɾʒ/ (pp. 7-8). As well, /j/ as a consonant only appears in foreign words, like /jaːwi/ (Mason, 1950, p. 10). The velar nasal /ŋ/ is considered pre-nasal by (Mason, 1950) and reported to be encountered only in songs (Mason, 1950, p. 10).

I use (Fitzgerald, 1997) and (Zepeda, 1983) to establish a vowel and diphthong inventory, seen in (14) below, as it corresponded with the facts presented in other sources. Vowels in Tohono O’dodham are either extra-short, short (normal) or long. Extra-short syllables are primarily found word finally, while long vowels are found only in the first syllable of the stem where the primary stress is found (Fitzgerald, 1997, p. 43; Saxton, 1996, p. 104; Zepeda, 1983, p. 3).
(14) **Vowel inventory:**  
(Fitzgerald, 1997, pp. 42-43)  

<table>
<thead>
<tr>
<th>Front</th>
<th>Central</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>i</td>
<td>u</td>
</tr>
<tr>
<td>Mid</td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>Low</td>
<td>a</td>
<td></td>
</tr>
</tbody>
</table>

(15) **Vowel devoicing** (Mason, 1950, p. 7): Vowels devoice between two voiceless stops or between a voiceless stop and the glottal stop.  
\[
V_{[\text{+voice}]} \rightarrow V_{[\text{-voice}]} /C_{\text{stop-[voice]}}, \{C_{\text{stop}-\text{voice}}; /?/\} 
\]

(16) **Preaspirated consonants** /p, t, k, tf/ (Mason, 1950, p. 7): The voiceless stops and affricate are preaspirated post-vocically.  
\[
C_{[\text{-voice}]} \rightarrow \overline{b}C_{[\text{-voice}]} /V_-
\]

(17) **Devoiced consonants** /m, n, p, b, r/ (Mason, 1950, pp. 7-8): The nasals, glide and flap are devoiced before voiceless segments and word-finally.  
\[
C \rightarrow C_{[\text{-voice}]} \{#}; X_{[\text{-voice}]} \}
\]

(18) **Preglottalized voiced stops and affricate** /b, d, g, dʒ/ (Mason, 1950, p. 8): Voiced stops and affricate are preglottalized before voiceless segments and word-finally.  
\[
C_{[\text{+voice}]} \rightarrow \overline{g}C_{[\text{-voice}]} \{#}; X_{[\text{-voice}]} \}
\]

(19) **Retroflex** /ɾ/ (Mason, 1950, p. 9): allophones /ɾ/, /ɾ/  
(20) **/h/ before /i/** (Mason, 1950, p. 9): /h/ has a stronger ‘apperceptual’ effect before /i/ becoming prepalatal /ç/.  
\[
/h/ \rightarrow /ç/ _i
\]
(21) **Devoicing of /β, w/** (Mason, 1950, p. 9): / β, w/ devoice in word final position and before voiceless segments.

\[
\{β, w\} \rightarrow [-\text{voice}] \_ \{#; X_{[-\text{voice}]}\}
\]

(22) **Partial devoicing of /j/** (Mason, 1950, p. 10): /j/ is partially devoiced before a final voiceless vowel.

\[
j \rightarrow j[-\text{voice}] \_ V[-\text{voice}]#\]

(23) **Partial vowel devoicing** (Mason, 1950, p. 7): The second vowel of a diphthong devoices in word final position.

\[
V_{[-\text{voice}]} \rightarrow V[-\text{voice}] \_ V_#\]

### 2.3.2 Syllable structure

The syllable structure in Tohono O’odham consists of an onset made up of one consonant, a nucleus made up of a vowel or a diphthong and an optional coda made up of at most four consonants: \textit{CV(i)C\textsubscript{0-4}}. The only exceptions are borrowed words, which can have a complex onset /tt/, and a few onset-less syllables containing /i/ in words like [oiopo]. All consonants can occur in the coda and all but /ŋ/ and /n/ consonants can appear as onsets (Fitzgerald, 1997, pp. 43-45).

### 2.3.3 Phonological processes

Phonological processes are processes that neutralize contrast and are not dependent on morphology.

(24) **Nasalization of vowels** (Mason, 1950, p. 7):

\[
V_{[-\text{nasal}]} \rightarrow V_{[+\text{nasal}]} \_ C_{[+\text{nasal}]}
\]

\[
V_{[-\text{nasal}]} \rightarrow V_{[+\text{nasal}]} \_ C_{[+\text{nasal}]}\_\]
(25) **Devoicing of nasals /m, n/** (Mason, 1950, p. 10): Nasals are semi-long intervocally, and completely devoiced between voiceless segments or in initial or final word position.

\[
\begin{align*}
N & \rightarrow \ N' / V \_ V \\
N & \rightarrow \ N / \{X_{[-\text{voice}]}, X_{[-\text{voice}]}\} \_ ; \_ ; \_
\end{align*}
\]

(26) **Palatalization of /l/** (Mason, 1950, p. 10): /l/ is palatalized before /i, i, u/ and becomes /j/, but not before epenthetic /i, i/.

\[
l \rightarrow j / \{i, i, u\}
\]

(27) **Neutralization of /ʃ, d/** (Mason, 1950, p. 11): /ʃ, d/ become affricates /ʧ, dʤ/ before /i, i, u/.

\[
\{ʃ, d\} \rightarrow \{ʧ, dʤ\} / \{i, i, u\}
\]

### 2.3.4 Prosody: stress and intonation

The unit of stress in Tohono O'odham is the syllable and, generally, the primary stress falls on the initial syllable of the word. Monomorphemic and polymorphemic words receive stress differently. In monomorphemic words, stress falls on every nonfinal odd syllable and never on the last syllable. In polymorphemic words, however, stress falls on every nonfinal odd syllable with a secondary stress on the final odd syllable (Fitzgerald, 1997, pp. 56-57).

Sentence intonation follows a pattern of raised pitch from the first stressed syllable to the last primary stress in each clause and phrase predicate (Saxton, 1982).

### 2.4 Other facts

In this section, I present details regarding auxiliaries and word order in Tohono O'odham. The auxiliary is always present both in the imperfective and the perfective, but the auxiliary changes form in the perfective. The forms of the auxiliary as well as its
position with respect to the perfective verb form are relevant. This is particularly true when considering concatenative analyses which suggest a link between the perfective form of the auxiliary and the deletion of the perfective verb form (Steins, 2000).

2.4.1 Auxiliaries

The Tohono O’odham auxiliary comes in two forms, one indefinite or imperfective form and one definite or perfective form. Each of these forms varies based on person and number in agreement with the subject of the sentence.

