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ABSTRACT

This document contains the full texts of six papers that were presented at the Southwest workshop on optimality theory. Papers include the following: "Shuswap Diminutive Reduplication" (Sean Hendricks); "On Multiple Sympathy Candidates in Optimality Theory" (Hidehito Hoshi); "A Perceptually Grounded OT Analysis of Stress-Dependent Harmony" (Tivoli Majors); "Less Stress, Less Pressure, Less Voice" (Mizuki Miyashita); "Causative Formation in Kammu: Prespecified Features and Single Consonant Reduplication" (Kazue Takeda); and "Roots and Correspondence: Denominal Verbs in Modern Hebrew" (Adam Ussishkin). (KFT)

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*Proceedings of*

# The 4th Annual Southwest Workshop on Optimality Theory

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# Proceedings of the 4th Annual Southwest Workshop on Optimality Theory

(SWOT IV)

Edited by
Jessica Maye
and
Mizuki Miyashita

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# PREFACE

This volume contains papers presented at the 4th Annual Southwest Workshop on Optimality Theory (SWOT IV), held at the University of Arizona on April 4-5, 1998. Not included in this volume are papers presented by the following authors: Diana Archangeli (*U AZ*), Dan Karvonen (*UC Santa Cruz*), Sung-a Kim (*UT Austin*), Laura Moll (*U AZ*), Scott Myers (*UT Austin*), Jaye Padgett (*UC Santa Cruz*), Doug Pulleyblank (*UBC*), Donca Steriade (*UCLA*), Bernard Tranel (*UC Irvine*), Jie Zhang (*UCLA*), and Kie Ross Zuraw (*UCLA*).

We would like to thank the following for their support of the conference:

- The Department of Linguistics at the University of British Columbia
- The Department of Linguistics at the University of California, Irvine
- The Department of Linguistics at the University of California, Los Angeles
- The Department of Linguistics at the University of California, Santa Cruz
- The Department of Linguistics at the University of Texas, Austin
- The Department of Linguistics and the Linguistics Circle at the University of Arizona

Special thanks goes to Diana Archangeli, Mike Hammond, and the student volunteers from the University of Arizona, whose efforts made the conference possible.

Finally, we would like to thank the contributors to this long-awaited volume!

Jessica Maye
Mizuki Miyashita



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# Shuswap Diminutive Reduplication

**Sean Hendricks**
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## 1 Introduction

In the language Shuswap (also known as Secwepemc), an Interior Salish language spoken in British Columbia, diminutives are marked by the reduplication of a single consonant (Kuipers 1974). Such patterns of reduplication have been called bare-consonant reduplication (Sloan 1988, Hendricks 1999). Representative data are given below, where the reduplicated consonant appears in underlined boldface:

(1) Diminutive Reduplication

| | | |
|---|---|---|
| (a) | s-qéxe | 'dog' |
| | s-qé-**<u>q</u>**-xe | 'little dog' |
| (b) | péseλk°e | 'lake' |
| | pé-**<u>p</u>**-seλk°e | 'little lake, pond' |
| (c) | cq'-éλp | 'fir tree' |
| | cq'-é-**<u>q</u>**-λp | 'little fir tree' |
| (d) | ṫq°-éws | 'both' |
| | ṫq°-é-**<u>q°</u>**-ws | 'companion' |

This type of reduplication also applies to some cases of first-person marking, as shown in (2):

(2) First-Person Reduplication

| | | |
|---|---|---|
| (a) | kəpqín | 'her head aches' |
| | kəpqí-**<u>q</u>**-n-kn | 'my head aches' |
| (b) | kícx | 'arrive' |
| | kí-**<u>k</u>**-cx-kn | 'I arrive' |
| (c) | cítx° | 'house' |
| | γ-n-cí-**<u>c</u>**-tx° | 'my house' |
| (d) | txíẃpm | 'trim horse's tail' |
| | txí-**<u>x</u>**-ẃpm | |



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There are a number of generalizations that can be made regarding this data. These generalizations are given in (3):

(3) Generalizations

(a) The reduplicant is infixed after the stressed vowel.
(b) The reduplicant matches the consonant before the stressed vowel.
(c) The reduplicant is a single consonant. Sometimes this single consonant surfaces as a coda, sometimes as an onset (*sqé<u>q</u>.xe*, but *t̓q°é.<u>q°</u>ws*)

The following sections provide an analysis which accounts for the generalizations in (3).

## 2 Analysis of Shuswap Reduplication

### 2.1. Placement of the reduplicant

The first generalization that I account for is that given in (3)(a). Since the reduplicant is an infix, the reduplicant is placed within the root. More specifically, the reduplicant is placed within the root to the right of the stressed vowel of the root, regardless of the location of the stressed vowel. I follow McCarthy & Prince (1993b) in proposing that this placement can be accounted for by constraints defined under Generalized Alignment. I propose, therefore, that the placement of the reduplicant is determined by the following constraint:

(4) ALIGN-RED-V́ (Based on McCarthy & Prince 1993b)

Align (RED, L, V́, R)
Align the left edge of the reduplicant with the right edge of the stressed vowel.[1]

This constraint ensures that the reduplicant will be placed to the right of the stressed vowel. The following tableau illustrates this interaction:

[1] Bird (to appear) presents a similar constraint for reduplication in Stl'atl'imcets, another Salish language, but defines the alignment in terms of the stressed mora, not the vowel. In this paper, the distinction is not crucial.

(5) Infixation:

| /RED, péseλk°e/ | ALIGN-RED- v́ |
|---|---|
| ☞ a. pé-**p**-seλk°e | |
| b. p-**p**-éseλk°e | é! |
| c. **p**-péseλk°e | pé |

In the above tableau, candidate (a) is chosen, as it satisfies ALIGN-RED- v́. Candidates (b) and (c) show that attempts to place the reduplicant elsewhere incur violations of ALIGN-RED- v́. Therefore, the placement of the reduplicant is accounted for by the constraint presented above.

## 2.2. Edge-matching of the reduplicant

The next condition on the reduplicant that I examine is the correspondence between the root and the reduplicant. The generalization is that the reduplicant matches the consonant directly preceding the vowel. This aspect of reduplicant identity falls under the category of the ANCHOR schema (McCarthy & Prince 1995), defined below:

(6) {RIGHT, LEFT}-ANCHOR($S_1$, $S_2$)

Any element at the designated periphery of $S_1$ has a correspondent at the designated periphery of $S_2$.

This constraint is satisfied when in a particular correspondence relation, any element at one edge of one string in the relation has a corresponding element at that same edge of the other string in the relation. In order to use such a constraint, it is necessary to determine the unit to which the reduplicant corresponds for such constraints. Under the Correspondence model, shown below, the reduplicant may either correspond to the input stem, or to the base:

(7) Modeled after McCarthy & Prince (1995)

Input: /AfRED + Stem/
*I-R Faithfulness* ⇅ *I-O Faithfulness*
Output: R ⇆ B
*B-R Identity*

Clearly, it is not the input root that serves as the corresponding unit, since the reduplicant does not consistently surface as a copy of either the initial segment or the final segment of the input root. For example,

(8) Root Edge-Matching

(a) s-[qé-**q**-xe]$_{Root}$
(b) [pé-**p**-seλk°e]$_{Root}$
(c) [kí-**k**-cx]$_{Root}$-kn
(d) γ-n-[cí-**c**-tx°]$_{Root}$

but

(e) [cq']$_{Root}$-é-**q**-λp

As shown in (8), the reduplicant in (a)-(d) surfaces as a copy of initial consonant of the input root, but in (e), the reduplicant surfaces as a copy of the final consonant of the input root. Therefore, the reduplicant does not correspond to the input root.

Does the reduplicant correspond to the input stem? McCarthy & Prince (1995) define the stem as a "morphologically-defined input construct". It is not clear from this definition what constitutes a stem, but clearly, the stem is somehow defined over the input. As discussed in Urbanczyk (1996) and Bird & Hendricks (in prep.), the reduplicant in Salish languages such as Lushootseed, Stl'atl'imcets and Shuswap must correspond to a unit that is defined at the output level, not the input. The main reason for this is that the reduplicant matches the consonant that precedes the stressed vowel. Stress is predictable in Shuswap, and therefore, not marked in the input. By virtue of these facts, the reduplicant does not correspond to the input stem, regardless of the definition of stem.

Therefore, the first parameter of ANCHOR is not part of the input, which leaves the possibility of the output base. If it is then the base, then it remains to define the base. Obviously, the base cannot be the root, for the same reasons as above. As discussed in previous chapters, there have been two different ways of defining the base in the literature. One definition is that the base is the "output of the input stem." However, since the base must be defined at the output level, there cannot be an input stem that corresponds with the base. Therefore, I will not consider this definition. Another definition of the base is the following:

(9) Base-Affixation Adjacency (after McCarthy & Prince (1993a))

"In any output candidate, the Base comprises the *morphologically-specified* phonological material that immediately precedes [or follows] the exponent of the...morpheme."

As discussed in Urbanczyk (1996) and Bird & Hendricks (in prep.), this definition can determine one edge of the base.

Since the reduplicant always follows the stressed vowel, then the right edge of the base is the stressed vowel, as shown below:

(10) Right Edge of the Base

(a) s-qé]-**q**-xe
(b) pé]-**p**-seλk°e
(c) kí]-**k**-cx-kn
(d) γ-n-cí]-**c**-tx°$_{Root}$
(e) cq'-é]-**q**-λp

As the diagrams in (10) show, the right edge of the base is at the stressed vowel. As for the other edge of the base, it is clear that the left edge of the base must be the consonant preceding the stressed vowel. Therefore, the domain that delimits the base begins at the consonant preceding the stressed vowel, and ends at the stressed vowel.

Another possible base for reduplication is then the stressed syllable. Taking this definition of the base into consideration[2], then the appropriate constraint would be LEFT-ANCHOR$_{BR}$. The following tableau illustrates this (I assume that the reduplicant is only a single segment):

(11) Anchoring to the Stressed Syllable

| /RED, péseλk°e/ | LEFT-ANCHOR$_{BR}$ | ALIGN-RED-V́ |
|---|---|---|
| ☞ a. [pé]$_{BR}$[**p**]seλk°e | | |
| b. [pé]$_{BR}$[**k°**]seλk°e | *! | |

As tableau (11) shows, the reduplicant must be anchored to a base, which is defined as the stressed syllable.

However, the data in (a), (d), and (e) show that the reduplicant does not seem to anchor to the leftmost onset of the stressed syllable, although it does anchor to the onset of the stressed syllable closest to the mora. The following tableau illustrates:

(12) Exception to Leftward Anchoring

| /RED, sqéxe / | LEFT-ANCHOR$_{BR}$ | ALIGN-RED-V́ |
|---|---|---|
| ☞ a. [sqé]$_{BR}$[**q**]xe | *! | |
| ❽ b.[sqé]$_{BR}$[s]xe | | |

In tableau (12), candidate (b) is incorrectly chosen as optimal, as it satisfies LEFT-ANCHOR$_{BR}$, while the correct surface form (a) is eliminated by that constraint.

[2] For further discussion of how bases for affixation are defined in OT, see Urbanczyk (1996) and Bird & Hendricks (in prep.)



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The selection of (12)(b) over (12)(a) assumes that the stressed syllable that forms the base for reduplication is actually the sequence [sqé]. As discussed, though, the reduplicant is always the consonant directly preceding the stressed vowel. If it is possible to characterize the CV sequence as a single prosodic unit, then it is possible to characterize the base for reduplication as that unit, avoiding the anchoring problems shown in (12).

I propose that this is possible, based upon work by Bagemihl (1991)[3]. In Bagemihl (1991), peripheral consonants in an apparent consonant cluster are often not part of the same prosodic unit as the nucleus, but are moraically licensed segments of their own. This move allows one to isolate the nucleus and an immediately preceding consonant as a single prosodic unit, namely a syllable. The structure of this is shown below:

(13) Moraically Licensed Peripheral Consonants (following Bagemihl (1991))


In a structure such as that in (13), only the consonant immediately preceding the nucleus is parsed as the onset of the syllable.

This type of structure is proposed based on proposals made by Bagemihl (1991), in which such onsets are proposed for Bella Coola, another Salishan language. The data that form the basis of his proposal are illustrated by the following examples:

(14) Bella Coola (Bagemihl 1991)

| | | |
|---|---|---|
| p'ła– | p'**ła**ła– | 'wink, bat the eyes/contin.' |
| tqn̩k – | t**qn**qn̩k – | 'be under/underwear' |
| st'$q^w$lus | st**$q^w$l**$q^w$lus–i | 'black bear snare' |

As shown in (14), this reduplicative pattern is characterized by the copy of a vowel and the immediately preceding consonant. This pattern is very similar to the pattern in Shuswap, although in Bella Coola, two segments are reduplicated. If the peripheral consonants in the Bella Coola forms are not parsed as part of the same syllable as the nucleus and immediately preceding consonant, then the reduplicant can anchor to the syllable.

[3] Shaw (1993) also proposes that the CV structure of a syllable with an onset consonant cluster is prosodically independent from other consonants of an onset cluster.

Due to the similarity in the pattern, and the genetic relationship between Shuswap and Bella Coola, I propose a similar characterization of the base in Shuswap. This allows the constraint LEFT-ANCHOR$_{BR}$ to be satisfied in cases like *sqéqxe*, as shown in the following tableau:

(15) Anchoring to the Stressed Syllable Revisited

| /RED, sqéxe / | LEFT-ANCHOR$_{BR}$ | ALIGN-RED-v́ |
|---|---|---|
| ☞ a. s.[qé]$_{BR}$[q].xe | | |
| b. s.[qé]$_{BR}$[s].xe | *! | |

As shown in (15), if the peripheral consonant is not parsed as part of the stressed syllable, then the reduplicant satisfies LEFT-ANCHOR$_{BR}$, while candidate (b) is eliminated by that constraint.

Therefore, the identity of the reduplicant is accounted for by the use of the ANCHOR schema evaluated over base-reduplicant correspondence. This base-reduplicant correspondence requires that the base be delineated as the stressed syllable. Also, this characterization of the stressed syllable relies upon extraprosodicity of peripheral consonants. In the next section, I account for the shape of the reduplicant, which is a single C. After all, the constraints proposed so far do not select between *sqéqxe* and **sqéqexe*.

### 2.2.1. *Shape of the reduplicant*

The third generalization regarding the reduplicant is the requirement that it be of the shape C, a single consonant. The shape of reduplicants in reduplicative theory has been accounted for by the application of a template constraint, such as that defined below:

(16) Template constraints (McCarthy & Prince 1993a):

Mcat = PCat

where Mcat ≡ Morphological Category ≡ Prefix, Suffix, RED, Root, Stem, LexWd, etc.

and PCat ≡ Prosodic Category ≡ Mora, Syllable (type), Foot (type), PrWd (type), etc.

Such constraints require that a morphological category such as RED must be mapped directly to a prosodic unit; no more, no less.

In this paper, the shape of the reduplicant will be accounted for without the use of a template constraint. In the case of Shuswap diminutive reduplication, the reduplicant is a single consonant which is either an onset or a coda, as



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discussed above. Therefore, the reduplicant does not surface in a consistent structural role, and sometimes as an onset, which is not a canonical prosodic unit.[4]

The following tableau illustrates the evaluation of *sqéqxe* without restrictions upon the shape of the reduplicant:

(17) Shape of the Reduplicant I

| /RED, sqéxe / | LEFT-ANCHOR$_{BR}$ | ALIGN-RED-$\acute{V}$ |
|---|---|---|
| ☞ a. s.[qé]$_{BR}$[**q**].xe | | |
| ❽ b. s.[qé]$_{BR}$[**qe**].xe | | |

As tableau (17) shows, both candidates are chosen as viable candidates. In candidate (a), the reduplicant surfaces as a single consonant of the base, which is the correct surface form. However, candidate (b) surfaces as a full copy of the base, which satisfies the constraint ranking equally with (a).

In Hendricks (1999), it is proposed that the size of a reduplicant surfaces minimally in order to allow root alignment or alignment of other affixes to be maximally satisfied (this is referred to as the compression model). In this case, the reduplicant does not surface between morphemes, but inside either a root, as in *s-qé-**q**-xe*, or inside another affix, as in *cq'-é-**q**-λp*. Therefore, the minimal size of the reduplicant cannot be driven by the maximization of the alignment constraints of other morphemes.