(28) ʔaŋi ʔaŋ ʔniok. ‘I am/was speaking’
ʔaŋi ʔaŋt ʔnio. ‘I spoke’

(Zepeda, 1983, pp. 61-62)

<table>
<thead>
<tr>
<th>Table 2.2 Auxiliary long form</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Singular</td>
</tr>
<tr>
<td>1st Person</td>
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<tr>
<td>2nd Person</td>
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<td>3rd Person</td>
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<td>Plural</td>
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<tr>
<td>1st Person</td>
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<tr>
<td>2nd Person</td>
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<td>3rd Person</td>
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</tbody>
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<table>
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<tr>
<th>Table 2.3 Auxiliary short form</th>
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<tr>
<td></td>
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<tr>
<td>Singular</td>
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<tr>
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<td>1st Person</td>
</tr>
<tr>
<td>2nd Person</td>
</tr>
<tr>
<td>3rd Person</td>
</tr>
</tbody>
</table>
2.4.2 Syntax and word order

The possible word orders are SVO, SOV, VSO, VOS, OVS, OSV, with SVO as the most common word order. However, the position of the auxiliary is always sentence second resulting in word orders such as SAVO, VASO, etc, as seen in (29) below (Zepeda, 1983, pp. 31, 62).

(29) Maria swept the house.

(Zepeda, 1983, pp. 31, 62)
2.5 Possible analyses of Tohono O’odham perfective

In this section, I investigate various analyses based on the language particular rules of phonology and morphology in Tohono O’odham that could account for the perfective formation. My methodology consists of finding likely rules that could explain the deletion of final segments, building an analysis around any such rule or collection of rules and then investigating the plausibility of such an analysis. My main requirement for a plausible analysis is that it is independently motivated and does not stipulate any rules that cannot be shown to apply elsewhere in the phonology and morphology of Tohono O’odham.

In section 2.3.1.1, according to allophonic variation rules (17) and (21), consonants /m, n, ñ, ñ, w/ undergo devoicing word finally. As well, voiced stops and affricates are weakened word-finally through preglottalization as seen in rule (18) in section 2.3.1.1. In order to account for the deletion of final consonants, one could propose a deletion rule fed by weakened consonants, but the input for this rule would be rather unsystematic consisting of voiceless segments and preglottalized consonants. As well, this deletion rule would not be independently motivated due to the fact that the deletion of weakened consonants would apply only to perfective forms.

The morphophonemic rule in (12) (in section 2.2.4), the deletion of a final /h/ between compounds, is the only rule in Tohono O’odham to include deletion. An analysis can be made based on the assumption that the perfective is marked by a C→/h/ change followed by a morphologically triggered /h/ deletion. /h/ deletion is at least attested in combination with other morphological processes such as compounding, so it is somewhat independently motivated. Instead of the perfective being marked by deletion,
the perfective is marked by C→/h/ (30). A phonological rule similar to the deletion of /h/ between compounds can be proposed, but this new rule would be triggered by the perfective category. As a result of final /h/ deletion, some verb forms violate a constraint against words ending in coronal plus high vowel and therefore the final V is deleted as well (32). Two phonological rules are necessary to ensure that monosyllabic verb forms are at least bimoraic (33, 34).

(30) Perfective:
  XC_{imperf} → X_{hperf}

(31) Final /h/ deletion:
  X_{hperf} → X_{perf}

(32) Final V deletion:
  XC[Cor]V[Hi] → XC[Cor]

(33) Vowel lengthening:
  CV → CV:

(34) Diphthongization:
  CV → CVi

To account for the interaction between the vowel lengthening or diphthongization and the /h/ deletion, rule ordering is needed as seen below in (35). The marking of the perfective category through C→/h/ is necessarily first, followed by final /h/ deletion triggered by the perfective category marker. Since final V deletion is triggered by the result of final /h/ deletion violating a phonological constraint, final V deletion must occur after final /h/ deletion. Vowel lengthening and diphthongization occur either before or after final V deletion, the order not being relevant, as it cannot be proven that final V
deletion occurs before vowel lengthening. Final V deletion results in forms ending in consonants while vowel lengthening and diphthongization impact forms ending in a vowel. Suffixation, as allowed, must occur at least before vowel lengthening and diphthongization because vowels remain unchanged when a suffix follows the stem. The perfective for the verb /bihi/ ‘to get something’ is /biii/ when no suffix is present and /bik/ when the mood suffix /k/ is present, showing that suffixation must precede vowel lengthening.

(35) Order of rules:

1. Base (imperfective)  mida
2. Perfective  mih
3. Final /h/ deletion  mi
4. Suffixation  -
5. Final V deletion  -
6. Vowel lengthening  mii
   Diphthongization  -

This analysis does not account for the /Ci/ and /VCV/ deletion, but even if we consider those cases as cases of suppletion rather than a part of the productive marking of the perfective, the analysis has other problems. While /h/ deletion is independently motivated, the final C → /h/ change to mark the perfective does not get realized in any surface forms. This can be taken as a strong argument that, indeed, final /h/ deletion applies to all forms marked for the perfective, but it is impossible to prove that this change does occur as it never shows up in the surface form of verbs. In the Muskogean language Koasati deletion marks plural, but there are a few forms that undergo C → /h/ change rather than deletion to mark plural (Horwood, 2000). Languages in the same family with Koasati, Muskogean, show varying degrees of C → /h/ changes and deletion.
While no support for the C→/h/ change can be found in Tohono O’odham, perhaps the presence of this change in combination with deletion in Muskogean languages suggests that this analysis is a possibility even in Tohono O’odham.

No other existing morphological or phonological rules have the potential to account for final segment deletion, so I have to go one step further and investigate what Tohono O’odham would require for a plausible analysis. One possibility is to consider final consonant deletion as phonological deletion triggered by a perfective feature or an empty morpheme marking the perfective (36). The rule ordering necessary would not change compared to the analysis above, just that the perfective rule C→/h/ would be replaced by a perfective feature (or empty morpheme) and the final /h/ deletion would be replaced by a final C deletion triggered by the perfective (37).

(36)  Final C deletion:

\[ XC_{\text{perf}} \rightarrow X_{\text{perf}} \]

(37)  Order of rules:

1. Base (imperfective)  \(\text{mid}_{\text{imperf}}\)  \(\text{cipka}_{\text{imperf}}\)
2. Perfective  \(\text{mid}_{\text{perf}}\)  \(\text{cipka}_{\text{perf}}\)
3. Final C deletion  \(\text{mi}_{\text{perf}}\)  \(\text{cipka}_{\text{perf}}\)
4. Suffixation  -  -
5. Final V deletion  -  \(\text{cipk}\)
6. Vowel lengthening  \(\text{mi}:\)  -
   Diphthongization

Similar to the first analysis, this approach does not explain /Ci/ and VCV deletion but those could be considered examples of suppletion, where the new perfective forms
are simply listed in the lexicon. The phonology of Tohono O’odham would require a final C deletion rule as part of either the phonological rules or the morphophonemic rules of the language. Without final C deletion present outside of the perfective, this analysis is not independently motivated. Proposing a final consonant deletion rule as part of the phonology of Tohono O’odham when it only surfaces in conjunction with the perfective does not offer any real advantages over using subtractive morphology. Independent support from the phonology of a language makes possible an analysis that only makes use of the language particular phonological rules. However, without this independent support, this type of analysis is just a different theoretical way of introducing the concept of subtractive morphology.

2.6 Conclusion

In this chapter, I present a sketch of the verb morphology and the phonology of Tohono O’odham and use the language specific morphological and phonological rules as a starting point for analyses of the perfective. While there is some potential for an analysis based on the language specific rules (/h/ deletion), close investigation reveals some valid problems, including the need to stipulate a perfective formation rule whose result is never realized on surface forms and therefore unprovable. As an alternative, I build a successful analysis that could account for the perfective and compare the required rules to the known language specific rules of Tohono O’odham. This language does not show any independent support for the required rule of final consonant deletion and therefore the proposed successful analysis is not independently motivated in Tohono O’odham. In chapter 3, I investigate other concatenative analyses that suggest potential
rules and constraints that may be present in Tohono O’odham and could account for the perfective.
Chapter 3 presents different concatenative analyses that are proposed as an alternative to subtractive morphology. Having carefully considered the potential for the language particular rules of Tohono O’odham to account for the perfective without much success, I have to consider other possible concatenative analyses. The scope of my investigation is to ask if any concatenative analyses already proposed for subtractive morphology can be independently motivated in Tohono O’odham and can account for the variation found in the perfective formation. A failure to find any analysis with those attributes would strengthen the argument for subtractive analysis.

Section 3.1 contains different analyses proposed for the Tohono O’odham perfective. Section 3.2 contains different analyses proposed for other cases of subtractive morphology, which I adapt to the facts of Tohono O’odham perfective.

### 3.1 Concatenative analyses proposed for Tohono O’odham

#### 3.1.1 Steins 2000

In Tohono O’odham, the perfective and imperfective constructions consist of an auxiliary and a verb form. The perfective auxiliary (2) is formed through the suffixation of /ŋ/ to the imperfective auxiliary (1), as seen in section 2.4.1. (Steins, 2000) argues that the suffix /ŋ/ is the only perfective marker. As well, (Steins, 2000) proposes a
phonological constraint of syllable conservativity on the (auxiliary + verb form) construction between the imperfective and the perfective. As a result of the suffixation of the auxiliary in the perfective construction, the final syllable of the verb form is deleted in order to conserve the number of syllables between the imperfective and the perfective.

(1)  ?a:ŋi  ?aŋ  ŋiok
    1.SG  1SG.AUX  speak

   ‘I am/was speaking’

(2)  ?a:ŋi  ?aŋ-ŋ  ŋio
    1.SG  1SG.AUX-PERF  speak.PERF

   ‘I spoke’

(Steins, 2000) remarks that in coordinating clauses, the coordination (or correlative) suffix (see section 2.2.3.4) attaches to the imperfective form of the verb despite still being in the perfective aspect (3). This is seen as support for the perfective aspect being carried by the auxiliary and not the verb form. However, (Mathiot, 1973) lists several examples of correlatives formed with the suffix /k/ attached to a perfective form rather than the imperfective form. This calls into question the assumption that the suffix /ŋ/ alone marks the perfective.

(3)  Juddumi  ?aŋ-ŋ  ciːg-k  gatwi
    bear  1SG.AUX-PERF  find-COR  shoot.PERF

   ‘I saw a bear and shot it’

However, I allow Steins this assumption and still find fault with the analysis. In order to account for the deletion of segments in the perfective form of the verb, (Steins, 2000) proposes that the syllable count of the string composed of the auxiliary plus verb form must remain constant between the imperfective and the perfective. This suggests
that the auxiliary plus verb form constitute a prosodic element and their prosodic size is conserved.

(4) \text{?ant\text{\textnot{I}}\text{\textnot{n\text{\textnot{o}}}}}

As seen above (4), the addition of the suffix /\text{\textnot{i}/} introduces a new syllable and, due to syllable conservativity, the final syllable of the verb form is deleted (Steins, 2000, p. 112). In order for the addition of the suffix /\text{\textnot{i}/} to cause an increase in syllable count, an underlying vowel V at the end of the auxiliary is assumed without being independently motivated. Also without independent motivation, (Steins, 2000) assumes that the verb form must end in an underlying vowel /a/, which never appears on the surface form. This is necessary for the analysis to work because without this underlying /a/ vowel, the deletion of the final consonant would not change the number of syllables, thus removing the motivation for deletion. No independent evidence is presented to support the underlying vowels, and their presence requires the stipulation of several deletion rules in order to account for their absence from all surface forms.

As discussed, this analysis requires some unmotivated assumptions about the underlying phonological structure of Tohono O’odham words, but even if these assumptions are allowed for, the analysis encounters further problems. Tohono O’odham is a language allowing free word order, as seen in section 2.4.2 of chapter 2. Furthermore, the auxiliary is always present in the 2nd position, which results in possible
word orders VASO or VAOS when the verb occurs first (see (29) in chapter 2). As well, the verb can occur sentence finally and therefore be separated from the auxiliary by the subject or the object of the sentence. If the perfective verb form were a result of a phonological restriction that auxiliary plus verb must always have the same number of syllables, how would the phonology have access to a string of syllables that are interrupted by either the subject or object? In order to account for such access, the analysis requires a new level of phonology applying at branch level in the syntactic tree rather than to the end result of syntax or to individual lexical entries.

Furthermore, we need to assume an interpretation of syntax where the sentence is based on an underlying syntactic tree with auxiliary and verb as one constituent. The various word orders (see section 2.4.2) would need to be the result of some sort of transformations akin to Chomsky's Aspects model. Even allowing for this, in order for this new level of phonology to have effect at branch level between the imperfective branch and the perfective branch, this new syntax would need to generate first a branch with imperfective auxiliary and verb form solely for comparison purposes. Within modern theories of syntax such as Minimalism, phonology applies to the end result of syntax without any feedback mechanisms between syntax and phonology. However, in order to accommodate the branch level phonology required by the (Steins, 2000) analysis, syntax and phonology would need to interact in a way similar to morphology and phonology within the Lexical Phonology and Morphology model.