However, the reduplicant can be seen as interrupting the root. In McCarthy & Prince (1995), a constraint is proposed which is violated by such interrupting material. This constraint is O-CONTIG, defined below:

(18) O-CONTIG (adapted from McCarthy & Prince 1995)

The portion of the output standing in correspondence forms a contiguous substring.

This constraint requires that material not be placed within a morpheme, as such intrusive material disrupts the contiguity of an output string.[5]

One may say that the bare-C reduplicant minimally violates O-CONTIG, while any further reduplication would serve to incur further violations of the contiguity of an output string corresponding to an input string. Thus, the limitation of the reduplicant to a single consonant is driven by the need to minimally violate contiguity. The following tableau illustrates the contiguity

[4] This move is consistent with current work in prosodic morphology in OT (Hendricks 1999; Walker 1999; McCarthy & Prince 1997, Carlson 1997; Spaelti 1997), in which the shape of the reduplicant is determined by alignment, faithfulness, and markedness constraints.
[5] A similar analysis is proposed by Coelho (1999) for Thompson River Salish, using output-output correspondence.

analysis:

(19) Contiguity and Shape

| /RED, sqéxe / | LEFT-ANCHOR$_{BR}$ | ALIGN-RED-v́ | O-CONTIG |
|---|---|---|---|
| ☞ a. s.[qé]$_{BR}$[**q**].xe | | | q |
| b. s.[qé]$_{BR}$[**qe**].xe | | | qe! |
| c. s. $_{R}$[**qé**].[qe]$_{B}$.xe | | * | |
| ❽ d. s.[qé]$_{B}$.xe | | | |

In the above tableau, candidate (d) is incorrectly chosen as optimal, as it vacuously satisfies all relevant constraints, as there is no reduplicant at all. In order to ensure that the reduplicant surfaces with some material, there must be a constraint that requires that all morphemes in the input be represented with distinct material in the output. Several constraints of this type have been proposed in the literature (EXPONENCE (Hendricks 1999); REALIZE MORPHEME (Gnanadesikan); MORPHDIS (McCarthy & Prince 1993)).

In this analysis, I represent such concerns with the constraint EXPONENCE, defined below.

(20) EXPONENCE
An input morpheme corresponds to some structure in the output.

The following tableau illustrates:

(21) Contiguity and Shape II

| /RED, sqéxe / | EXPONENCE | LEFT-ANCHOR$_{BR}$ | ALIGN-RED-v́ | O-CONTIG |
|---|---|---|---|---|
| ☞ a. s.[qé]$_{BR}$[**q**].xe | | | | q |
| b. s.[qé]$_{BR}$[**qe**].xe | | | | qe! |
| c. s. $_{R}$[**qé**].[qe]$_{B}$.xe | | | * | |
| d. s.[qé]$_{B}$.xe | *! | | | |

In tableau (21), candidate (a) is chosen, even though it violates O-CONTIG, as the reduplicant must be minimally represented. Candidate (c) shows that an attempt to satisfy O-CONTIG by prefixing the reduplicant violates higher-ranked constraints. Candidate (b) shows that if more of the base is copied into the reduplicant, then fatal violations of O-CONTIG are incurred. Candidate (d), the null candidate, is eliminated by EXPONENCE, as the input morpheme RED does not have a surface exponent.



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### 2.2.2. *Shuswap Bare-Consonant Reduplication: Summary*

In this paper, I have provided an account of the bare-consonant reduplicant in Shuswap. The placement of the reduplicant is based upon alignment with a stressed syllable. The identity of the reduplicant is based upon anchoring to the stressed syllable and extraprosodicity of peripheral consonants. The shape of the reduplicant is minimally a consonant, in order to maximally satisfy both exponence and O-CONTIG. Shuswap reduplication is accounted for without the use of a prosodic template constraint.

This non-templatic account is advantageous, as it avoids the problems with the non-uniform prosody of the reduplicant. In some cases, the reduplicant is the coda of the stressed syllable, and sometimes the reduplicant surfaces as the onset of the following syllable. The following figures illustrate:

(22) Structural Role of the Reduplicant


'little dog' 'companion'

A single prosodic template cannot capture this phenomenon.

When the reduplicant surfaces as a coda, it fits the category of mora, which is a prosodic unit. Therefore a constraint such as RED=Mora would be satisfied by the reduplicant. However, when the reduplicant surfaces as an onset, the reduplicant is not in a moraic position, and does not satisfy RED=Mora. In fact, as an onset, the reduplicant is not a prosodic unit at all. The analysis presented in this paper accounts for the shape of the Shuswap reduplicant by contiguity, rendering the prosodic categorization of the reduplicant irrelevant.

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# On Multiple Sympathy Candidates in Optimality Theory*

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## 1 Introduction

McCarthy (1997, 1998) argues, on the basis of data from Tiberian Hebrew, that Optimality Theory (OT) (Prince and Smolensky 1993, among others) can allow a failed candidate to affect the choice of the actual output: faithfulness relation between the failed candidate and possible candidates is crucial to determining the actual output. Following McCarthy, let us call the failed candidate a "sympathy" candidate (= ❁-ed candidate). He claims that in addition to ordinary IO-Faithfulness constraint, there is a new type of Faithfulness constraint called "Sympathy"-Output Faithfulness (= ❁O-Faithfulness) constraint, which requires that the actual output must be identical with the ❁-ed candidate.[1] Furthermore, McCarthy suggests that (i) some designated IO-Faithfulness constraint be chosen as the "selector" (= C❁), which is relevant to the algorithm for determining the ❁-ed candidate, and that (ii) the ❁-ed candidate obey C❁ that the actual output violates (McCarthy 1997).[2]

In this paper I will pursue the possibility that the notion of sympathy can shed some light on phonological "opacity" (Kiparsky 1971, 1973), assuming that the ideas suggested by McCarthy are basically on the right track. However, even if so, some non-trivial questions arise immediately as to the basic assumptions of sympathy: how can we choose a particular IO-Faith constraint as C❁ to determine the ❁-ed candidate? Why is it that C❁ is restricted to the IO-Faith family of constraints which the actual output violates? Is it the case that the number of ❁-ed candidates is limited to only one? Are "multiple ❁-ed candidates" allowed if every IO-Faith constraint potentially serves as C❁?

I will suggest that every IO-Faith constraint can serve as C❁ regardless of whether or not the actual output violates it. I will argue that "multiple ❁-ed candidates" should be allowed in OT once we assume that every IO-Faith constraint serves as C❁, demonstrating that "multiple ❁-ed candidates" are empirically motivated in certain vocalic alternations in Yawelmani, where various opacity effects are created by the interaction among the vocalic alternations.

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* I am very grateful to Bernard Tranel and Moira Yip for their valuable comments and discussions.

[1] Note that this analysis enables us to say that the ❁-ed candidate can play the role of something like "intermediate stages", although it is not necessarily the same as the "intermediate stage" postulated in rule-based generative phonology. See the discussion in section 4.

[2] In section 3.2 we will discuss the mechanism of sympathy in detail.

Furthermore, I will claim that language variations with respect to opacity effects can be captured by the re-ranking of ❁O-Faith constraints.[3]

The organization of this paper is as follows. In section 2, we deal with basic facts about vocalic alternations in Yawelmani. In section 3, we provide an OT analysis for the vocalic alternations in Yawelmani and demonstrate that the notion of sympathy is indispensable to explain complicated opacity effects generated by counter-bleeding. In section 4, we propose that more than one ❁-ed candidate play very crucial roles in opacity effects in Yawelmani vocalic alternations, suggesting that every language potentially has multiple ❁-ed candidates. Section 5 states some concluding remarks.

## 2 Vocalic Alternations in Yawelmani: Basic Facts

First of all, let us consider the following examples involving Vowel Harmony (VH), Vowel Lowering (VL) and Vowel Shortening (VS) and examine how they interact with one another to create opacity effects. Following Kenstowicz and Kisseberth (1979), I assume that the rule ordering is specified as follows: after VH, VL occurs. VS takes place after VL.[4,5]

In VH, if the vowels [u] and [o] precede the vowels [i] and [a], respectively, [i] becomes [u] and [a] becomes [o]. (1a) illustrates VH with the high vowel [u]. (1b) indicates that vowels participating in VH must be the same with respect to vowel height. This is what I call the "monotonicity" effect (cf. Cole and Kisseberth 1995).

In VL, long [u:] and [i:] become long [o:] and [e:], respectively. Notice that in (1a), just looking at the relation between the input (= UR) and the output, VH should not apply due to the monotonicity effect, but actually it does. This is a case of counter-bleeding. On the other hand, in (1b), judging from the relation between the input and the output, VH should be expected since both of the vowels relevant to round harmony are [-high] vowels, but VH does not occur. This is a case of counter-feeding.

[3] For more detailed discussion on opacity effects in Yawelmani and the analysis of the multiple sympathy candidates, see Hoshi 1998.

[4] See also Archangeli 1985, Kuroda 1967 and Newman 1944.

[5] The vowel inventory of Yawelmani is assumed to be as follows:

| | i | e | a | o | u |
|---|---|---|---|---|---|
| high | + | – | – | – | + |
| low | – | – | + | + | – |
| round | – | – | – | + | + |
| back | – | – | + | + | + |

(1) VH & VL:

a. (counter-bleeding)

| | | |
|---|---|---|
| UR: | /ʔu:t'-it/ | |
| VH: i → u /u___ | ʔu:t'-**ut** | |
| VL: u: → o: | ʔ**o:**t'-**ut** | 'steal' (passive aorist) |

b. (counter-feeding)

| | | |
|---|---|---|
| UR: | /ʔu:t'-ʔas/ | |
| VH: a → o/o___ | ------------ | |
| VL: u: → o: | ʔ**o**:t'-ʔas | 'steal' (predicative gerundial) |

As indicated in (2), VS, which applies after VL, makes long vowels short in closed syllables. Interestingly enough, the example in (2) shows both cases of opacity: VL should not be expected because of VS (= counter-bleeding) while VH should occur because the domain of round harmony is monotonic with respect to vowel height, in this case [-high] (= counter-feeding).

(2) VL & VS: (counter-feeding & counter-bleeding)

| | | |
|---|---|---|
| UR: | /bok'-i:n/ | |
| VH: i → u/u___ | ----------- | |
| VL: i: → e: | bok'-**e**:n | |
| VS: V: → V/___C]$_\sigma$ | bok'-**en** | 'will find' |

(3) is also a case of counter-bleeding. The difference between (2) and (3) is that in (2) VH does not apply due to the monotonicity effects while in (3) it does.

(3) VH & VL & VS: (counter-bleeding)

| | | |
|---|---|---|
| UR: | /dub-i:n/ | |
| VH: i → u/u ___ | dub-**u:**n | |
| VL: u: → o: | dub-**o:**n | |
| VS: V: → V/___C]$_\sigma$ | dub-**on** | 'will lead by the hand' |

## 3 Opacity Effects and Sympathy in Yawelmani

### 3.1 Constraints & Canonical Examples

In this section we will see how the above opacity effects can be captured within the framework of OT. As a first approximation, let us assume that the constraints in (4) are relevant to vocalic alternations in Yawelmani. Among Phono-Constraints, *HIGHLONG, $*[\mu\mu\mu]_\sigma$ and MONO are undominated.[6]

(4) i. Phono-Constraints:

a. *HIGHLONG: Long vowels with [+hi] are prohibited. (Lubowicz 1997)

b. $*[\mu\mu\mu]_\sigma$: Trimoraic syllables are prohibited.

c. MONO: The domain of round harmony in the output must be monotonic with respect to [± high] (cf. Cole & Kisseberth 1995)

d. ALIGN [+rd]: The [+rd] feature aligns with the right edge of the word. (Prince & Smolensky 1993, McCarthy & Prince 1993a, 1993b, Pulleyblank 1993, 1996)

ii. Faithfulness Constraints:

a. IDENT-IO (hi): [hi] feature in input and output must be identical in corresponding segments.

b. IDENT-IO (rd): [rd] feature in input and output must be identical in corresponding segments.

c. MAX-IO (μ): Deletion of μ is prohibited.

Given the above relevant constraints, let us examine the tableaux in (5i-v). The following canonical examples of vocalic alternations clearly indicate how the constraints work and how they are ranked.

In (5i), *HIGHLONG and MAX-IO (μ) are more dominant than IDENT-IO (hi), and thus the candidate (5ia) is correctly chosen as optimal, excluding both (5ib) and (5ic).

(5) i. Vowel Lowering (VL): *HIGHLONG, MAX-IO (μ) >> IDENT-IO (hi)

| /i:/ /u:/ | *HIGHLONG | MAX-IO (μ) | IDENT-IO (hi) |
|---|---|---|---|
| a. ☞ e: o: | | | * |
| b. i: u: | *! | | |
| c. i u | | *! | |

(5ii) demonstrates that VS is derived from the constraint-ranking $*[\mu\mu\mu]_\sigma$ >> MAX-IO (μ). The candidate (5iib) violates undominated $*[\mu\mu\mu]_\sigma$ and thus it is ruled out. Therefore, (5iia), which satisfies $*[\mu\mu\mu]_\sigma$, is chosen as the optimal candidate.

ii. Vowel Shortening (VS): $*[\mu\mu\mu]_\sigma$ >> MAX-IO (μ)

*sap-hin* 'burn' (non-future)

[6] However, later we will see that MONO is dominated by a "sympathy" constraint.



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| /sa:p-hin/ | $*[\mu\mu\mu]_\sigma$ | MAX-IO (μ) |
|---|---|---|
| a. ☞ sap.-hin. | | * |
| b. sa:p.-hin. | *! | |

(5iii) shows that VH is induced by the constraint ranking ALIGN [+rd] >> IDENT-IO (rd). Since (5iiia) respects ALIGN [+rd], it is chosen as optimal.

iii. Vowel Harmony (VH): ALIGN [+rd] >> IDENT-IO (rd)
*dub-hun* 'leads by the hand' (non-future)

| /dub-hin/ | ALIGN [+rd] | IDENT-IO (rd) |
|---|---|---|
| a. ☞ dub-hun | | * |
| b. dub-hin | *! | |

However, as we mentioned before, it is not necessarily the case that VH always occurs. MONO has to dominate ALIGN [+rd], otherwise VH would always apply, contrary to fact. The monotonicity effect can be captured by the constraint hierarchy MONO >> ALIGN [+rd]. (5iva) is selected as the optimal candidate because it satisfies MONO. In contrast, (5ivb) violates MONO because of VH and thus it is correctly excluded.

iv. Monotonicity Effect: MONO >> ALIGN [+rd]
*dub-al* 'might lead by the hand'

| /dub-al/ | MONO | ALIGN [+rd] |
|---|---|---|
| a. ☞ dub-al | | * |
| b. dub-**ol** | *! | |

(5v) shows that vowel height cannot be changed freely to satisfy the requirements of both monotonicity and the alignment condition. Assume that IDENT-IO (hi) dominates ALIGN [+rd]. Then, (5va), which satisfies both IDENT-IO (hi) and MONO, is selected as the optimal output.

v. Restriction on vowel height alternation: IDENT-IO (hi) >> ALIGN [+rd]

| /dub-al/ | IDENT-IO (hi) | MONO | ALIGN [+rd] |
|---|---|---|---|
| a. ☞ dub-al | | | * |
| b. dub-**ol** | | *! | |
| c. d**o**b-**ol** | *! | | |
| d. dub-**ul** | *! | | |

Given the above basic facts, we tentatively assume here that the relevant constraint ranking for Yawelmani vocalic alternations is represented as in (6):

(6) *HIGHLONG  *[μμμ]$_{\sigma}$

MAX-IO (μ)

IDENT-IO (hi)  MONO

ALIGN [+rd]

IDENT-IO (rd)

Keeping this in mind, let us first examine examples with one of the cases of opacity, namely, counter-bleeding, which clearly shows that the basic OT analysis cannot straightforwardly capture the opacity of counter-bleeding interactions.