Finally, (Steins, 2000) remarks that the perfective in Tohono O'odham is similar to English in that /-ed/ in English is not considered to be the perfective marker and, if so the deletion in the Tohono O'odham perfective should not be considered a perfective
marker either. The problem with this argument is that an assumption is made that only one part of the verb construction is marked for aspect, tense, number, etc. In many languages, however, both auxiliary and verb forms are marked for the different morphological categories at the same time and yet the inflectional morphology of the auxiliary is treated separately from the inflectional morphology of the verb. Similarly, in Tohono O’odham, the auxiliary is marked for perfective by the addition of a suffix, while the verb form is marked by the deletion of segments.

### 3.1.2 Stonham 1994

(Stonham, 1994) proposes that the underlying base for Tohono O’odham verbs is shorter than assumed by analyses that employ subtractive morphology and that both the imperfective and the perfective forms are expanded from this shorter underlying base through suffixes (pp. 70-72). As seen below in (5), for the verb ‘to cut’ /hikčk/, there are several nouns and verbs that appear to be in the same word family. The verbs /hi:/ and /hi:k/ suggest, according to (Stonham, 1994), that the underlying verb form is shorter than the verb base /hikčk/. The argument is that, if the underlying base is /hikčk/, the verbs in (5) would require that the base undergo deletion to /hik/ (or /hi/) before suffixes are attached. For example, /hikčk/ would become /hik/ through deletion and then the suffix /šap/ is attached producing /hikšap/.

(5)  

<table>
<thead>
<tr>
<th>Verb</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>hikčk</td>
<td>‘to cut’</td>
</tr>
<tr>
<td>hi:</td>
<td>‘to cut hair, cut grass’</td>
</tr>
<tr>
<td>hi:k</td>
<td>‘to clip’</td>
</tr>
<tr>
<td>hikiwoŋi</td>
<td>‘to cut jaggedly’</td>
</tr>
<tr>
<td>hikšap</td>
<td>‘to trim’</td>
</tr>
<tr>
<td>hikčkakud</td>
<td>‘saw’</td>
</tr>
</tbody>
</table>
While (Stonham, 1994) argues for the derivational base of the words in the word family above, the analysis does not extend to inflectional morphology. Take into consideration a simple English example, the word ‘kingdom’. While the word ‘kingdom’ is derived from the word ‘king’ and the derivational suffix ‘dom’, the base for the inflection of the word ‘kingdom’ is ‘kingdom’ and not ‘king’. The plural for ‘kingdom’ is ‘kingdoms’ and not a plural formed through the addition of both a suffix ‘dom’ and a suffix ‘s’ to the base ‘king’. Similarly, even though /hibqüp/ may be derived from the word /hiː/ through the addition of one or several derivation suffixes, inflectional morphology acts on the base /hibqüp/ and not on the word family root /hiː/. The perfective in Tohono O’odham is inflectional due to the two traits that classify it as inflectional: there is a perfective for every verb, and it depends on the syntax as shown by the morphosyntactic relationship between the auxiliary and the following verb. The morphosyntactic relationship consists of the fact that the perfective form of the auxiliary always appears alongside the perfective form of the verb.

Another argument can be made that the stipulation of suffixes being added to the perfective to form the imperfective would lead to a claim that most (at least 12 from a rough estimate based on direct sources available to me, see some examples in (6) below) of the consonants of Tohono O’odham constitute suffixes to mark the imperfective. Moreover, this does not consider the other types of deletion, Ci and VCV. While allomorphy is often encountered in languages, proposing a suffix with almost as many allomorphs as there are consonants in the language seems rather implausible and problematic. (Martin, 1988) remarks that proposing many suffixes increases complexity and leads to complications to language learnability.
(6) Alternative analysis examples: perfective $\rightarrow$ imperfective

<table>
<thead>
<tr>
<th>Perfective</th>
<th>Imperfective</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>hihi</td>
<td>hihim</td>
<td>'to laugh'</td>
</tr>
<tr>
<td>hihi</td>
<td>hihim</td>
<td>'to walk (pl)'</td>
</tr>
<tr>
<td>hi:u</td>
<td>hi:uk</td>
<td>'to bark'</td>
</tr>
<tr>
<td>huhu?i + i</td>
<td>huhu?iq</td>
<td>'to chase'</td>
</tr>
<tr>
<td>golo</td>
<td>golopi</td>
<td>'to rake'</td>
</tr>
<tr>
<td>?o?oha + i</td>
<td>?o?ohapi</td>
<td>'to write'</td>
</tr>
</tbody>
</table>

3.2 Alternative analyses adapted for Tohono O’odham

3.2.1 Stonham 1994 – French

The analysis of French adjectives in (Stonham, 1994) consists of reanalysing the underlying phonological structure of adjectives, as seen in section 1.3. The key requirements of this analysis, taken as it is, are the deletion rule presented in section 1.3 (6), some condition motivating final consonant deletion (consonant cluster simplification) and an underlying motivation for why the condition for deletion does not apply to all forms (feminine suffix consisting of an underlying vowel /a/). In order to apply this analysis to the Tohono O’odham perfective, a deletion rule is necessary but Tohono O’odham does not have a final consonant deletion rule in the phonology. Therefore final consonant deletion is not independently motivated in Tohono O’odham. The deletion rule in French is phonologically conditioned as it applies to simplify a consonant cluster that appears as a result of the following word. In Tohono O’odham, a similar phonological condition does not apply because the perfective undergoes deletion regardless of the words following. Looking for other possible phonological conditions
for final consonant deletion, we can consider the addition of /j/ to the auxiliary form as the phonological condition, but that analysis is discussed and rejected in section 3.1.1.

3.2.2 Stonham 1994 – Nootka

The analysis of Nootka hypocoristic names/terms in (Stonham, 1994) maps the names to a melodic template which results in the removal of excess segments (as seen in section 1.3 example (9)). According to (Bat-El, 2002), deletion that lends itself to a templatic process is not in fact subtractive morphology but a type of “fake truncation”. While Nootka hypocoristic names/terms are clearly an example of such “fake truncation”, there is no obvious application of the template that would be successful with Tohono O’odham perfective. A template of the sort used in the analysis of Nootka hypocoristic names/terms generates outputs with a fixed number of syllables, while the Tohono O’odham perfective forms vary greatly in the number of syllables and segments.