### 3.2 Counter-Bleeding and Sympathy

Consider the following example of counter-bleeding (1a). Examine the tableau (7). If the constraint rankings are as in (6), we would wrongly predict that the output is (7a), which does not undergo round harmony, but satisfies MONO (the candidate wrongly chosen as optimal is indicated by ❸):

(7) tableau based on the constraint-ranking in (6): wrong result[7]
*HIGHLONG >> IDENT-IO (hi), MONO >> ALIGN [+rd]

| /ʔu:t'-it/ | IDENT-IO (hi) | MONO | ALIGN [+rd] |
|---|---|---|---|
| a. ❸ ʔo:t'-it | * | | * |
| b. (☞) ʔo:t'-ut | * | *! | |

In (7), the actual output (7b) violates MONO, and is wrongly excluded. Since the canonical examples (5iv) and (5v) definitely show that MONO is higher-ranked than ALIGN [+rd], we cannot resort to any re-ranking of the constraint hierarchy given in (6) to obtain the right result for (7). So, the question is how we can capture the opacity example as well as the simple canonical examples on the basis of the constraint hierarchy given in (6).

In what follows, we will demonstrate that the notion of sympathy can straightforwardly save the correct output in (7). Following McCarthy (1997, 1998), as in Tiberian Hebrew, IO-Faith constraints can serve as C❀. In particular,

[7] Here I ignore the candidates [ʔu:t'-it] and [ʔu:t'-ut], both of which violate undominated *HIGHLONG.

it seems reasonable to assume that in Yawelmani IDENT-IO (hi) is responsible for determining the ❁-ed candidate. Since the vowel [u] triggering round harmony in the input in (1a) is [+hi] and the harmony domain is monotonic with respect to [+hi], the ❁-ed candidate must be a candidate that preserves this height feature, i.e., a candidate that observes IDENT-IO (hi).[8] Before turning to the tableau incorporating the sympathy account, let us explain how a ❁-ed candidate is determined among reasonable candidates generated by GEN. The definition of a ❁-ed candidate is given in (8) (Ito & Mester 1997a):

(8) Given a constraint hierarchy $[C_1 >> \ldots C_i >> C^{\circledast} >> C_j >> \ldots C_n]$, the sympathy candidate selected under $C^{\circledast}$ is the candidate that, among the candidates best-satisfying $C^{\circledast}$, best satisfies $[C_1 >> \ldots C_i >> C_j >> \ldots C_n]$ (i.e., the remainder of the constraint hierarchy).

To put it simply, to be qualified as a ❁-ed candidate, first, candidates have to satisfy $C^{\circledast}$. Then, among the candidates satisfying $C^{\circledast}$, the most harmonic one is selected as the ❁-ed candidate. Now let us consider the tableau (9).[9] (9b) is selected as the sympathy candidate since (9b), satisfying IDENT-IO (hi), is more harmonic than (9a), which violates ALIGN [+rd].

(9) tableau for ❁-ed candidate: $C^{\circledast}$ = IDENT-IO (hi)

| | /ʔu:t'-it/ | IDENT-IO (hi)❁ | ALIGN [+rd] |
|---|---|---|---|
| a. | ʔut'-it | | *! |
| b. ❁ | ʔut'-ut | | |

Following Ito & Mester (1997b), we assume that ❁O-Faith constraints can be feature-specific like ordinary IO-Faith constraints. I claim here that the [rd] feature is relevant to the ❁O Faith constraint. More specifically, to obtain the right result, I assume that the relevant ❁O Faith constraint is IDENT-❁O (rd).[10] Let us further assume that IDENT-❁O (rd) has to dominate MONO because as we saw in tableau (7), the actual output crucially violates MONO. Therefore, IDENT-❁O (rd) can circumvent the effect of MONO.

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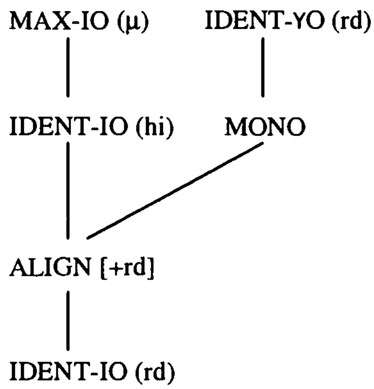
8 See McCarthy 1998, where it is also claimed that IDENT-IO (hi) can be $C^{\circledast}$ in Yawelmani.

9 For ease of reference, one tableau is divided into two: one tableau is for selecting the ❁-ed candidate and the other tableau is for selecting the actual output. Dividing one tableau into two does not mean that calculation of both the ❁-ed candidate and the actual output takes place separately.

10 A natural question arises as to why the (rd) feature is chosen as the relevant feature. The reason might be the following: round harmony has to apply to the input, creating an "intermediate stage" and thus roundness of the "intermediate stage" crucially affects the actual output. Since the ❁-ed candidate roughly corresponds to the "intermediate stage", the (rd) feature of the ❁-ed candidate is regarded as the relevant one for the ❁o-Faith constraint.

(10)




Given these assumptions, examine (11). In (11), although the candidate (11c) violates MONO, (11c) wins over (11b) because (11c) satisfies IDENT-❀O (rd): (11c) has a [+round] suffix vowel and the ❀-ed candidate also has a [+round] suffix vowel. However, (11b) violates it because it has a [-round] suffix vowel [i]:

(11) tableau for the actual output:[11]

| | /ʔu:t'-it/ | MAX-IO (μ) | IDENT-❀O (rd) | MONO |
|---|---|---|---|---|
| a. ❀ | ʔut'-ut | *! | | |
| b. | ʔo:t'-it | | *! | |
| c. ☞ | ʔo:t'-ut | | | * |

Therefore, we can conclude that the sympathy account can correctly capture the opacity interaction between VH and VL.

### 3.3 Is IDENT-IO (hi) the only Selector?

So far we have claimed that IDENT-IO (hi) is regarded as C❀ to choose the ❀-ed candidates. A question arises here as to whether or not IDENT-IO (hi) is the only selector for a ❀-ed candidate. In this subsection, we will demonstrate that this is not the case. More specifically, we will argue that MAX-IO (μ) can also be a relevant C❀ to determine a ❀-ed candidate.

Before turning to the example in (2), let us consider for the moment the following example in (12), where unlike the example in (2), VH is totally irrelevant:

[11] Here I ignore the candidate [ʔu:t'-ut] as a possible ❀-ed candidate since it violates the undominated Phono-Constraint *HIGHLONG.

(12) UR: /xat-i:n/
VL: i: → e: xat-e:n
VS: V: → V/___C]$_\sigma$ xat-en 'will eat'

The following tableau (13) shows that the candidate in (13c) would be wrongly selected as optimal without a ✿-ed candidate because it obeys IDENT-IO (hi) in contrast to the actual output (13d):

(13) tableau without ✿-ed candidates: wrong result

| /xat-i:n/ | *[μμμ]$_\sigma$ | *HIGHLONG | MAX-IO (μ) | IDENT-IO (hi) |
|---|---|---|---|---|
| a. xat-i:n | *(!) | *(!) | | |
| b. xat-e:n | *! | | | * |
| c. ❽ xat-in | | | * | |
| d. ☞ xat-en | | | * | *! |

However, in (13), if IDENT-IO (hi) is still C$^{✿}$, we cannot capture the fact that (13d) is the actual output. Look at the tableau (14), which selects the ✿-ed candidate. Since (14b) obeys not only IDENT-IO (hi) but also *[μμμ]$_\sigma$, it is selected as the ✿-ed candidate.

(14) tableau for the ✿-ed candidate:
C$^{✿}$ = IDENT-IO (hi)

| /xat-i:n/ | *[μμμ]$_\sigma$ | MAX-IO (μ) | IDENT-IO (hi)$^{✿}$ |
|---|---|---|---|
| a. xat-i:n | *! | | |
| b. ✿ xat-in | | * | |

Next, look at the tableau (15) for the actual output. The actual output (15d) satisfies IDENT-✿O (rd) since (15d) has a [-round] suffix vowel and the ✿-ed candidate also has a [-round] suffix vowel. However, (15d) violates IDENT-IO (hi) because of VL and thus it is wrongly excluded.

(15) tableau for the actual output: wrong result[12]

| /xat-i:n/ | *[μμμ]$_\sigma$ | *HIGHLONG | IDENT-✿O(rd) | IDENT-IO (hi) |
|---|---|---|---|---|
| a. xat-i:n | *(!) | *(!) | | |
| b. xat-e:n | *(!) | | | *(!) |
| c. ✿ ❽ xat-in | | | | |
| d. ☞ xat-en | | | | *! |

[12] Actually, there is no example to indicate the ranking between IDENT-✿$_{HI}$O (rd) and IDENT-IO (hi). But for the sake of argument, I assume that IDENT-✿$_{HI}$O (rd) dominates IDENT-IO (hi).

So the question is how we can accommodate this fact to the sympathy account. Notice that in (12) VL occurs because the high vowel is long in the input. Thus, the sympathy candidate might be a candidate that preserves vowel length, i.e., a candidate that satisfies MAX-IO (μ). Let us assume, then, that in addition to IDENT-IO (hi), MAX-IO (μ) is also responsible for determining a ❁-ed candidate.[13] For ease of reference, let us label ❁$_{MAX}$ the ❁-ed candidate selected by MAX-IO (μ) and ❁$_{HI}$ the ❁-ed candidate selected by IDENT-IO (hi). Examine the tableau in (16). (16b) is selected as the ❁$_{MAX}$-candidate since it does not violate *HIGHLONG:

(16) tableau for the ❁$_{MAX}$-ed candidate:

□ &❁ = MAX-IO (μ)

| /xat-i:n/ | *HIGHLONG | MAX-IO (μ)❁ | IDENT-IO (hi) |
|---|---|---|---|
| a. xat-i:n | *! | | |
| b.❁$_{MAX}$xat-e:n | | | * |

Before turning to the tableau for determining the actual output, I have to point out two crucial assumptions in order to account for the opaque interaction in (12): one assumption is that the ❁O Faith constraint relevant to the ❁$_{MAX}$-candidate, which I call IDENT-❁$_{MAX}$O, must dominate IDENT-IO (hi). Since as the tableau in (13) indicates, the actual output is wrongly excluded due to a violation of IDENT-IO (hi), the effect of IDENT-IO (hi) must be circumvented. The other assumption is that IDENT-❁$_{MAX}$O has to be specific to the height feature.[14] Consider the tableau (17).

(17) tableau for the actual output: IDENT-❁$_{MAX}$ O (hi) >> IDENT-IO (hi)

| /xat-i:n/ | *[μμμ]$_\sigma$ | IDENT-❁$_{MAX}$O (hi) | IDENT-IO (hi) |
|---|---|---|---|
| a.❁$_{MAX}$ xat-e:n | *! | | * |
| b. xat-in | | *! | |
| c. ☞ xat-en | | | * |

In (17), the candidate (17c) is correctly selected as the optimal candidate since it does not violate either *[μμμ]$_\sigma$ or IDENT-❁$_{MAX}$O (hi). On the other hand, the candidate (17b) violates IDENT-❁$_{MAX}$O (hi) since the vowel height of the suffix in (17b), which is [+high], is not identical with that of the suffix in the ❁$_{MAX}$-candidate (17a), which is [-high]. Therefore, on the assumption that MAX-IO (μ) is qualified as C❁, we can explain the fact that (17c) is the actual output.

[13] See McCarthy 1998, where it is also claimed that MAX-IO (μ) can be C❁ in Yawelmani. Note that McCarthy's (1998) analysis of Yawelmani is basically the same as the analysis presented here, although McCarthy does not provide extensive discussion concerning Yawelmani vocalic alternations and the mechanism of multiple ❁-ed candidates. For further discussion, see Hoshi 1998, where it is argued that the "sympathy" analysis in OT is superior to the "rule-based" approach in generative phonology.

[14] The reason why IDENT-❁$_{MAX}$O is specific to the (hi) feature might be that the "intermediate stage" created by the application of VL roughly corresponds to the ❁-candidate and thus the (hi) feature of the ❁-candidate is crucial to determining the actual output.



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# 4 On the Necessity of Multiple Sympathy Candidates

## 4.1 Counter-Feeding & Counter-Bleeding

So far we have shown that both IDENT-IO (hi) and MAX-IO (μ) serve as C❀ to determine the ❀-candidates. Let us now examine the example in (2). Note here that in (2), VL need not occur to avoid a violation of *HIGHLONG since VS eventually takes place (= counter-bleeding). Thus *bok'-in* would be expected, but actually it is excluded. In addition, VH is expected to take place because the domain of round harmony is monotonic with respect to vowel height (= counter-feeding). So, *bok'-on* would be expected because both [o] and [e] are specified as [-high], but, in fact, VH does not occur.

Here I demonstrate that (2) is an example where multiple ❀-ed candidates are necessary to explain the vocalic alternations in a single form. Developing the original idea of sympathy given by McCarthy (1997), I propose that every IO-Faith constraint serves as C❀ regardless of whether or not the actual output violates it. Let us examine the tableaux (18) and (19). What is crucial here is that now we have multiple ❀-ed candidates related to both MAX-IO (μ) and IDENT-IO (hi): both a ❀$_{MAX}$ and a ❀$_{HI}$-candidate come into play at the same time in one tableau to regulate the identification between the multiple ❀-ed candidates and the possible outputs.

In (18i), which is the tableau for the ❀$_{MAX}$-candidate, the candidate (18ic) is chosen as the ❀$_{MAX}$-candidate since it obeys ALIGN [+rd]. In (18ii), which is the tableau for the ❀$_{HI}$-candidate, the candidate (18iib) is regarded as the ❀$_{HI}$-candidate since it does not violate MONO or any of the relevant Phono-Constraints.

(18) tableaux for multiple ❀-ed candidates:

i. C❀ = MAX-IO (μ)

| /bok'-i:n/ | *HIGHLONG | MAX-IO (μ)❀ | IDENT-IO (hi) | ALIGN [+rd] |
|---|---|---|---|---|
| a. bok'-i:n | *! | | | * |
| b. bok'-e:n | | | * | *! |
| c.❀$_{MAX}$bok'-o:n | | | * | |

ii. C❀ = IDENT-IO (hi)

| /bok'-i:n/ | *[μμμ]$_σ$ | IDENT-IO (hi)❀ | MONO | ALIGN [+rd] |
|---|---|---|---|---|
| a. bok'-i:n | *! | | | * |
| b.❀$_{HI}$ bok'-in | | | | * |
| c. bok'-un | | | *! | |



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(19) tableau for the actual output:

| /bok'-i:n/ | *[μμμ]$_\sigma$ | IDENT-✿$_{MAX}$O (hi) | IDENT-✿$_{HI}$O (rd) |
|---|---|---|---|
| a.✿$_{MAX}$ bok'-o:n | *! | | * |
| b.✿$_{HI}$ bok'-in | | *! | |
| c. bok'-on | | | *! |
| d. bok'-un | | *(!) | *(!) |
| e. ☞ bok'-en | | | |

As indicated in the tableau (19), we can successfully exclude the competing candidates because of the two ✿O-Faith constraints. The candidate in (19a) is immediately excluded because it violates *[μμμ]$_\sigma$. (19b) is ruled out because of a violation of IDENT-✿$_{MAX}$O (hi): it has a [+high] suffix vowel, but the ✿$_{MAX}$-candidate has a [-high] suffix vowel. The candidate in (19c) is excluded due to a violation of IDENT-✿$_{HI}$O (rd): (19c) has a [+round] suffix vowel, but the ✿$_{HI}$-candidate in (19b) has a [-round] suffix vowel. Finally, the candidate (19d) is ruled out because of a violation of both IDENT-✿$_{MAX}$O (hi) and IDENT-✿$_{HI}$O (rd): the height and the round features in the suffix of (19d) are not identical with those of the ✿$_{MAX}$-candidate and the ✿$_{HI}$-candidate, respectively. Therefore, (19e), which both satisfies IDENT-✿$_{MAX}$O (hi) and IDENT-✿$_{HI}$O (rd), can be selected as the optimal candidate by postulating multiple ✿-ed candidates.

Notice that the two IDENT-✿O constraints play very crucial roles in selecting the actual output in the tableau (19). Without IDENT-✿$_{MAX}$O (hi), [bok'-in] in (19b), which satisfies IDENT-IO (hi), would be chosen as optimal since the actual output (19e) violates IDENT-IO (hi) ([i:] is changed into [e] in (19e)). On the other hand, if it were not for IDENT-✿$_{HI}$O (rd), then [bok'-on] in (19c) would be wrongly selected as the optimal output since it does not violate ALIGN [+rd], but the actual output in (19e) violates it ([e] is not changed into [o]). Thus, we can conclude that we need at least two ✿-ed candidates in order to account for the counter-bleeding & counter-feeding cases of opacity, which suggests that the analysis of multiple ✿-ed candidates is empirically well-motivated.