The proposal in (Steins, 2000) makes use of different template constraints based on syllable conservativity between two levels of analysis, but that proposal has several problems discussed in section 3.1.1 above. The only alternative is to allow for a more flexible template. For example, the template for the perfective can be stipulated as XV where X is a variable string. An XV template can account for XVC → XV (case (1) in section 2.1) and even XVC → X (case (2) in section 2.1) in combination with a constraint against verb forms ending in C[Cor]V[+hi]. The same XV template would need to apply for the XVCi → XV cases (case (3) in section 2.1). A further template can be proposed for the XCVCV → XC cases (case (4) in section 2.1) in the form of XC. The XV template works by associating the rightmost vowel with the V node and all the segments to the left of this node with the X node, as seen in (7).
The analysis encounters several problems, the first of which is that the template XV must apply to both XVC and XVCi inputs. The template itself, while flexible enough to accommodate different structures, does not contain enough information to distinguish between the need to delete C or Ci. With the input of the type XVCi, the template XV is satisfied without deletion, as the /i/ vowel would associate with the V node and all the other segments with the X node. Perhaps a second XV template can be proposed which associates the V node with the second rightmost vowel and the X with all the segments to the left.

As well, if the template is based on whether a word ends in a vowel or a consonant, the template XC should apply to XVCi inputs and XCVCA inputs. The only solution is to specify that verbs of the form XVC undergo the templatic process XV1, XVCi verbs undergo the templatic process XV2 and the verbs of the form XCVCA (with VCV being ani, ani, V?V or VhV) undergo the templatic process XC. The template XC only works by associating the second rightmost consonant with the node C and all other segments to the left with the node X. At this point, the analysis seems to reach a high level of complexity as it requires conditions not only on outputs but on mappings as well. Therefore it does not seem to provide any improvements over subtractive morphology.
3.2.3 Martin 1988 and Hale 1965

Within an auto-segmental framework, (Martin, 1988) describes Koasati plural formation as a case of final rhyme deletion where the final rhyme is delinked from the syllable node, as seen below in (8) (p. 231). While (Martin, 1988) presents a process-based morphology analysis, I attempt to discuss a purely phonological analysis using the idea of delinking and based on a rule system proposed by (Hale, 1965).

(8) Koasati rhyme deletion (Martin, 1988, p. 231):

Similarly to Koasati rhyme deletion, the Tohono O'odham perfective can be analysed as a case of final syllable delinking. (Hale, 1965) argues that Tohono O'odham words have an underlying phonological form based on CV syllables, which, as illustrated below, makes a delinking analysis more tractable. Several rules seen in (9) apply to the underlying form of words resulting in the deletion of some vowels in the phonetic form of words.

(9) Phonetic Rules (Hale, 1965, pp. 299-300):

(R1) Stress the first vowel in stems (nouns and verbs).
(R2) Replace dentals by laminals when followed by high vowels.
(R3) Replace Ʉ by Ʉ and ç by ɘ before front vowels.
(R4) Reduce short unstressed vowels in CV to extra-short if followed by word boundary or if followed by a syllable other than CV in which C is lax and V extra-short (i.e., reduced by a previous application of this rule). This rule applies cyclically from right to left.
(R5) Delete extra-short back vowels after nonlaryngeals.
(R6) Delete extra-short front vowels as follows: when preceded by nongrave consonants, when flanked by homorganic grave consonants, and when flanked by heterorganic grave consonants where the next vowel to the right is [i].
(R7) Reduce unstressed long vowels to short.
If Tohono O'odham verbs conform to a basic CV template, then all imperfectives end in final vowel and therefore the perfective is formed through final syllable deletion (11). Using the autosegmental approach in (Martin, 1988), perfective formation in Tohono O'odham can be reduced to the delinking of the final σ node of the imperfective (10) as illustrated in (11).

(10) Wd#

[Diagram]

(11) Final syllable deletion:

Input (imperfective): /hihima/ /hubaŋa/
Final σ delinking: Wd# Wd#

Underlying form:

/hihima/ /hubaŋa/
Phonetic rules: [hihì] [hub]

(12) Imperfective:

Underlying form: /hihima/
Phonetic rules: [hihím]

The analysis accounts for /C/ and /Ci/ deletion with ease as final syllable deletion, but it does not explain the few cases where there is no final syllable deletion, as in the case of some imperfectives ending in vowel. As well, the analysis does not account for deletion of an extra vowel in the cases of /VCV/ deletion. The forms for the verbs
undergoing no deletion or /VCV/ deletion need to be specified, but this analysis is at least able to explain /Ci/ deletion successfully.

Even allowing for the gaps in the analysis regarding vowel-ending imperfectives, the biggest problem with this analysis is that the (Martin, 1988) delinking proposal cannot be concatenative in Tohono O’odham. In order for the analysis to be concatenative, the delinking of the final consonant must be phonological in nature as morphological delinking is not concatenative.

If we use a zero morph or perfective feature as the condition for delinking at a phonological level, then the analysis is the autosegmental equivalent of a lexical phonology analysis akin to (Kiparsky, 1984). Such an analysis suffers from the same failing attributed to process-based morphology: that of predicting a range of possible morphological processes that are rarely or never encountered in language. Concatenative morphology provides more concrete predictions about what kind of phenomena can be found in morphology. The autosegmental analysis of phonological delinking triggered by a zero morph or feature allows for any combination of phonological process and morphological category, exactly as process-based morphology.

If instead the delinking of the final syllable is a morphological rule or process, then the morphology is suddenly allowed access to the same kinds of autosegmental operations allowed in phonology, delinking and spreading. This alternative leads to the same issue discussed above, and the resulting theoretical framework would offer no improvement over process-based morphology.
4: PROCESS BASED MORPHOLOGY ANALYSIS: OPTIMALITY THEORY

In chapter 3, I outline and critically assess several concatenative proposals with respect to the Tohono O'odham perfective. In chapter 4, I present two process-based approaches to Tohono O'odham perfective, an operations inventory analysis based on (Zwicky, 1988) and a rules analysis based on (Anderson, 1983). These analyses allow for a wide range of possible morphological processes, a fact that has raised criticisms against process-based morphology. Contrastively, I outline an analysis of the Tohono O'odham perfective using antifaithfulness (Alderete, 2001) in Optimality Theory adapted from existing analyses in (Fitzgerald, 1997; Fitzgerald & Fountain, 1995; Horwood, 2000). The analyses in this chapter are provided as a point of comparison to the concatenative analyses in chapter 3 and a basis for addressing criticisms to process-based morphology. While I suggest some predictions based on the types of constraints required within an analysis of Tohono O'odham perfective (in section 4.2.3), the analysis mostly provides a basis for future work to examine the array of predictions of the antifaithfulness theory of subtractive morphology.