Next, let us examine the following example which also involves the interaction among VH, VL and VS. Consider the example in (3) and the tableaux (20i) and (20ii), which determine the ✿$_{MAX}$-candidate and the ✿$_{HI}$-candidate, respectively. In (20i), (20ib) is selected as the ✿$_{MAX}$-candidate since it does not violate MONO. In (20ii), (20iib) is chosen as the ✿$_{HI}$-candidate since it does not violate ALIGN [+rd]:

(20) tableaux for multiple ✿-ed candidates:

i. C$^{✿}$ = MAX-IO (μ):

| /dub-i:n/ | *[μμμ]$_\sigma$ | MAX-IO (μ)$^{✿}$ | MONO | ALIGN [+rd] |
|---|---|---|---|---|
| a. dub-o:n | * | | *! | |
| b.✿$_{MAX}$ dub-e:n | * | | | * |



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ii. C✿ = IDENT-IO (hi):

| /dub-i:n/ | IDENT-IO (hi)✿ | ALIGN [+rd] |
|---|---|---|
| a. dub-in | | *! |
| b. ✿$_{HI}$ dub-un | | |

(21) tableau for the actual output:

| /dub-i:n/ | *[μμμ]$_σ$ | IDENT-✿$_{MAX}$O (hi) | IDENT-✿$_{HI}$O (rd) |
|---|---|---|---|
| a.✿$_{MAX}$ dub-e:n | *! | | |
| b.✿$_{HI}$ dub-un | | *! | |
| c. dub-en | | | *! |
| d.☞ dub-on | | | |

In (21), the candidate (21d) is regarded as optimal since it satisfies all the relevant constraints. The competing candidate (21b) fatally violates IDENT-✿$_{MAX}$O (hi): (21b) has a [+high] suffix vowel [u], which is incompatible with the [-high] suffix vowel [e] of the ✿$_{MAX}$-candidate. The other competing candidate (21c) violates IDENT-✿$_{HI}$O (rd): (21c) has the [-round] suffix vowel [e], which is incompatible with the [+round] suffix vowel [u] of the ✿$_{HI}$-candidate in (21b).

## 4.2 Counter-Feeding

In this subsection we will examine the case with counter-feeding only and confirm that the same analysis applies to counter-feeding.

Consider the example of counter-feeding in (1b). The relevant tableaux for the counter-feeding case are as in (22). In (22i), the candidate (22ib) is more harmonic than the other candidate since it satisfies ALIGN [+rd], whereas the competing candidate (22ia) violates it; (22ib) is thus selected as the ✿$_{MAX}$-candidate. Tableau (22ii) shows that the candidate (22iia) is the ✿$_{HI}$-candidate due to the fact that it satisfies MONO:

(22) tableaux for ✿-ed candidates:

i. C✿ = MAX-IO (μ):

| /ʔu:t'-ʔas/ | MAX-IO (μ)✿ | IDENT-IO (hi) | ALIGN [+rd] |
|---|---|---|---|
| a. ʔo:t'-ʔas | | * | *! |
| b.✿$_{MAX}$ʔo:t'-ʔos | | * | |

ii. C✿ = IDENT-IO (hi):[15]

| /ʔu:t'-ʔas/ | IDENT-IO (hi)✿ | MONO | ALIGN [+rd] |
|---|---|---|---|
| a. ✿$_{HI}$ ʔut'-ʔas | | | * |
| b. ʔut'-ʔos | | *! | |

[15] Here I ignore the candidate [ʔu:t'-ʔas] because it violates undominated *HIGHLONG.

(23) tableau for the actual output:

| /ʔu:t'-ʔas/ | IDENT-❀$_{MAX}$O (hi) | IDENT-❀$_{HI}$O (rd) |
|---|---|---|
| a. ❀$_{HI}$ ʔut'-ʔas | *! | |
| b.❀$_{MAX}$ ʔo:t'-ʔos | | *! |
| c. ☞ ʔo:t'-ʔas | | |

(23a) is excluded due to a violation of IDENT-❀$_{MAX}$O (hi). The actual output (23c) satisfies both of the IDENT-❀O constraints in contrast to the competing candidate (23b), in which IDENT-❀$_{HI}$O (rd) is fatally violated because of the [+round] the suffix vowel [o], which is not identical with the [-round] suffix vowel [a] of the ❀$_{HI}$-candidate. Therefore, (23c) can be correctly selected as the optimal candidate.[16]

## 5 Concluding Remarks

We have argued that every IO-Faith constraint serves as C❀, which implies that there exist "multiple sympathy candidates" and that more than one ❀O-Faith constraint selected by multiple ❀-ed candidates are allowed to evaluate the candidates generated by GEN in a parallel fashion. Notice that if we just take a look at opaque languages in which only one ❀-ed candidate might be relevant, we cannot say anything decisive about the possibility of "multiple ❀-ed candidates". However, if there is a language such that more than one ❀-ed candidate play an important role in the grammar of the language, then it sounds reasonable to assume that ❀-ed candidates can be multiple, which is exactly the case of vocalic alternations in Yawelmani that we have seen so far. A stronger claim is that, on the basis of the assumption that every IO-Faith constraint serves as C❀, in any language, a ❀-ed candidate exists and ❀-ed candidates can be multiple. However, whether or not ❀-ed candidates come into play in the grammar of a language depends on its independent constraint hierarchy. Consider the following abstract schemata of the constraint-hierarchies (24), in which we can make a distinction among the languages with or without opacity effects:

---

16 The actual output in (27c) apparently violates *[μμμ]$_{\sigma}$ , but note here that the consonant [t'] is a glottalized C and to my knowledge this is the only exception for *[μμμ]$_{\sigma}$. I tentatively assume that the glottal stop [ʔ] is not counted as a crucial segment for the purpose of syllabification and thus VS does not apply to (27c).

(24) a. "Transparent" languages:

$C_1 \gg C_2 \gg \ldots \gg C_n \gg \ldots \gg$ ❀O-FAITH$_{1,\,2,\,3,\,\ldots n}$

b. "Opaque" languages:

$C_1 \gg$ ❀O-FAITH$_1 \gg C_2 \gg \ldots \gg C_n \gg \ldots \gg$ ❀O-FAITH$_{2,\,3,\,\ldots n}$

c. "More opaque" languages:[17]

$C_1 \gg$ ❀O-FAITH$_1 \gg C_2 \gg$ ❀O-FAITH$_2 \gg \ldots \gg C_n \gg \ldots \gg$ ❀O-FAITH$_{3,\,\ldots n}$

In the case of what I call "transparent" languages, the family of ❀O-Faith constraints are lowest-ranked, and they do not exhibit any substantial effects in the grammar. As for "opaque" languages, one member of the family of ❀O-Faith constraints is higher-ranked than some other Phono-Constraints or IO-Faith constraints, and thus it comes into play, yielding usual "opacity" effects. On the other hand, in the case of what I call "more opaque" languages such as Yawelmani, more than one ❀O-Faith constraints are higher-ranked and crucially affect the choice of the actual output. Therefore, from the fact that the typology of "opacity" fits perfectly into the framework of OT, it seems tenable to conclude that "multiple ❀-ed candidates" are allowed in the grammar of any language, regardless of whether or not it exhibits "opacity" effects.

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[17] Here "more opaque" means that the degree of opaqueness is higher. This seems to be intuitively correct. Notice that in Yawelmani, VH, VL and VS interact with one another and create more than one "intermediate stages" in terms of the "rule-ordering" analysis, in contrast to the example involving vowel epenthesis and ?-deletion in Tiberian Hebrew, in which McCarthy (1997) shows that only one "intermediate stage" is involved. However, see Idsardi 1998 and McCarthy 1998 for more complicated "opaque" examples of spirantization in Tiberian Hebrew.

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A Perceptually Grounded OT Analysis of Stress-Dependent Harmony

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## 1 Introduction

Stress-dependent harmony (SDH) systems are systems in which an unstressed vowel must agree with the stressed vowel of the word in terms of one or more harmonic feature(s). In this paper, I provide cross-linguistic support for the notion of SDH. I then provide an Optimality Theoretic analysis of the SDH of Old Norwegian. In addition to providing a core analysis that accounts for the SDH in several typologically distinct languages, I provide external support for my analysis with experimental studies that phonetically ground the constraint driving the harmony.

In exploring the phonetic basis of SDH, I am drawing on a rich history of inquiry into the relationship between phonetics and phonology. Two methodological approaches can be distinguished: constraining phonological analyses via phonetic grounding through formal modeling of phonological phenomena (e.g. Archangeli and Pulleyblank 1994, Beckman 1998, Hayes 1996, Kaun 1996, Myers 1996, Padgett 1998, Steriade 1997), and experimental approaches that seek to explain phonology systems by providing grounding via empirical studies (Busa and Ohala 1997, Cohn 1990, De Jong et al. 1993, Doran 1998, Fowler 1981, Guion 1996, Hura et al. 1992, Keating 1985, Kohler 1990, Myers 1998, Pierrehumbert 1980). These approaches have the same goal: to place constraints on phonological analyses such that they have external explanations lying outside of the formal theory being used to capture the phonological pattern under scrutiny. Using both formal and experimental methods of phonetic grounding provides a more complete analysis of the relationship between phonetics and phonology.

### 1.1 Stress-dependent harmony

The table in (1) contains a list of languages containing SDH systems. Overall, the languages shown in (1) are typologically distinct, sharing only minimal contact and genetic ancestry.

(1)

| Language Family | | Language | Harmonic Feature(s) | Source |
|---|---|---|---|---|
| Austronesian | | Chamorro | height | Topping 1968 |
| Finno-Ugric | | Eastern Cheremis (Mari) | color | Isanbaev 1975, Sebeok et al. 1961 |
| Gondi | | Koya | all (total) | Tyler 1969 |
| Indo-European | Celtic | Breton | height | Anderson 1974 |
| | Germanic | Old Norwegian | height | Hagland 1978 |
| | Romance | Pasiego Montañes Spanish<br>Brazilian Portuguese | height<br>height | McCarthy 1984<br>Bisol 1989 |
| Semitic | | Tiberian Hebrew | all (total) | McCarthy 1979 |
| Sino-Tibetan | | Lhasa Tibetan | height | Ultan 1973 |
| Tupi | | Ava Guaraní<br>Chiriguano | nasal<br>nasal | Gregores&Suarez 1967<br>Dietrich 1986 |

The languages in the table in (1) and the harmonic features therein form such a diverse group that it is highly unlikely that the SDH systems present in these languages are due to language contact or an inherited linguistic trait. These systems no doubt arose independently of one another and since this phenomena is so wide spread, I contend that this is a naturally occurring pattern arising from the equally natural phonetic phenomena of vowel-to-vowel (V-V) coarticulation. I will return to the relationship between SDH and V-V coarticulation in section 3, but first, in section 2, I will outline in detail a phonetically motivated Optimality Theoretic account of the SDH system that was present in Old Norwegian.

## 2 Phonological Analysis: Old Norwegian Height Harmony

### 2.1 Old Norwegian data

The language referred to as Old Norwegian was spoken roughly from 1050-1370. The vowel system of Old Norwegian, taken from Hagland (1978), is shown in (2).

(2) Vowel System of Old Norwegian

| | | | |
|---|---|---|---|
| i y | u | i: y: | u: |
| e ø | o | e: ø: | o: |
| æ | a | æ: | a: |

Norwegian inherited its stress pattern from ancestral Germanic. With the exception of loanwords and weakly accented prefixes, the word initial syllable carried the stress. Old Norwegian developed a vowel harmony similar to the more well known SDH system in the Pasiego Montañes dialect of Spanish (McCarthy 1984). In Old Norwegian, the non-low unstressed vowels agreed in height with the initial stressed vowels (Hagland 1978, Gordon 1957). Old Norwegian differs from Pasiego in that it had a phonemic vowel length distinction. This length distinction plays a role in the low vowels: long low vowels trigger a lowering of high vowels to mid, whereas short low vowels do not. The data in (3) below illustrates the harmony of the non-low vowels (Hagland 1978).

(3) Height Harmony in Old Norwegian

| [+high] stressed vowel | | | [-high] stressed vowel | | |
|---|---|---|---|---|---|
| 'inni | 'inside' | (*'inne) | 'dømdo | 'sentenced' | (*'dømdu) |
| 'undir | 'under' | (*'under) | 'Þesser | 'these' | (*'Þessir) |
| 'pinur | 'plagues' | (*'pinor) | 'opet | 'open' | (*'opit) |
| 'sunir | 'sons' | (*'suner) | 'retto | 'right' | (*'rettu) |
| 'systur | 'sister' | (*'systor) | 'toko | 'took' | (*'toku) |

The forms in the left column all contain a high stressed vowel. Forms in which a high stressed vowel is followed by a mid vowel do not occur. The right column contains forms with a stressed mid vowel. In these cases, the following vowel may not be high.

(4) contains data illustrating that the short low vowels of Old Norwegian failed to trigger the height harmony.

| | | | | |
|---|---|---|---|---|
| (4) | 'adrum | 'other' | 'hafde | 'had' |
| | 'ællu | 'all, singular' | 'aller | 'all, m. plural' |

The data in the first column contains forms in which a stressed short low vowel is followed by an unstressed high vowel, and in the second column, the stressed short low vowel is followed by an unstressed mid vowel. Thus, these short low vowels do not appear to trigger harmony. Unlike the short low vowels, long low vowels are always followed by mid vowels. The data in (5) illustrate this restriction.

| | | | | | | |
|---|---|---|---|---|---|---|
| (5) | 'va:rer | 'our' | (*'va:rir) | 'læ:rder | 'learned' | (*'læ:rdir) |
| | 'a:re | 'year' | (*'a:ri) | 'væ:re | 'were' | (*'væ:ri) |
| | 'va:rom | 'owned' | (*'va:rum) | 'mæ:lto | 'said' | (*'mæ:ltu) |

Hagland analyzes this as vowel reduction rather than vowel harmony because a similar pattern is seen in final unstressed syllables of trisyllabic words. Regardless of the harmony, the final unstressed vowels of trisyllabic words are mid. Forms illustrating this generalization are shown in (6).

(6) 'kælingom 'woman'
'stukunne 'chapel'
'iattado 'affirmed'

There is some evidence that the forms in (6) above are not subject to a general final neutralization process. The forms *'adrum* and *'œllu* contain short low vowels followed by high vowels. There is no harmony acting in these forms, so the final vowels would be free to undergo the final neutralization to mid vowels, but they do not.

The form *'stukunne* in (6) above has the regular height harmony, but the final unstressed syllable is mid, in defiance of the harmony. One might take this as evidence that the harmony is bound to the stress foot. Given the patterns above, the generalization appears to be that final unstressed syllables that do not belong to a stress foot are the targets of final neutralization. I leave the analysis of the final neutralization for further study.

## 2.2 OT Analysis of Old Norwegian height harmony

To account for the SDH, I posit a family of constraints called Stress-Prominence, shown in (7).

(7) **Stress-Prom(inence)(F)**
Every instance of the feature [F] must be associated with a stressed vowel.

Stress-Prom(F) is satisfied when the harmonic feature is associated with the salient stressed vowel and is violated for every unstressed vowel that is associated with a feature [F] that is not also associated with a stressed vowel. Stress-Prom(F) is a family of constraints, and I assume that F can be filled by any vowel feature. SDH systems can have various harmonic features, as demonstrated in the table in (1). The relevant member of the Stress-Prom family for Old Norwegian is Stress-Prom(high) since it contains a height harmony. Stress-Prom(high) is defined in (8) below.

(8) **Stress-Prom(high)**
Every instance of the feature [high] must be associated with a stressed vowel.

Stress-Prom(high) accounts for the fact that stressed and unstressed vowels share the harmonic feature [high], but this constraint says nothing with regards to which [high] feature they share. The fact that unstressed vowels alternate in agreement with stressed vowels rather than the other way around can be accounted for using a positional faithfulness framework (Beckman 1998). The faithfulness constraints in (9) and (10) are used in this analysis of Old Norwegian.

(9) **Ident(high)**
An output segment in a stressed syllable and its corresponding input must be identical with respect to the feature [high].
(McCarthy and Prince 1995)

(10) **Ident-□(high)**

An output segment in a stressed syllable and its corresponding input must be identical with respect to the feature [high].

(Beckman 1998)

The constraint in (10) is a positional faithfulness constraint motivated by the fact that segments in prominent positions such as stressed syllables tend to maintain contrasts that are lost elsewhere. The constraint hierarchy given in (11) is the core SDH ranking.

(11) Ident-□(high), Stress-Prom(high) >> Ident(high)

Ident-□(high) is undominated, giving the result that stressed vowels will always be faithful to their input [high] specification. Since Stress-Prom(high) outranks the general faithfulness constraint Ident(high), unstressed vowels will be unfaithful to their input specification of [high] and share the [high] specification of the stressed vowel in order to satisfy the harmony requirement imposed by Stress-Prom(high). The tableau in (12) illustrates how this constraint hierarchy applies to the Old Norwegian form *'opet 'open'*.

(12)

| /opit/ | Ident-□ (high) | Stress-Prom(high) | Ident(high) |
|---|---|---|---|
| a. 'upit | *! | | * |
| b. 'opit | | *! | |
| Xc. 'opet | | | * |

Candidate (a) violates the positional faithfulness constraint because the vowel in the stressed syllable in the output is specified as [+high], but its correspondent in the input contains a [-high] specification. Candidate (b), the faithful candidate, violates Stress-Prom(high) since the unstressed vowel does not share its [+high] specification with the stressed vowel. Candidate (c) emerges as the optimal candidate since the unstressed vowel shares the [-high] specification of the stressed vowel, satisfying both the positional faithfulness and Stress-Prom constraints.

Low vowels do not undergo the height harmony in Old Norwegian. The faithfulness constraint Ident(low), shown in (13), is undominated in this language.

(13) **Ident(low)**

Output segments and their input correspondents must have identical specifications for the feature [low].

The failure of the short low vowels to trigger a harmonic lowering of high vowels can be accounted for by a constraint, Uniform(low), adapted from Uniform(round) (Kaun 1995). This constraint is defined in (14) below.



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(14) **Uniform(low)**

Two segments can only share a [high] specification if they share a [low] specification.

This constraint rules out a configuration in which a low vowel and a mid vowel share a [-high] specification. This constraint dominates Stress-Prom(high) in Old Norwegian, giving the result that unstressed high vowels do not lower to mid in order to share [-high] with a low vowel. The ranking thus far is given in (15) and demonstrated by the form *'adrum* in the tableau in (16).

(15) Ident- □(high), Ident(low), Uniform(low)>> Stress-Prom(high)

(16)

| /adrum/ | Ident-□ (high) | Ident (low) | Uniform (low) | Stress-Prom (high) | Ident (high) |
|---|---|---|---|---|---|
| a . 'idrum | *! | * | | | * |
| b. 'adram | | *! | | | * |
| c. 'adrem | | | *! | | * |
| Xd. 'adrum | | | | * | |

Candidate (a) is ruled out because it violates the positional faithfulness constraint since the stressed vowel contains a [+high] specification that its corresponding input did not. Candidate (b) is ruled out because the unstressed vowel contains a [+low] specification in the output but not in the corresponding input. Candidate (c) violates the uniformity requirement since the stressed and unstressed vowels share a [-high] feature, but not a [low] feature. Candidate (d) emerges as optimal despite its violation of Stress-Prom(high) since it fares better on the higher ranking constraints.

As discussed above, the stressed long low vowels of Old Norwegian conditioned a one-step lowering of high vowels to mid. The constraint on the height of the unstressed vowels following stressed, long low vowels may be due to an extra degree of influence exerted by the vowels which are both stressed and long. These vowels are prominent in that they are stressed, and also prominent in that they are long. The fact that length is a form of prominence is captured in the family of prominence constraints, Long-Prom(F), defined in (17) below.

(17) **Long-Prom(F)**

Every instance of the feature F must be associated with a long vowel.

Long vowels are prominent and as such, may trigger phonological alternations similar to SDH. An example of this type of phonological harmony exists in Tigre, a Semitic language spoken in Eritrea and Sudan, which possesses a palatal vowel harmony in which the only short vowels of the language, [χ] and [Ξ], agree in backness with a following long vowel. An analysis similar to the one developed here using Stress-Prom as the driving force behind SDH systems could be developed for Tigre using Long-Prom.

Since the harmony in Old Norwegian concerned the feature [high], the member of the Long-Prom family relevant to this analysis, Long-Prom(high), is defined in (18).

(18) **Long-Prom(high)**
Every instance of the feature [high] must be associated with a long vowel.

In Old Norwegian, the fact that long stressed vowels are prominent in two manners can be captured using constraint conjunction as outlined in Crowhurst & Hewitt (1998). In this form of constraint conjunction, a candidate passes a conjunction A^B if and only if this candidate passes Constraint A *and* Constraint B. Stated negatively, a candidate violates the conjuction A^B if it violates either Constraint A or Constraint B.

In Old Norwegian, the fact that stressed, long low vowels trigger a lowering of high vowels to mid can be captured by conjoining the two prominence constraints, Stress-Prom(high) and Long-Prom(high). The conjunction of Stress-Prom(high) and Long-Prom(high) is given in (19).

(19) **Stress-Prom(high) ^[hi] Long-Prom(high)**
Every instance of the feature [high] must be associated to a stressed long vowel.

Any candidate that violates either of the members of this conjunct will violate the entire constraint. This constraint conjunction allows for an unstressed vowel to share a [high] specification with the stressed long vowel. This constraint must by ranked above Uniform(low) so that it may override the restriction in which, if segments share a specification of [high], they must also share a specification of [low]. The ranking is given in (20) and illustrated in the tableau in (21).

(20) Stress-Prom(high) ^[hi] Long-Prom(high) >> Uniform(low)

(21)

| /va:rir/ | StressProm (high) | ^[hi] | Long Prom (high) | Uniform(low) |
|---|---|---|---|---|
| a. 'va:rir | (*) | *! | (*) | |
| Xb. 'va:rer | | | | * |

Candidate (a) is ruled out because the unstressed vowel has a [+high] specification that is not associated with the stressed vowel or a long vowel. Although candidate (b) violates the Uniform(low) constraint, it satisfies the higher ranked conjunction because the [-high] specification is associated with the stressed long vowel.

Given a form in which the stressed vowel is a short low vowel such as *'aller*, the current constraint ranking would not rule out a candidate in which a mora is added to the stressed vowel to make it long, because it would then satisfy the constraint conjunction. However, in Old Norwegian, short vowels were never lengthened. The constraint that captures this fact is Weight-Ident, given in (22) below.

(22) **Weight-Ident**

An output segment and its corresponding input must be identical in weight. (McCarthy 1995)

Weight-Ident assigns violations if a vowel is short in the input and long in the output or vice versa. This constraint dominates the constraint conjunction, accounting for the fact that vowels are not lengthened in the output in Old Norwegian, in order to satisfy the prominence conjunction. This ranking is given in (23) below and the tableau in (24) illustrates how this applies to the Old Norwegian form *'adrum*.

(23) Weight-Ident >> Stress-Prom(high) $^{\wedge[hi]}$ Long-Prom(high)

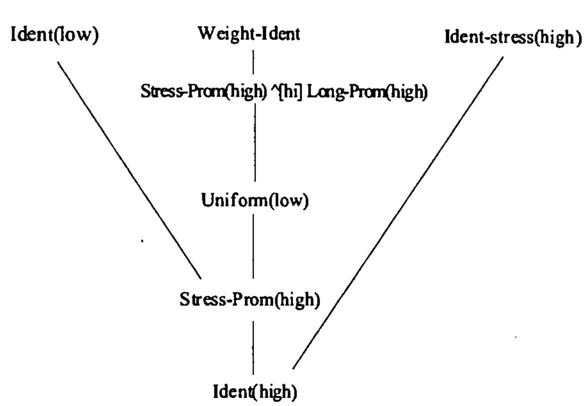
(24)

| /adrum/ | Weight-Ident | Stress Prom | ^hi | Long Prom |
|---|---|---|---|---|
| [-high] / \ a. 'a:drem | *! | | | |
| X b. 'adrum | | (*) | * | (*) |

Candidate (a) satisfies the constraint conjunction since, by adding a mora to the stressed vowel, the [-high] specification of the unstressed vowel is shared with both a stressed and a long vowel. This candidate is ruled out though by the higher ranked constraint Weight-Ident so candidate (b) emerges as the optimal candidate.

The diagram in (25) shows the final ranking of constraints that accounts for the SDH pattern of Old Norwegian.

(25)




The fact that Stress-Prom(high) outranks Ident(high) yields a vowel harmony and since Ident (high) outranks Ident(high), only the unstressed vowels will undergo the harmony. Uniform(low) and Ident(low) outrank Stress-Prom(high), so low vowels will not trigger or undergo the harmony. The constraint conjunction Stress-Prom(high) ^ Long-Prom(high) outrank Uniform(low) accounting for the fact that long low vowels do trigger a harmony, but since Weight-Ident is unviolated, low vowels are never lengthened to satisfy the constraint conjunction.

## 3 Phonetic Support for Stress-Prom Analysis

The Stress-Prom family of constraints plays a crucial role in the analysis of Old Norwegian. Specifically, it is the driving force behind the harmony. Similar analyses of SDHs such as the color harmony in Eastern Cheremis or the nasal harmony in Chiriguano make use of other members of the Stress-Prom family, namely Stress-Prom(color) and Stress-Prom(nasal).

I argue that SDH has phonetic origins in V-V coarticulation (Majors 1998a, 1998b). I have conducted both acoustic and perceptual experiments that provide further phonetic grounding for the constraint family Stress-Prominence. In the remainder of section 3, I briefly summarize my findings from these experiments.

### 3.1 Stress-effects on V-V coarticulation in English

A few acoustic studies have reported that unstressed vowels are more likely to undergo coarticulation with surrounding vowels than stressed vowels are (Fowler 1981, Van Bergem 1994). Most studies of stress effects on V-V coarticulation have investigated the behavior of the vowel schwa, which has been argued to be either targetless (Van Bergem 1994), or represent a neutral tongue position (Browman & Goldstein 1992). In either case, schwa tends to be a heavily reduced vowel in many vowel systems, and thus much more likely to undergo coarticulation with surrounding sounds. I have chosen to investigate the effect of stress on V-V coarticulation observable on vowels that resist massive reduction when occurring in unstressed position.

#### 3.1.1 Methods

I chose to use English for the phonetic studies for several reasons. I am investigating V-V coarticulation as a phonetic basis of SDH harmony. In order to do so, I must look to a non-harmony language to find the phonetic beginnings of a harmonic system. The dominant stress system of English also provides a robust difference in the stressed and unstressed vowels. I chose to investigate the vowels /i/ and /o/ because, of the English vowels, these are the two that best resist reduction in unstressed position.

My hypothesis was that unstressed vowels would undergo a greater amount of V-V coarticulation than vowels bearing primary stress. To test this hypothesis, I constructed reiterant CVCV speech data sets in which I varied the following: (i) the quality of the vowel (/i/ or /o/), (ii) level of stress (primary stress or no stress), (iii) the quality of the vowel in the adjacent syllable (/i/ or /o/), and (iv) the position of the vowel in the $V_1CV_2$ sequence ($V_1$ or $V_2$). Due to space considerations, I will discuss only the results that pertain to $V_2$ position. Similar results obtained for $V_1$ position, but to a lesser extent. Subjects were presented with actual words of English but were asked to replace all non-final consonants with the voiced bilabial [b], retaining the normal stress pattern of the original word. [b] was chosen to maximize the opportunity for V-V coarticulation. (26)

contains the carrier phrase used and (27) shows the reiterant tokens used for this experiment.

(26) Did you say you saw Fred's ___ before, or Ted's ___ before?
(27) 'bibi bi'bi 'bobo bo'bo 'bibo bi'bo 'bobi bo'bi

Four native speakers of American English (3M, 1F) provided the speech tokens for the acoustic experiment. Speakers were first trained on the consonant replacement task. Speakers were asked to speak at a self-selected fast rate of speech, producing ten repetitions of each token. Any tokens for which the target vowels were judged to be reduced to schwa or incorrectly stressed were not included in the study. Six formant measurements were made for each vowel: vowel onset, midpoint, and offset for both the first and second formant.

### 3.1.2 Results

V-V coarticulation occurs when a speaker anticipates or carries over one or more aspects of the articulation of one vowel to neighboring vowels. Acoustically, V-V coarticulation is evident when the formant values of the affected vowel are closer to the values of the vowel triggering the coarticulation. For example, in the sequence [bibo], the [o] vowel in the second syllable might be higher and more front than [o]s found in other contexts because the previous syllable contains a high, front vowel, [i].

Two of the four speakers exhibited significant stress effects on V-V coarticulation, supporting my hypothesis that unstressed vowels tend to undergo a greater amount of V-V coarticulation than stressed vowels. This was true particularly for the second formant, indicative of coarticulation in the front/back dimension. There were also vowel specific differences; the formant values of unstressed /i/ were affected more by the transconsonantal vowel than stressed /i/, but the formants of both stressed and unstressed /o/ were greatly influence by the transconsonantal vowel. The figure in (28) shows the mean formant values (speaker 2) of the unstressed vowel /i/ in the 'bi.bi and 'bo.bi contexts. The second formant values at onset and midpoint are visibly separated, indicating that the identity of the previous vowel has an affect on the quality of this unstressed /i/. ANOVA results confirm that these differences are significant at the .05 level.



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(28)

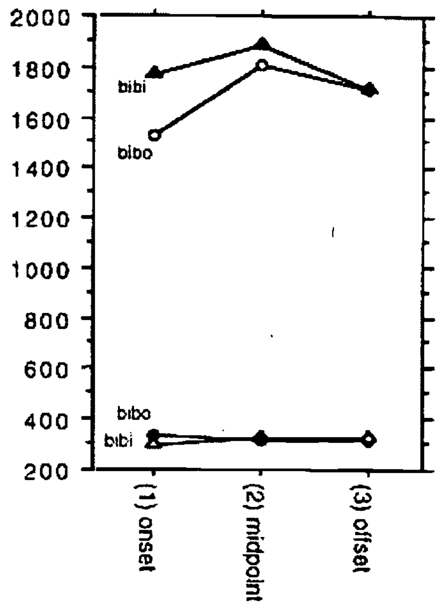
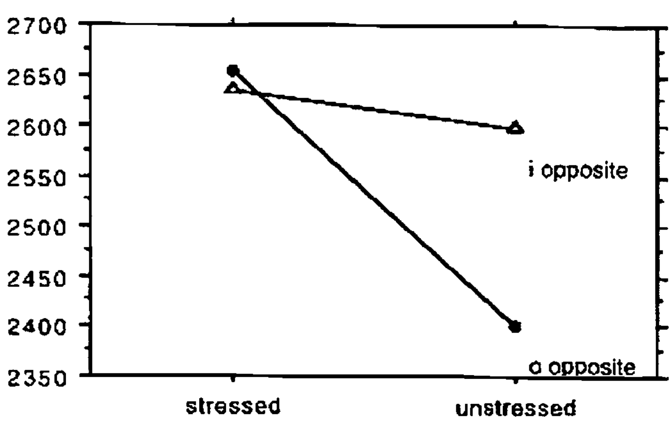



Figure (29) is an interaction diagram showing the effects of the transconsonantal vowel on F2 across stress level (subject 1). For the unstressed /i/, the difference in the ['bibi] and ['bobi] contexts is about 250 Hz., but for the stressed vowel /i/, the difference is negligible. The interpretation of this is that the stressed /i/ did not undergo V-V coarticulation while the unstressed vowel did.

(29)




The results of these acoustic experiments indicate that, at least for some speakers of English, unstressed vowels undergo a greater degree of V-V coarticulation than stressed vowels. While this supports my hypothesis that such stress asymmetries are plausible and likely phonetic origins of phonological SDH systems, in order for a sound change such as the one I am proposing to occur, the listeners in the speech community must be able to hear the differences in order for the asymmetry to influence the direction of the sound change. The perception experiment I describe in the next section was designed to test whether or not the stressed differences described above can be detected by naïve listeners of English.