4.1 Process-based morphology

(Zwicky, 1988) proposes a process-based morphology based on operations and rules. Operations are phonological processes that encompass feature changes, deletion of segments, insertion of segments, etc. The rules refer to morphological processes that associate one or more operations with a morphological category.
Tohono O'odham perfective can be characterized using the concepts of operations and rules as seen in (1). Tohono O'odham grammar can contain the operations in (1) and several inflectional rules can make use of these operations. For example, for the imperfectives undergoing final C deletion, the inflectional rule IR 1 would apply, but for the imperfectives that would become monomoraic after the final C deletion, the inflectional rule IR 2 would apply. The inflectional rule IR 2 has two operations associated with it because the monomoraic perfective forms undergo deletion and vowel lengthening (or diphthongization). For the imperfectives undergoing final VC deletion, the inflectional rule IR 3 would apply, while for the few perfectives that are marked for correlative as well, the inflectional rule IR 4 would apply. The inflectional rule IR4 is associated with two operations because these verbs undergo both deletion and suffixation.

(1) Operations:
(a) Op 1: Final C deletion
(b) Op 2: Final VC deletion
(c) Op 3: Final Ci deletion
(d) Op 4: Final VCV deletion
(e) Op 5: Final vowel lengthening/diphthongization
(f) Op 6: Suffix /k/

(2) Inflectional Rules:
(a) IR 1: Op 1
(b) IR 2: Op 1 and Op 5
(c) IR 3: Op 2
(d) IR 4: Op 1 and Op 6

(Anderson, 1983) proposes a different formalization of process-based morphology, based on a different interpretation of morphological rules. Morphological
rules, in this interpretation of process-based morphology, operate on a pair \{S, M\} consisting of a phonological form (the inflectional base; S) and its morphosyntactic representation (M). The rules manipulate the phonological form (feature change, deletion, affixation, etc.) according to the morphosyntactic representation.

In the case of Tohono O'odham, the pair would consist of the phonological form of the imperfective together with the morphosyntactic representation, containing the specification for perfective. Due to the presence of the perfective specification, the morphological rule would choose to perform deletion on the phonological form resulting in the correct perfective form (3).

(3) Perfective in Tohono O'odham based on (Anderson, 1983):
Rule: \{XC, +perf\} \rightarrow \{X, +perf\}
Example: \{/hihim/, +perf\} \rightarrow \{/hihi/, +perf\}

4.2 Antifaithfulness

4.2.1 Theoretical assumptions

Antifaithfulness theory proposes that the universal grammar contains a set of antifaithfulness constraints alongside the markedness and faithfulness constraints proposed by Optimality Theory (Alderete, 2001). In essence, for every faithfulness constraint F, there is a corresponding antifaithfulness constraint \neg F which is satisfied every time there is a violation of constraint F (Alderete, 2001, p. 210).

Based on the theory of antifaithfulness, (Horwood, 2000) and (Fitzgerald, 1997; Fitzgerald & Fountain, 1995) present Optimality Theory analyses of subtractive morphology. (Horwood, 2000) proposes an anti-faithfulness constraint called \neg Max-Cat, where Cat needs to be specified and can be any category such as vowel, consonant or
The $\neg$Max-$Cat$ constraint is an antifaitfulness constraint dictating that at least one element of the type $Cat$ must be deleted (4). (Fitzgerald & Founatin, 1995) propose a similar constraint, TRUNC, which stipulates that perfective forms must contain fewer segments than the imperfective.

$$\neg$Max-$Cat$: 'Delete at least one element of category $Cat$'

It is not the case that every element of type $Cat$ in $S_1$ has a correspondent element of type $Cat$ in $S_2$.

$$\neg \forall x [x \in \{S_1 \cap Cat\} \Rightarrow \exists y [y \in \{S_2 \cap Cat\} \wedge xRy]]$$

(5) TRUNC: output form must contain fewer segments than input form

The $\neg$Max-$Cat$ constraint allows for more flexibility in stipulating exactly which elements are preferred as targets for deletion, and therefore I choose to use this constraint over TRUNC. As (Horwood, 2000) argues, even though both $\neg$Max-$Cat$ and TRUNC achieve the same results, choosing $\neg$Max-$Cat$ with respect to the correspondence relation between imperfective and perfective leads to a more constrained theory of process based morphology (p. 11). According to (Horwood, 2000), a more constrained theory is needed to avoid the problematic extensions of proposing ad-hoc morpheme-constraints. It must be understood that the $\neg$Max-$Cat$ constraint is morphologically triggered and only applies in Tohono O’odham with respect to the correspondence relation between imperfectives and perfectives.

Alongside antifaitfulness constraints such as $\neg$Max-$Cat$, the universal grammar contains faithfulness constraints such as Max-IO (6), I-Contig (7) and L-Anchor (8). The Max-IO constraint is the unnegated constraint matching the antifaitfulness constraint $\neg$Max-$Cat$ and opposes any deletion. The I-Contig constraint requires indices of input and output segments to match and, therefore, ensures that no changes have occurred word
internally. In the case of subtractive morphology, the I-Contig constraint ensures that no segments are deleted word internally. The L-Anchor constraint gives precedence to the left edge and ensures that, whatever changes occur, the input and output must begin with the same segment.

(6) Max-IO: ‘No deletion’
Input segments must have output correspondents.

(7) I-Contig: ‘No skipping’
The portion of S₁ standing in correspondence forms a contiguous string.
Domain(R) is a single contiguous string in S₁.

(8) L-Anchor: ‘Left edge of input and output must align’
Any element at the left periphery of S₁ has a correspondent at the designated periphery of S₂.
Let $\text{Edge}(X, L) = \text{the element standing at the left edge of } X$.
If $x = \text{Edge}(S₁, L)$ and $y = \text{Edge}(S₂, L)$ then $xRy$.

4.2.2 Analysis
The present analysis is based mainly on the (Horwood, 2000) analysis, but it combines elements from the (Fitzgerald & Fountain, 1995) analysis where necessary. The main facts of Tohono O’odham perfective are that the majority of perfective forms undergo either final C or final VC deletion, with imperfective forms ending in vowels undergoing no deletion or different deletion patterns such as final Ci deletion or final VCV deletion (see section 2.1). As well, few truncated forms co-occur with other inflectional suffixes, but when they do, the segments targeted for deletion are the final segments of the root and not suffix segments (see section 2.1). This is in contrast with subtractive morphology as it applies to complex words and words containing derivational
suffixes, where the segments targeted for deletion are the final segments of the complex word, often part of the derivational suffixes (9).