### 3.2 The perception of V-V coarticulation on unstressed /i/

In order to test whether the differences in vowel quality of the unstressed vowels in the two coarticulatory contexts were great enough to be perceived, I constructed an ABX discrimination task in which the unstressed [bi] syllables were excised from their phonetic context and placed in triads of stimuli. The first and second member of the triad were always taken from the different coarticulatory contexts ([‘bi.bi] and [‘bo.bi]) and the third member matched one of the first two tokens in coarticulatory context, but was never token identical. Twelve native English speakers were asked to report which of the first two tokens the third token sounded most like. The test consisted of 80 triad, grouped into ten groups of eight triads each.

#### 3.2.1 Results

Overall, subjects reported that the test token sounded more like the reference token 80% of the time. The table in (30) shows the number of times the actual token of [$bi_i$] and [$bi_o$] were judged to be most similar to the [$bi_i$] and [$bi_o$] reference tokens. If the subjects had performed at chance level (50%), each cell would contain the number 120. The percentage of the total is given in parentheses.

(30)

| Similar to reference token: | Actual [$bi_i$] | Actual [$bi_o$] |
|---|---|---|
| [$bi_i$] | 225 (94%) | 45 (19%) |
| [$bi_o$] | 15 (6%) | 195 (81%) |

The actual [$bi_i$] and [$bi_o$] tokens were identified with the reference token from the same context far more than the chance 120 times. The result of a two-way Chi-square test indicate that these four groups were significantly different from one another ( $\chi^2$ = 271.24, df=1, p <.05). A strength of association test indicated a very strong relationship between actual coarticulatory context and the coarticulatory context of the token to which it was judged to be most similar ($\phi$= .75). These results suggest that, independent of vowel reduction, sufficient cues were present in the unstressed [bi] syllables such that listeners were able to perceive differences based on the identity of the transconsonantal vowel.

## 4 Conclusion

I have provided evidence that stress dependent harmony is a cross-linguistic pattern, and have posited a family of constraints, Stress-Prominence, which acts as the driving force behind the harmony. I have argued that this constraint family is motivated by acoustic and perceptual considerations, and have provided not only a grounded theoretical account of the pattern, but I have also conducted acoustic and perceptual experimentation that serves as further evidence for the phonetic plausibility of my account. Providing both theoretic modeling and empirical evidence of phonetic grounding of the SDH serves to triangulate the analysis, yielding a more robust understanding of the phenomenon. As such, I have provided not only an account of the synchronic pattern, but a window into the origins, and a plausible *explanation* for the existence of SDH in these languages.

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ERIC

Less Stress, Less Pressure, Less Voice*

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## 1 Introduction

In this paper, I provide an analysis of Tohono O'odham vowel devoicing with respect to physiological explanation. There are three points in this paper. First, this paper provides data of devoicing (consonants and vowels) in Tohono O'odham. Second, analysis of devoicing in terms of subglottal pressure drop is provided. Third, the devoicing is accounted for within the framework of OT (McCarthy and Prince 1993, Prince and Smolensky 1993).

The organization of the paper is as follows. In section 2, the background of the language including both voiced and voiceless vowels is described. In section 3, the data of Tohono O'odham words with voiceless vowels are provided. Then the distribution of devoiced segments is discussed. In section 4, an analysis of devoicing with respect to subglottal pressure drop is presented with schematic diagrams. Then an OT account utilizing phonetic constraints is presented.

## 2 Background

Tohono O'odham is a Uto-Aztecan language spoken in southern Arizona and northern Mexico. In this language, both consonant and vowel devoicing phenomena are found. This fact is interesting because some languages have either consonant devoicing (Dutch: Booij and Rubach 1987) or vowel devoicing (Japanese: Shibatani 1990), but it is rare to find a language which devoices both consonants and vowels.

### 2.1 Voiceless vowels

Native speakers of Tohono O'odham distinguish [go:ki̥] 'a species of cactus', a word with a voiceless vowel, from [go:k] 'two', a word without a voiceless vowel. Since the voicing of [i̥] is reduced and the coda consonant [k] is

* I would like to thank Diana Archangeli, Dick Demers, Mike Hammond, Jane Hill, Jessica Maye, Laura Moll, Ofelia Zepeda, and the audience at the SWOT 4 Conference. All mistakes are mine.

pronounced with a release, the two words sound identical to non-native speakers of O'odham.

The orthography, the Alvarez-Hale writing system, distinguishes voiceless vowels from regular vowels. (e.g. regular [i] as *i* vs. voiceless [i̥] as ĭ)

## 2.2 Vowels in Tohono O'odham

There are five basic vowels in the language. As shown in (1), the O'odham vowel inventory exhibits an asymmetry. While there are three High vowels (front, central and back), there is only one Mid vowel and only one Low vowel.

(1) Asymmetric vowel inventory

| | front | Central | Back |
|---|---|---|---|
| High | i | ɨ | u |
| Mid | | | o |
| Low | | a | |

The language has only one front vowel [i], which is high, and only this vowel appears as a voiceless vowel in Mathiot's (1973) dictionary.

There are very few examples of non-front voiceless vowels (Zepeda 1983)

(2) hehe̥ 'laugh'
wo:po'o̥ 'running (pl)'
dahḁ 'sitting'

The environments in which non-front voiceless vowels appear differ from those in which the front voiceless vowel appears. Non-front voiceless vowels appear word-finally preceded by glottal consonants (Hale 1965, Zepeda 1983). Besides the examples above, the vowel [u] is devoiced between [k] and [s] ([waku̥s] 'flat surface', Hill and Zepeda (1992)). On the other hand, [i] is devoiced in an unstressed position preceded by a non-coronal consonant. The devoiced vowels after glottal consonants are optional (Hale 1965), and the devoiced [u] between [k] and [s] occurs only in very limited data. Therefore, the analysis here treats only the appearance of the devoiced front vowel.

## 3 Data Description and Analysis

In this section, the data that are used in my analysis are described. The environment of devoiced [i] (a) is always in an unstressed syllable position[1], and (b) is preceded by a [-COR] consonant: [Labial] or [Dorsal]. (Fitzgerald and Fountain 1997)[2].

As mentioned in the introduction, both vowels and consonants can be devoiced in Tohono O'odham. First, vowels are devoiced in word-final position (3).

(3) final vowel devoicing
- a. [gó:ki̥] 'footprint'
- b. [jú:ki̥] 'rain'

Word-final consonants are also devoiced, as shown in (4).

(4) final consonant devoicing
- c. [gá:g̥] 'to look for'
- d. [kú:b̥] 'to be blowing around'

Third, when a devoiced final vowel is preceded by a consonant, the consonant is also devoiced, as shown in (5).

(5) final vowel and preceding consonant devoicing
- e. [gá:g̥i̥] 'looking for'
- f. [ó:b̥i̥] 'non-Tohono O'odham person'

Fourth, when the final consonant is sonorant, it is not devoiced (6).

(6) final sonorant (not devoiced)
- g. [čɨ́m] 'small'
- h. [gɨ́w] 'snow'

However, when these sonorants precede a devoiced vowel, they are also devoiced as in (7). This is interesting because sonorants do not have voiceless counterparts in the phoneme inventory of the language.

(7) devoicing of sonorants preceding final devoiced vowel
- i. [čɨ́:m̥i̥] 'a species of a cactus'
- j. [čɨ́:w̥i̥] 'jackrabbit'

---

[1] The first syllable of a word is never devoiced. The Tohono O'odham primary stress is always on the first syllable (Saxton 1983, Fitzgerald 1996).

[2] They claim that adjacency of [+COR] and [+high] is dispreferred in truncated forms.

In the following sections, the devoicing of phenomena presented in (3) through (7) above are analyzed.

### 3.1 Location of devoiced segment

If the devoicing phenomena are dealt with using alignment constraints, then there must be a systematic position of devoicing in the prosodic structure. For example, a final devoicing would be accounted for by ALIGN [- voice], PROWD, R (8). However, in Tohono O'odham devoicing does not occur in a single prosodic position. I explain why one devoicing environment cannot be determined in the following paragraphs.

(8) ALIGN [- voice], PROWD, R: Voiceless seglent is aligned with the right of prosodic word.

First, as a possibility, the position of devoicing might be the right of a morpheme or root. As shown in (9a) and (9b), however, devoicing is not always in a root. While (9a) shows that devoicing occur in the end of a root of a word, (9b) shows that devoicing does not need to occur at the end of the root of a word. Also, it does not have to do with the position of a morpheme in a word, as shown in (9c) and (9d). (9c) shows that devoicing can occur at the end of the leftmost morpheme, and (9d) shows that devoicing does not have to occur at the end of the leftmost morpheme in a word.

(9) Root/Morpheme ? (indicated by [ ])

| | | |
|---|---|---|
| a. | [jú:ki̥] 'rain' | [júki̥][to] 'stop raining' |
| b. | [ɨ́da] 'inside' | [ɨ́da][pi̥] 'to remove guts from an animal' |
| c. | [giˀi̥] 'fat' | [giˀi̥][pi̥] 'to remove fat' |
| d. | [nowi̥] 'arm' | [nowi̥][kam] 'one with a hand' |

Second, the devoicing does not always correspond to a foot boundary. In order to explain this, I must mention one problem regarding syllables which are elements in foot structure. It is not clear whether Tohono O'odham voiceless vowels are syllabic. I list both cases here in (10). (10a) and (10b) are two cases of voiceless vowels which are footed as syllables. In (10a), devoicing occurs at the right edge of the foot, while in (10b), it does not occur in the same position. Even if voiceless vowels were considered to be non-syllabic, it is impossible to determine the position of devoicing by prosodic position, as shown in (10c) and (10d).



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(10) Footing alternations

if voiceless vowels are syllabic

a. (juki̥)to

b. (giˀi)pi̥

if voiceless vowels are not syllabic

c. (juki̥to)

d. (giˀipi̥)

Therefore, the syllabification of a word containing a voiceless vowel is uncertain, and it is a problem for an analysis using an Alignment constraint. Even when we consider both cases, neither case will help determining the environment for the devoicing phenomena. An alternative solution is presented in the following section.

### 3.3 Voicing due to subglottal pressure drop

I make some assumptions here in order to solve this problem. There must be a cause that the devoicing occurs. Also, there must be a point where devoicing is targeted. The targets are (i) syllable-final (or coda) position in consonant devoicing, and (ii) unstressed [i] in vowel devoicing (cf. [i] [u] in Japanese Shibatani 1990).

I assume that the cause of devoicing is due to a pressure difference between the subglottal area and the supralaryngeal area. In (11), three axioms are established that will be referred to in the following analysis.

(11) Axioms

i) Voicing is easier when pressure below the glottis exceeds pressure above the glottis (Bernoulli's principle).

ii) Supralaryngeal pressure is higher for obstruents than for sonorants.

iii) Subglottal pressure falls following a stressed syllable (Lehiste 1970).

I make two specific assumptions for the O'odham devoicing. One is that the vowel [i] is targeted for devoicing in Tohono O'odham when in unstressed position. Another is that consonants in coda position are targeted for devoicing.

The schematic diagrams shown in (12) illustrate the relationship between devoicing and subglottal pressure drop.



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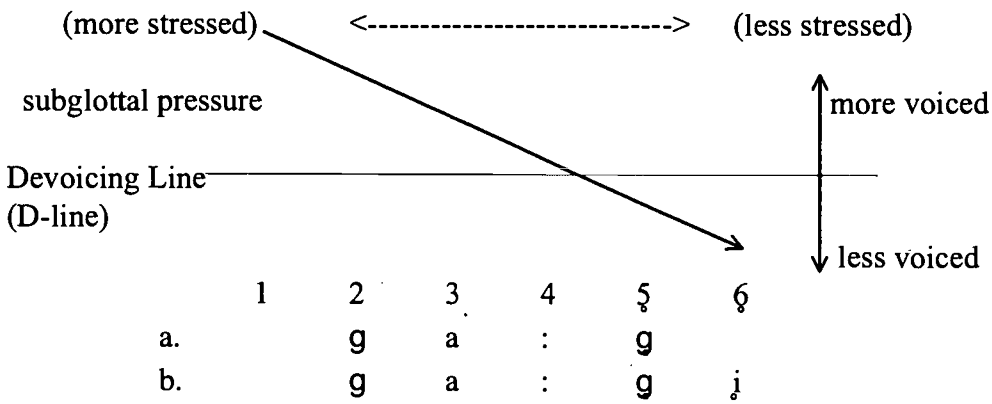
(12) Schematic illustration of devoicing and pressure interaction.

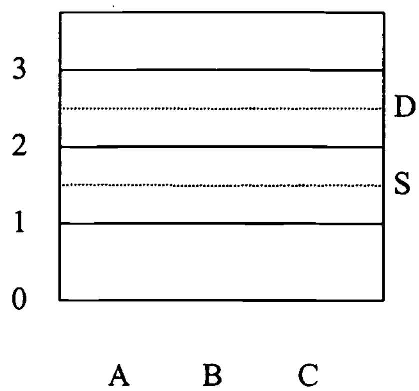



The diagonal line indicates the subglottal pressure drop. The higher the line, the greater the pressure. The dotted line shows the gradation of stress. Towards the left is more stressed, and towards the right is less stressed. The vertical line shows the gradation of voicing. The higher the line, the more voiced, and the lower the line, the less stressed. The horizontal line lies in the middle is called the Devoicing Line or D-line. When the subglottal pressure is above this line, the segment is pronounced as voiced. On the other hand, when the pressure is below the line, the segment is pronounced as unvoiced. Although the features utilized, stress, pressure and voicing, are all gradient, this D-line categorizes segments into two categories: stressed or unstressed, voiced or unvoiced.

This will treat the devoicing of both final consonants and final hi-front vowels well. However, there is a problem with this diagram. In O'odham, final sonorant consonants are not devoiced. The diagram above does not distinguish between obstruents and sonorants (Axiom ii).

In order to solve this problem, I add another assumption to the ones already presented above. That is, there is another line below D-line where sononants are recognized as voiceless. I call this the Sonorant Devoicing Line (S-line). The modified diagram is shown in (13).

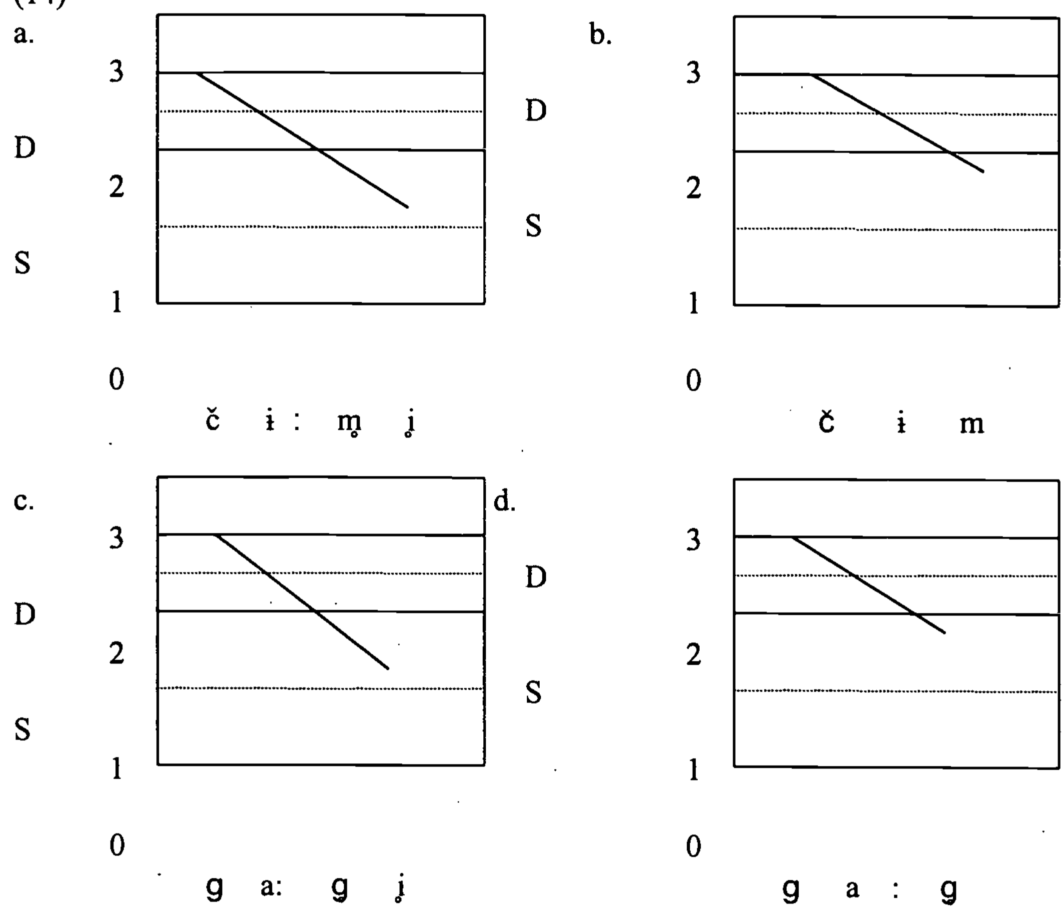
(13) Modified schematic illustration




The vertical axis is numbered from 0 to 3 to show the strength of subglottal pressure. The D-line is located between 2 and 3, and the S-line is located between 1 and 2. A devoiced vowel's subglottal pressure falls down to 0, and a devoiced consonant's subglottal pressure falls down to 2. Note that obstruents are devoiced when the subglottal pressure is below the D-line, and sonorants are devoiced when the subglottal pressure is below the S-line.

The graphs below (14) show the subglottal pressure drop and devoicing of the four words, [čɨ:m̥i̥][čɨm][ga:g̊i̥] and [ga:g]. Slope of the line for the subglottal pressure drop varies depending on the targeted segment (steeper for a word with a devoiced vowel than for a word with a devoiced consonant), and the length of the word (the shorter the word is the steeper the slope is).

(14)




Having two separate points for obstruent and sonorant devoicing accounts for the sonorant not being devoiced when it is at the end of a word, but devoiced when it is followed by a devoiced vowel. In the following section, I present an analysis in terms of OT. The assumptions and analysis given above are all reflected.

## 4 OT Account

In this section, an OT analysis is provided. My OT analysis departs from the standard OT in that candidates show gradient subglottal pressure. No such phonetic information is represented in standard OT. Different pressure levels are represented by three different font sizes (see 15) in the tableaux. Segments pronounced with the subglottal pressure above D-line are represented in the largest font size. Those pronounced with subglottal pressure between D-line and S-line is indicated by the middle font size. The smallest font size indicates the segments pronounced with subglottal pressure below S-line.

(15) **X**: above D-line

X: below D-line, above S-line
x: below S-line

The first constraint introduced here is [-V]<DLINE (16).

(16) [-V]<DLINE: Obstruents are devoiced when the subglottal pressure is below D-line (combination of axioms 1 and 2)

This constraint eliminates candidates with no final consonantal devoicing. In tableau (17), both candidates have final consonant that are below D-line. Candidate (a) is selected because the final consonant is devoiced, while candidate (b) fails because its final consonant is not devoiced.

(17) input: ga:g 'to look for'

| | | [-V]< DLINE |
|---|---|---|
| ☞ a | gá:g̊ | |
| b | gá:g | *! |

With this constraint, there is a problem for final sonorant consonant. Since sonorants behave differently from obstruents, candidates with sonorant final consonants are incorrectly evaluated as shown in (18). In the tableau below, candidate (b) is incorrectly selected for devoicing the last consonant. However, this last consonant is sonorant, and sonorants in O'odham should not be devoiced in final position. The correct candidate must be candidate (a). This suggests that the constraint [-V]<DLINE alone cannot account for the O'odham devoicing phenomena. Another constraint is introduced next.

(18) input: čɨm 'small'

| | | [-V]<DLINE |
|---|---|---|
| (☞) a | čɨ́m | |
| ☹b | čɨ́m̥ | |

The next constraint is SONORANTVOICING (SV).

(19) SV: Sonorants are voiced. (combination of Axioms 1 and 2 )



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This captures the analysis in the previous section that a sonorant consonant is still voiced even when its subglottal pressure is below the D-line only if it is above the S-line. The tableau below shows the evaluation with both constraints. Now, the correct candidate (a) is selected, because it satisfies SV. Candidate (b) is ruled out because the last consonant which is sonorant is devoiced.

(20) input: čɨ́m 'small'

| | | SV | [-V]<DLINE |
|---|---|---|---|
| ☞ a | čɨ́m | | |
| b | čɨ́m̥ | *! | |

So far, both devoicing of the final obstruent consonants and non-devoicing of the final sonorant consonants are accounted for.

There is another devoicing phenomenon that needs to be accounted for. When a consonant is followed by a devoiced vowel, the consonant must be devoiced, regardless of its sonority. With these two constraints given above there is a problem for a devoiced vowel preceded by a sonorant consonant. The problematic evaluation is shown in tableau (21) below. Candidate (a) is the correct output, but it is ruled out because it violates SV in that the last two segments are devoiced although they are sonorants. Candidate (b) viotales SV once. As a result, candidate (c) is selected because its last two sonorant segments do not violate SV.

(21) input: čɨ́:mi 'a species of cactus'

| | | SV | [-V]<DLINE |
|---|---|---|---|
| (☞) a | čɨ́:m̥i̥ | *!* | |
| b | čɨ́:mi̥ | *! | |
| ☹c | čɨ́:mi | | |

Another constraint is introduced below in order to solve this problem. The constraint is [-V]< SLINE, and it states that sonorant segments are devoiced when the subglottal pressure is below S-line.

(22) [-V]< SLINE: Sonorants are devoiced when the subglottal pressure is below the S-line (combination of Axioms 1 and 2).

The tableau below shows the correct evaluation of 'čɨ:mi'. Candidate (a), which is the correct output, is now optimal because it satisfies the [-V]< SLINE constraint which dominates SV. Candidates (b) and (c) fail since they violate the [-V]< SLINE constraint.

(23) input: čɨ:mi 'a species of cactus'

| | | [-V]<SLINE | SV | [-V]<DLINE |
|---|---|---|---|---|
| ☞ a | čɨ́:m̥i̥ | | ** | |
| b | čɨ́:mi̥ | *! | * | |
| c | čɨ́:mi | *!* | | |

With these constraints and this ranking, the sequence of obstruent and devoiced vowel is also accounted for. In (24), candidates (a) and (b) satisfy the constraint [-V]<SLINE by devoicing [i] due to the subglottal pressure being lower than S-line. Since candidate (c) violates it, this is ruled out. Candidate (a) is then chosen because it violates only one of the lower constraints, while candidate (b) violates both constraints.

(24) input: ga:gi

| | | [-V]<SLINE | SV | [-V]<DLINE |
|---|---|---|---|---|
| ☞ a | ga:g̊i̥ | | * | |
| b | ga:g̊i | | * | *! |
| c | ga:gi | *! | | * |

In sum, the constraints and their ranking are as shown in (25). [-V]< SLINE outranks SV and [-V]< DLINE, and ranking between SV and [-V]< DLINE is insignificant.

(25) Ranking: [-V]<SLINE >> SV, [-V]<DLINE

Although the analysis given above accounts only for Tohono O'odham devoicing phenomena, it is predicted that a language with a SV >> [-V]<DLINE >> [-V]<SLINE constraint hierarchy will have final obstruent devoicing but no vowel devoicing. This type of language is seen relatively commonly (e.g. German, Dutch, and Russian). It may not, however, predict the existence of languages that have only vowel devoicing, such as Japanese. Such languages devoice vowels

only in environments where they are preceded or surrounded by non-voiced segments. Therefore, the schema given above still accounts for such languages.

## 5 Conclusion

In this paper, devoicing in Tohono O'odham is accounted for by phonetic constraints in a phonological framework (OT). Three constraints, SV, [-V]<SLINE and [-V]<DLINE and their ranking shown in (25) select the correct outputs in Tohono O'odham devoicing. The appearance of voiceless vowels in O'odham is not systematic in terms of alignment. In other words, alignment constraints are irrelevant for an OT analysis in the case of devoicing phenomena. Obstruents and sonorants are recognized as voiceless when they fall below two different subglottal pressure levels: D-line and S-line. Also, devoicing is accounted for in this analysis in terms of subglottal pressure. I did not utilize the stiffness and spreadness of the glottis for this analysis (cf. Halle and Stevens 1971). Changes in these features would alter the basic picture of the devoicing range shown in the diagrams. My analysis shows that the devoicing is accounted for by the use of subglottal pressure drop without these glottal features.

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## Causative Formation in Kammu: Prespecified Features and Single Consonant Reduplication[*]

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### 1 Introduction

This paper investigates single consonant reduplication (henceforth SCR) and related affixation processes for the causative formation in Kammu, a language belonging to the Mon-Khmer branch of the Austro-Asiatic language family, spoken in northern Laos and in adjacent area of Vietnam, Thailand and China.[1] Figure (1) illustrates the process of SCR in the derivational framework, given by Svantesson (1992):

```
(1)                 p                 p
                    |                 |
      CVVC    →   CC-CVVC    →    CC-CVVC    →   ps.ʔəs
      | V |          | V |        |  | V |
      ʔ ə s          ʔ ə s       ʔəs ʔ ə s     (Svantesson 1992, 1983)
```

SCR like (1) has posed a problem for the analyses that claim that reduplication affixes should be regarded as a syllable (Broselow and McCarthy (1983), among others), since that kind of reduplication process needs to refer to a phonological

* I am greatly indebted to Bernard Tranel and Moira Yip for their insightful comments and suggestions. I am also grateful to Naomi Harada and Hidehito Hoshi for their helpful comments. Thanks also go to the participants of SWOT IV.

[1] The following phonemes are observed in Kammu (see Svantesson 1983 for detailed characterization).

| Vowels: | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| short | | | long | | | diphthongs | | |
| i | ɨ | u | i: | ɨ: | u: | ia | ɨa | ua |
| e | ə | o | e: | ə: | o: | | | |
| ɛ | a | ɔ | ɛ: | ʌ: | ɔ: | | | |
| | | | | a: | | | | |

| Consonants: | labial | dental/coronal | palatal | velar | glottal |
|---|---|---|---|---|---|
| stops: unaspirated | p | t | c | k | ʔ |
| aspirated | pʰ | tʰ | cʰ | kʰ | |
| implosive | b | d | | | |
| nasals | m | n | ɲ | ŋ | |
| fricatives | | s | | | h |
| lateral | | l | | | |
| trill | | r | | | |
| glides | w | | y | | |
| laryngealized glides | ʔw | | ʔy | | |

unit smaller than a syllable. On the other hand, it has served as a piece of evidence for positing a templatic specification for the reduplicant (Marantz (1982), Bell (1983)). In this paper, I argue, on the basis of syllable-final consonant reduplication in Kammu, that we can explain the pattern of SCR by interacting constraints and do away with a templatic specification of C in the framework of Optimality Theory (Prince and Smolensky (1993), McCarthy and Prince (1993a, b, 1994, 1995) (henceforth M & P), among others).

Other than the reduplication process in (1), Kammu has three kinds of causative formation (two prefixes ([p-], [pn-]) and an infix ([-m-])). No one has argued so far, by presenting a convincing analysis of their distribution, that all these causative affixes, including the one which induces SCR, are allomorphs of the same morpheme.[2] In this paper, I examine the distribution of these affixes and argue that they are allomorphs of the same morpheme, with their distribution being determined by the interaction of general constraints and some phonotactic constraints active in Kammu. I assume that the causative morpheme consists of [labial] and [nasal] features, and a reduplicative affix. What is characteristic about causative formation is that not all the features specified for the causative affix can be realized on the surface due to the dominant constraint curtailing the shape of prosodic word: the realization of the reduplicative affix is suppressed in some cases, and the [nasal] feature is sacrificed in other cases. The hierarchically ordered violable constraints in Optimality Theory enable us to successfully characterize a seemingly complicated distribution pattern of four allomorphs, which cannot be easily achieved in a rule-governed system.

The following is the constraint hierarchy I propose to characterize the distribution of the four allomorphs of the causative morpheme:

(2) Necessary Constraints :

MAX-IO [lab]
IDENT-BR
ALIGN — MAX-IO — MAX-BR — PHONOCON (2) — MAX-IO [nas]
R-ANCHOR
PHONOCON (1)

(3) a. Phonological Constraints (1)
MINIMAL WORD, ONSET,
IAMBIC FOOT, *ONSET [nas],
FOOT CONSTRAINT, *NUC/[laryn],
*LAB-LAB, *C-CLUSTER

b. Phonological Constraints (2)
*STRUCTURE/$\sigma$
*STRUCTURE/$\mu$

In (2), we see that various phonological constraints dominate MAX-BR, which captures the properties of the causative reduplication in Kammu that MAX-BR is sacrificed in various cases for the observance of the phonological constraints in

[2] Svantesson (1992) suggests the possibility of treating [p-] and [-m-] as allomorphs. See Chen (1988) for a similar analysis.

(3a). The constraints in (3b) play a role in choosing between [p]-prefixation and [pn]-prefixation, when the candidate with [pC]-prefixation violates more highly ranked constraints.

The organization of this paper is as follows. In section 2, we provide the basic data of causative formation. Section 3 deals with characteristic syllable structures in Kammu, which play important roles in determining the shape of outputs in causative formation. Section 4 presents an analysis of the four types of causative affixes within Optimality Theory. Section 5 summarizes the paper.

## 2 Basic Data[3]

As briefly mentioned in the previous section, Kammu has four types of causative affixes: three of them are prefixes and the other is an infix, as shown in (4): [4, 5]

(4)

• monosyllabic words CVV/CV(V)C →

(i) pC-: words with a minor syllable bearing tone
mec (`) → pc.mec (´ `)

(ii) a. p-: monosyllabic words with a consonant cluster
rəh (`) → prəh (´)

b. p-: words with a toneless minor syllable
ŋɔ:m (`) → p.ŋɔ:m (`)

(iii) pn-: words with a minor syllable bearing tone
sis (´) → pn.sis (` ´)

• words with toneless minor syllable C.CVV/C.CV(V)C →

(iv) -m- : words with a minor syllable bearing tone
s.ka:t (´) → sm.ka:t (´ ´)

---

[3] All the data in Kammu discussed in this paper are taken from Svantesson 1983, 1992.

[4] I will use terms such as minor/major syllables and sesqui-syllables to refer to the structure and its subparts in (i), following Svantesson (1983, 1992). Sesqui-syllables consist of a minor syllable (without a vowel) and a major syllable (with a vowel).

(i) Sesqui-Syllable

(Minor Syllable) Major Syllable
C (R). C V C

[5] Diacritics within parentheses indicate tone: (• ) corresponds to high tone and (• ) to low tone. The basic tonal pattern in Kammu is as follows: Here I assume that a syllable containing at least one mora is a tone bearing unit.

Single Syllable --- (H)/(L)/*(HL)/*(LH)
Sesqui-Syllable With Minor Syllable consisting of single consonant --- (H)/(L)/*(HL)/* (LH)
With Minor Syllable consisting of two consonants --- (HL)/(LH)/(LL)/*(HH)

The prefixes are attached to monosyllabic verbs, while the infix goes with sesqui-syllabic words. By attaching the prefix [pC-], we obtain sesqui-syllabic causative forms with a copy of the syllable-final consonant of the base in the second position of the minor syllable, as in (4i). The prefixation of [p-] is divided into two sub-cases. In one case, the resulting form ends up in a monosyllabic word with a consonant cluster, as in (4iia). In the other case, the prefixation of [p-] yields a word with a toneless minor syllable, as in (4iib). (4iii) illustrates [pn]-prefixation. By prefixing [pn-], we obtain sesqui-syllabic causative forms with a minor syllable bearing tone. The last type of causative formation involves the infix [-m-]. Infixation of [-m-] produces sesqui-syllabic forms with a minor syllable bearing tone, as in (4iv) .[6]

## 2.1 [pC]-Prefixation

The most unmarked way to form causative expressions is to attach the prefix [pC]-to the base, as exemplified in (5). This process involves copying of the syllable-final consonant onto the second position of the minor syllable. In (5a-d), copied consonants are stops, fricatives, nasals, and liquids, respectively.

| | | | | | | |
|---|---|---|---|---|---|---|
| (5) a. | la:k (`) | 'to tell lies' | pk.la:k (´`) | mec (`) | 'to hear' | pc.mec (´`) |
| b. | ro:s (`) | 'angry' | ps.ro:s (´`) | ʔə:s (`) | 'to cover' | ps.ʔə:s (´`) |
| c. | pa:n (`) | 'to drunk' | pn.pa:n (´`) | ma:n (`) | 'pregnant' | pn.ma:n (´`) |
| d. | ca:r (`) | 'thin' | pr.ca:r (´`) | kə:y (`) | 'to be used' | py.kə:y (´`) |

The consonants that do not undergo copying are the glottals [h, ʔ], and labials [p, m, w]. When the base ends with one of these sounds, other types of causative formation (such as [p]-/[pn]- prefixation) are chosen over [pC]-prefixation, as shown in the following subsections. This indicates that causative formation seeks to adopt [pC]-prefixation whenever possible, and that [p]-/[pn]-prefixation applies only if [pC]-prefixation is prohibited by other independently motivated constraints.