(9) Complex words (Fitzgerald, 1997, p. 194):

\[
/wakọŋ-a-miŋ/ \rightarrow /wakọŋ-a-m/ \quad \text{‘to go and wash’}
\]

Analysing only the imperfective forms ending in consonant, a constraint \(\neg\text{Max-C}\), “Delete at least one consonant”, is necessary alongside faithfulness constraints ensuring that deletion is minimal. The main faithfulness constraint opposing \(\neg\text{Max-C}\) will be \text{Max-IO}, the constraint against any deletion (6).

In Tohono O’odham, the deletion of segments occurs at the right edge of an inflectional base rather than at the left edge or word internally. In order to account for these facts, two further constraints are necessary for the analysis. The first constraint is I-Contig (7), “No skipping”, which ensures that medial deletion does not occur as the indices between the input and the output would no longer match in that case. The second constraint is L-Anchor (8), which states that the input and output must be aligned at the left edge and therefore ensures that deletion does not occur at the left edge. Between the I-Contig and L-Anchor constraints, deletion in Tohono O’odham is assured to occur at the right edge. The ordering of I-Contig, L-Anchor and Max-IO with respect to each other is not important, as long as \(\neg\text{Max-C}\) is ranked above Max-IO to ensure that deletion does occur. However, I-Contig and L-Anchor could be ranked above \(\neg\text{Max-C}\). Without I-Contig and L-Anchor, any output with at least one segment deleted would be a successful candidate, but in Tohono O’odham deletion does not occur word internally or to the right edge (see Table 4.1).
Some Tohono O'odham imperfectives ending in a consonant undergo final VC deletion rather than final C deletion. According to (Fitzgerald, 1997; Fitzgerald & Fountain, 1995), the imperfectives undergo final VC deletion due to the fact that final C deletion results in ill-formed perfective forms ending in C_Cor_V_hi, which is not permitted. While it is true that perfective forms do not end in coronal consonant plus high vowel, there are two problems with this proposal. The constraint against coronal plus high is not true of the language as a whole and therefore it is possible that the non-occurrence of coronal+high ending perfectives is a coincidence. Furthermore, a few imperfectives such as /hu:paQ/ do undergo final VC deletion even though the result of final C deletion would not ending in a coronal+high (Horwood, 2000, p. 11). These exceptions are very few, however, and many authors such as (Hale, 1965; Hill & Zepeda, 1992) agree that there is some phonological basis for the deletion of the vowel in the case of VC deletion.

In lieu of a more encompassing phonological explanation, I use the phonological constraint against coronal+high ending for perfectives with the stipulation that any forms undergoing VC deletion otherwise must be irregular forms. I am using the constraint proposed by (Fitzgerald & Fountain, 1995), *Cor-Hi, which applies only to perfective verb forms (10). As seen in Table 4.2, *Cor-Hi must be ranked above Max-IO but it is

<table>
<thead>
<tr>
<th>Table 4.1 Tableau: Final C deletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>/hihim\textsubscript{IMPERF}/</td>
</tr>
<tr>
<td>/hihi/</td>
</tr>
<tr>
<td>/hi\textsubscript{im}/</td>
</tr>
<tr>
<td>/ihim/</td>
</tr>
<tr>
<td>/hihim/</td>
</tr>
</tbody>
</table>
irrelevant how it is ranked with respect to $\neg$Max-C. I-Contig must be ranked above Max-IO, but its ranking with respect to $\neg$Max-C is not important.

(10) $*$Cor-Hi: perfective forms cannot end in coronal consonant and high vowel

<table>
<thead>
<tr>
<th>/ciposig/IMPERF/</th>
<th>$\neg$Max-C</th>
<th>*Cor-Hi</th>
<th>I-Contig</th>
<th>Max-IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>/ciposi/</td>
<td></td>
<td>$*$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$/$ciposi/</td>
<td></td>
<td></td>
<td></td>
<td>$*$</td>
</tr>
<tr>
<td>/ciposig/</td>
<td></td>
<td>$*$</td>
<td></td>
<td>$*$</td>
</tr>
</tbody>
</table>

Table 4.2 Tableau: Final VC deletion

In order to account for the behaviour of complex words, like the one in (9), the Max-IO constraint must be specified separately for roots and inflectional affixes (11-12). In the case of inflectional affixes, the deletion does not target the affixes, but rather the inflectional base. In the case of derivational affixes and compounds, the entire word is considered the inflectional base including the derivational affixes (see table 4.3 vs. table 4.4). It is feasible to imagine that languages would want to preserve inflectional affixes as they convey crucial information about aspect, number, tense, etc. In the case of Tohono O’odham, for example, the deletion of the final */-k/ suffix would leave the resulting form unmarked for correlative and therefore no different than the imperfective indicative.

(11) Max-IO_R:\ do not delete from root
(12) Max-IO_Af:\ do not delete from affix (inflection)
Table 4.3 Tableau: Inflectional affix

<table>
<thead>
<tr>
<th>/jūn+kIMPERF/</th>
<th>Max-IOAf</th>
<th>¬Max-C</th>
<th>I-Contig</th>
<th>Max-IO_Ri</th>
</tr>
</thead>
<tbody>
<tr>
<td>/jūn/</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>¬/jūn_k/</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>/jūnk/</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.4 Tableau: Complex word

<table>
<thead>
<tr>
<th>/wakoñ-a-midIMPERF/</th>
<th>Max-IOAf</th>
<th>¬Max-C</th>
<th>I-Contig</th>
<th>Max-IO_Ri</th>
</tr>
</thead>
<tbody>
<tr>
<td>¬/wakoñ-a-m/</td>
<td></td>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>/wak---a-mid/</td>
<td></td>
<td>*!</td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>/wakoñ-a-mid/</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the case of /jūnk/, ¬Max-C must be ranked above I-Contig to prevent the fully faithful candidate /jūnk/ from being the winner. The ordering between I-Contig and Max-IO_Ri is not relevant for the two examples.

While this analysis accounts for the perfective in Tohono O'odham, (McCarthy & Prince, 1995) argue that root faithfulness constraints and affix faithfulness constraints are in a fixed ranking with root faithfulness ranked above affix faithfulness. The analysis presented above contradicts this ranking between root and affix Max-IO constraints. The alternative is to consider the root antifaithfulness constraint, ¬Max-C_Ri (13), along with the general antifaithfulness constraint, ¬Max-C. It is feasible that languages prefer to mark a root/stem through deletion rather than inflectional affixes because deleting segments from affixes could remove key contrasts marking morphological categories. In Tohono O’odham, ¬Max-C_Ri is ranked above ¬Max-C in order to ensure that the segments deleted are always part of a root/stem and never part of an inflectional affix (see tables 4.5 and 4.6).

(13) ¬Max-C_Ri: delete at least one consonant from the root
According to (Fitzgerald & Fountain, 1995), imperfective forms ending in vowels are ‘underrepresented’ and typically act irregularly and often fail to reduplicate (p. 8). There are only two cited examples of vowel-ending imperfectives undergoing final vowel deletion (14), but quite a few more examples of vowel-ending imperfectives not undergoing deletion (15). As well, imperfective forms ending in Ci undergo deletion as well as forms ending in VCV (where VCV is api, oni, V?V or VhV) as seen in section 2.1.

(14) Final V deletion cases (Fitzgerald, 1997; Fitzgerald & Fountain, 1995):

\[
\begin{align*}
\text{/ti:k/} & \rightarrow \text{/ti:/} \\
\text{/hiwa/} & \rightarrow \text{/hiw/}
\end{align*}
\]

‘to drink’

‘to rub against object’

(15) No deletion cases (Horwood, 2000, p. 11):

\[
\begin{align*}
\text{/gagswua/} & \rightarrow \text{/gagswua/} \\
\text{/da\text{"a}da/} & \rightarrow \text{/da\text{"a}da/} \\
\text{/mu:/} & \rightarrow \text{/mu:/} \\
\text{/bia/} & \rightarrow \text{/bia/} \\
\text{/\text{"e}nga/} & \rightarrow \text{/\text{"e}nga/}
\end{align*}
\]

‘to comb’

‘to arrive’

‘to wound by shouting’

‘to dish out food’

‘to own’
There are several possibilities to account for the deletion of forms ending in vowels. One possibility is to consider all vowel-ending imperfectives as irregular verbs since they are few and they tend to act irregularly. This possibility would render the current analysis no worse than alternative concatenative analyses, but with the added bonus of predictions about the various targets for deletion cross-linguistically based on different rankings of constraints.

Another possibility is to consider the cases of no final vowel deletion as irregular and stipulate that the constraint in Tohono O'odham is $\neg\text{Max}-S$, where S represents any segment. However, even in this scenario it is not possible to account for final VCV deletion, only CV deletion perhaps by stipulating a constraint against words ending in /h/, /l/ or /n/. While stipulating such a constraint would not be unfounded as these segments are not permitted as codas in the language in general, the deletion of the remaining final vowel after the CV deletion can still not be explained. Furthermore, there is no phonologically based reason why some imperfectives that end with /Ci/ undergo final CV deletion and others undergo final VCV deletion. As well, final /Ci/ deletion cannot be explained even if perfectives are formed due to an antifidelity constraint demanding final segment deletion rather than final consonant deletion.

The two possible analyses suffer from the same inability to account for /Ci/ and /VCV/ deletion. However, the number of vowel-ending forms that do not undergo deletion is higher than the number of vowel-ending forms that do undergo deletion. Based on that fact as well as the fact that there are really only two forms cited in any source that do undergo final V deletion, I think the initial analysis using $\neg\text{Max}-C$ has more support than the second analysis using $\neg\text{Max}-S$. 
Finally, there are a few cases of /ʊ/ deletion, which appear to be consonant deletion medially and therefore violate I-Contig, but (Hill & Zepeda, 1992) argues that these forms underlyingly end in /ʊ/ and only end in vowels at the surface level (16). If this is the case, these forms do not violate I-Contig, in fact they behave exactly like any other C-final imperfective (table 4.7).

(16) /ʊ/ deletion (Fitzgerald & Fountain, 1995, p. 9):
/huʔa/ → /hua/ ‘to rake together’

Table 4.7 Tableau: /ʊ/ deletion

<table>
<thead>
<tr>
<th>/huaʔ IMPERF/</th>
<th>I-Contig</th>
<th>L-Anchor</th>
<th>~Max-C</th>
<th>Max-IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>/hua/</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>/huʔ/</td>
<td>!</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>/uaʔ/</td>
<td>!</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>/huaʔ/</td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
</tr>
</tbody>
</table>

4.2.3 Discussion

The antifaithfulness analysis accounts for some of the variation in the perfective construction, though it encounters difficulties when trying to account for the cases where the imperfective ends in a vowel. From this point of view, none of the analyses presented, concatenative or non-concatenative, are successful in accounting for all variation in the perfective construction. However, the antifaithfulness analysis does not require non-independently motivated rules or conditions, unlike the concatenative analyses which do. In comparison to an analysis that proposes that the perfective is the base for the imperfective, which would lead to more than 12 suffixes, the antifaithfulness analysis associates only one process with the perfective. As well, the antifaithfulness
analysis, unlike the (Steins, 2000) analysis does not require that the auxiliary be adjacent to the verb, nor does it require a branch level phonology to be introduced.

The antifaithfulness approach does make some predictions about the cross-linguistic variations of subtractive morphology. Because $\neg$Max-Cat is a family of antifaithfulness constraints, which can be specified for either consonant, vowel, syllable or any other phonological constituent, it is possible for different languages to target only vowels for deletion or entire syllables. As well, the fact that $\neg$Max is specified with respect to phonological categories, the analysis predicts that languages tend to delete phonological units rather than any number of segments. While this approach to antifaithfulness leads to a less powerful tool with more restrictions, it also makes substantive distinctions between the kinds of subtractive morphology found across languages and the kinds of subtractive morphology that would never be found in a language.

The interplay between the antifaithfulness constraint $\neg$Max and the faithfulness constraints I-Contig and L-Anchor predicts languages where the deleted segments are either at the beginning or inside the word. Making use of a constraint like $\neg$Max-CRt alongside the general antifaithfulness constraint, $\neg$Max-C, highlights the fact that languages are more likely to care about marking contrasts on a root/stem or not care at all about which segments are targeted for deletion (root or affix). A language like Colloquial Hebrew where parts of the prefix are deleted could be predicted by a higher ranking $\neg$Max constraint and an interplay between L-Anchor, I-Contig and R-Anchor constraints which forces the deletion at the left edge.
The analysis described in section 4.2.2 above provides the basis for exploring, in future work, all of the potential predictions of Antifaithfulness Theory based on the Tohono O'odham perfective. The above cursory look at potential predictions suggests that a process-based theory of morphology can make predictions about the kinds of morphological processes that languages make use of and predictions about which processes are not possible in any language.
REFERENCE LIST


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