[6] What is worth mentioning here is that according to Svantesson (1983), if the root verb is bigger in size than a monosyllable or a sesqui-syllable with a toneless minor syllable, prefixation or infixation is not available but rather modal verbs /ʔəh/ (`) 'to make' and /ʔuun/ (`) 'to let, to give' are used to form causative expressions. This strongly suggests that the morphological process of causative formation is restricted by some phonological constraints regulating the prosodic size of words. Bernard Tranel (p.c.) pointed out to me that this sensitivity to the size of the base is reminiscent of the condition observed for the comparative/superlative formation (-er/-est vs. more/most) in English. I will leave the problem of selecting between periphrastic and affixal causative formation open, and will restrict myself to the analysis of affixal causative formation.



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## 2.2 [p]-Prefixation

A second type of causative formation, [p]-prefixation, is further divided into two subtypes. In the first type, the resulting causative expression yields the form of single syllable with a consonant cluster beginning with [p], as in (6a). In the other type, [p]-prefixation produces a sesqui-syllabic word with a minor syllable consisting of [p] alone, as in (6b) and (6c). The crucial difference between the two subtypes lies in the fact that in the first subtype, the combination of the prefix [p-] and the first consonant of the base verb yields licit consonant clusters in Kammu, while that is not the case in the second subtype.

| | | | | | | |
|---|---|---|---|---|---|---|
| (6) a. | rəh (ˋ) | 'to rise' | prəh (ˊ) | luh (ˊ) | 'to have a hole' | pluh (ˊ) |
| b. | ŋo:m (ˋ) | 'to weigh down' | p.ŋo:m (ˊ ˊ) | cra:p (ˊ) | 'to get stuck' | p.cra:p (ˊ ˊ) |
| c. | ka: (ˋ) | 'to climb' | p.ka: (ˋ) | cɨa (ˊ) | 'seed' | p.cɨa (ˊ) |

Notice here that the examples in (6a) and (6b) involve base verbs ending with glottals and labials, which are not attested in [pC]-prefixation. It seems plausible to consider that [p]-prefixation is adopted in these examples since [pC]-prefixation is not available for them.

## 2.3 [pn]-Prefixation

A third type of causative formation involves [pn]-prefixation, which yields a sesqui-syllabic form with a minor syllable consisting of [pn], as in (7). Here again, we observe that the base verbs in (7) end with consonants which cannot undergo syllable-final consonant reduplication in [pC]-prefixation. This also suggests that the same line of explanation as we provided for [p]-prefixation is applicable: [pC]- prefixation is unmarked and [pn]-prefixation emerges only when the former is unavailable.

| | | | | | | |
|---|---|---|---|---|---|---|
| (7) a. | mah (ˋ) | 'to eat' | pn.mah (ˊ ˋ) | kleʔ (ˋ) | 'husband' | pn.kleʔ (ˊ ˋ) |
| b. | tɨ:m (ˋ) | 'to believe' | pn.tɨ:m (ˊ ˋ) | nʌ:m (ˋ) | 'happy' | pn.nʌ:m (ˊ ˋ) |

## 2.4 [m]-Infixation

The fourth type of causative formation is [m]-infixation, which applies only to sesqui-syllabic base verbs and yields sesqui-syllabic forms with the infix [-m-] in the second position of the minor syllable.[7]

| | | | | | | |
|---|---|---|---|---|---|---|
| (8) | k.ses (ˊ) | 'to fall' | km.ses (ˋ ˊ) | t.lu:y (ˊ) | 'to hang' | tm.lu:y (ˊ ˋ) |
| | h.cɔʔ (ˊ) | 'thin' | hm.cɔʔ (ˊ ˋ) | s.kar (ˊ) | 'straight' | sm.kar (ˊ ˋ) |

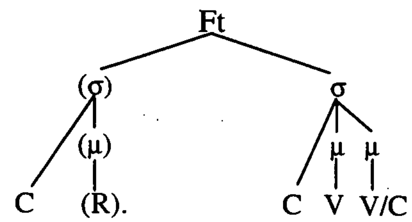
[7] The infix can be realized as the coronal nasal [n] or the palatal nasal [ɲ]. See Takeda 1997 for the relevant discussion.

None of the prefixes may occur with base verbs in (8). Since the infix [-m-] and the prefix [pn-] share [labial] and [nasal], it seems plausible to regard the infix [-m-] as an allomorph of the causative morpheme.

## 3 Syllable Structure in Kammu

First, let us consider the structure of basic words in Kammu, which is schematized in (9).[8] I regard as a nucleus the first moraic segment either in the minor or in the major syllable. Although consonants can appear in the onset or coda position of the major syllable in a fairly free manner, we have narrower restrictions on consonant clusters and on the combination of consonants which form a minor syllable.

(9)




V: vowels
R: resonants
C: consonants
(including R)

The segments that can form a minor syllable alone are [p, t, c, k, $c^h$, $k^h$, h, r]. If we have two consonants in the minor syllable, the second one must basically be either a liquid or a nasal.[9]

If we examine the structure in (9), we immediately notice that Kammu lacks patterns such as simple V, CV, and VC. The following is a list of constraints which are necessary to characterize the properties of basic words in Kammu.

(10) MINIMAL WORD: A prosodic word must be at least bimoraic.
(11) ONSET: A syllable must have an onset.
(12) FOOT CONSTRAINT: A foot must have a $\sigma_H$ . ($\sigma_H$ = head syllable)
(13) HEAD SYLLABLE CONSTRAINT: $\sigma_H$ must have a [-cons] segment.
(14) *NUCLEUS/[-sonorant]: [-sonorant] segments cannot appear in the nucleus position of the syllable.
(15) IAMBIC FOOT: A foot must be maximally iambic.

MINIMAL WORD in (10) explains why Kammu does not allow forms such as V or CV: They are not bimoraic. ONSET in (11) plays a role in excluding onsetless syllables such as V and VC. FOOT CONSTRAINT in (12) guarantees, in combination with HEAD SYLLABLE CONSTRAINT in (13), that a foot involves a

---

[8] See Gafos 1998 and Sloan 1988 for different approaches to minor syllables.

[9] Palatal nasal [ɲ], however, cannot show up freely in the second position of the minor syllable.

syllable which dominates [-cons], as in (16). They exclude feet without a vowel (e.g. CRC).

(16)

Ft<br>
|<br>
$\sigma_H$<br>
|<br>
$\mu_H$<br>
|<br>
[-cons] ($\sigma_H$ = head syllable; $\mu_H$ = head mora)

The constraint *NUCLEUS/[-son] in (14) belongs to a family of constraints *NUCLEUS/[F] and has the effect of excluding [-son] from the second position of the minor syllable. This explains the fact that only nasals and liquids can appear in that position in Kammu in the non-reduplicative context.[10]

IAMBIC FOOT in (15) ensures that a foot must be right headed in Kammu. It explains the absence of CVC.CR and CVC.CV in the language.[11] Furthermore, the qualification "maximally iambic" requires that the right hand side of the foot be salient enough in contrast with the left hand side of the foot. Here I claim that forms such as CV.CV and CR.CV are prohibited since they are not asymmetric enough.[12] In these forms, both sides of the foot have the same saliency in terms of the number of mora. Hence they are nonexistent in Kammu. One might wonder why then CV.CVC is not allowed. It is clear that CV.CVC is normally regarded as a licit iambic foot with the right syllable heavier than the left syllable. I assume here that there is a scale on stress patterns, as illustrated below.[13]

[10] See Takeda 1997 for the explanation of the obstruents occurring in the relevant position as a result of reduplication.

[11] This nicely accords with the fact that there is no suffixing process in Kammu. I am grateful to Moira Yip for bringing this point to my attention.

[12] What is worth mentioning here is that Kammu lacks CV syllables altogether, which is very rare cross-linguistically, considering that a CV syllable is the most unmarked of all possible syllables and prevalent among languages. The lack of CV syllables in Kammu can be derived from IAMBIC FOOT in this language. This suggests that syllable types allowed in a given language are not obtained simply by drawing an arbitrary line in the static markedness hierarchy of syllable types. But rather they are determined through interaction of several constraints. The reason why a CV syllable is prevalent in many languages is because it satisfies ONSET and NO CODA. With no other constraint, Kammu should have allowed CV syllables. But MINIMAL WORD excludes a word consisting of CV alone and IAMBIC FOOT rules out a word with a CV.CV or CV.CVC pattern, which altogether yields the total absence of CV syllables. I owe these observations to Moira Yip (p.c.).

[13] The scale in (17) is different from the one proposed by Prince (1990), which is shown below.

(i) a. Iambic. LH >> {LL, H} >> L  b. Trochaic. {LL, H} >> HL >> L

The difference between (17) and (i) lies in the status of the H syllable (CVC, in my notation). In this paper, I will just postulate the scale in (17) and leave justification and discussion on theoretical implications for future research.

(17) ← Kammu →|

0.CVC (>> C.CVC >> CR.CVC) >> CV.CVC >> CV.CV >> CVC.CV

← iambic trochaic →

Figure (17) illustrates a scale between the extreme iamb and the extreme trochee. In a language which does not allow the presence of minor syllables, only CVC and CV.CVC patterns emerge as an iambic foot. Kammu, however, has minor syllables attached to the major syllable, and C.CVC. and CC.CVC patterns can be realized as legitimate iambic feet. The CV.CVC pattern is excluded from the legitimate iambic feet, because of the constraint in (15).[14] The decision on where to draw a line separating a licit from an illicit one depends on each language, and in Kammu, the line should be drawn between CR.CVC and CV.CVC.

To sum up the observation, the size and shape of the basic words in Kammu are strictly regulated by the constrains listed in (10)-(15). Most of the constraints in (10)-(15) are undominated in Kammu, and importantly, the forms resulting from causative formation are also regulated by these constraints. The basic word forms allowed in the language are given below, for the sake of exposition.[15]

(18) a. CVV/CVC  b. C. CVV/C.CVC  c. CR. CVV/CR.CVC

## 4 An Optimality Theoretic Analysis

In this section, I explain the distribution of the four types of causative in terms of interacting constraints in Optimality Theory. First, let us consider the input of causative expressions. We have an overt realization of a [labial] feature in all the patterns of causative formation: [labial] is realized as [p] in [pC]-, [p]-, and [pn]-prefixation, and as [m] in [m]-infixation. However, a [nasal] feature and a reduplication affix show up in some cases but not in others. For example, the [nasal] feature is overtly realized only in [pn]-prefixation and [m]-infixation, and the reduplication process is visible on the surface only in the case of [pC]-prefixation. In spite of the partial realization of the [nasal] feature and reduplication affix, we still assume that the [nasal] feature and reduplication affix constitute a causative affix together with the [labial] feature, since that will enable us to provide a principled explanation of the distribution of the four types of causative affixes, with interacting constraints provided below.

In the first subsection, we provide an account for the [pC]-prefixation pattern and show that this prefixation pattern is the least marked. In the

[14] Griffith (1994) and Hayes (1995) observe that Cambodian also has an iambic pattern and exhibits a vowel reduction/ shortening in the minor syllable, reinforcing the durational contrast between syllables within the iambic foot.

[15] For a more detailed discussion on how to exclude other potential syllable structures, see Takeda 1997.

subsequent subsections, we reveal how the other affixation patterns emerge in place of [pC-] prefixation.

## 4.1 [pC]-prefixation

[pC]-prefixation involves SCR, by which the syllable-final consonant is copied onto the second position of the minor syllable prefixed to the base. The relevant data are partially repeated in (19):

(19) (=(5)) a. la:k (`) 'to tell lies' pk.la:k (´`) mec (`) 'to hear' pc.mec (´`)

Regarding [pC]-prefixation, we have several questions to address: (i) why do we have SCR rather than total reduplication?; (ii) why are the [labial] feature and the reduplicant realized overtly on the surface but not the [nasal] feature?; (iii) why does only the syllable-final consonant undergo reduplication?

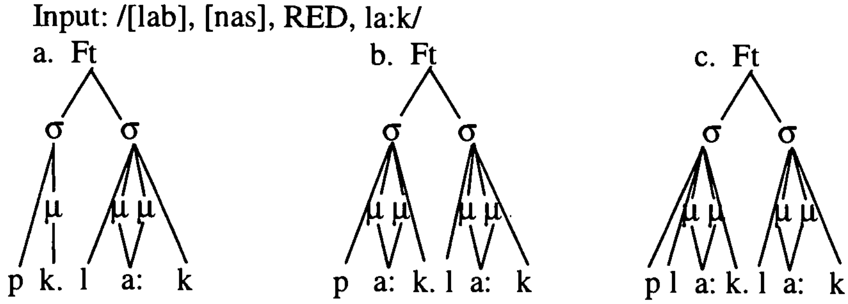
The answer to the first question is directly related to the shape of basic words in Kammu we discussed in the previous section. Recall here IAMBIC FOOT in (15): A foot must be maximally iambic. We assume that IAMBIC FOOT, as well as other constraints such as MINIMAL WORD and FOOT CONSTRAINT, is undominated, hence the ranking in (21).

(20) MAX-BR: Every segment of the base has a correspondent in the reduplicant. (M & P (1995))

(21) IAMBIC FOOT >> MAX-BR

Given the undominated status of IAMBIC FOOT, words of the form CV.CVC or CVC.CVC cannot be realized on the surface. This explains why the form resulting from total reduplication in (22c), is not possible: It involves no violation of MAX-BR, but crucially violates a highly ranked IAMBIC FOOT. The same constraint prohibits the reduplication of a nucleus vowel along with the final consonant in (22b).

(22) Input: /[lab], [nas], RED, la:k/



In either (22b) or (22c), the right syllable has the same number of moras as the left one and hence the entire foot does not qualify as a licit iambic foot in Kammu.[16] As a result, these two are ruled out due to the violation of IAMBIC FOOT, leaving the form [pk.la:k] in (22a) as the optimal output, although it involves more violations of MAX-BR.[17] Now the answer to the first question is clear. The choice of SCR over total reduplication follows from the ranking in which IAMBIC FOOT is ranked higher than MAX-BR.[18, 19]

Next, let us consider the second question: why does the [nasal] feature never show up on the surface in [pC]-prefixation, while the [labial] feature is realized overtly? This property of [pC]-prefixation is captured by positing the constraint ranking in (25). The definitions of the constraints in (25) are given in (23)-(24).

(23) MAX-IO [labial]: [labial] in the input has a correspondent in the output.[20]

(24) MAX-IO [nasal]: [nasal] in the input has a correspondent in the output.

(25) MAX-IO [labial] >> MAX-BR >> MAX-IO [nasal]

(26) Input: /[lab], [nas], RED, la:k/

| | MAX-IO [lab] | MAX-BR | MAX-IO [nas] |
|---|---|---|---|
| a.☞ pk.la:k | | ** | * |
| b. lk.la:k | *! | * | * |
| c. pn.la:k | | ***! | |

[16] I consider that the syllable-final consonant [k] in the base in (22) is not moraic. If it were, this would create a sufficient moraic asymmetry between the two syllables in (22b, c). The problematic candidates are excluded by a dominant constraint $*[\mu\mu\mu]_\sigma$. I owe this argument to Bernard Tranel (p.c.).

[17] Note here that *NUCLEUS/[-son] in (14) is violated in (22a). In fact, the occurrences of obstruents in the second position of the minor syllable are allowed in reduplication. See Takeda 1997 for the relevant discussion.

[18] Another possible way to characterize SCR, which Bernard Tranel (p.c.) pointed out to me, is to assume a constraint regulating the size of reduplicative affixes to minimum and to rank it higher than MAX-BR. Although this explanation is plausible, I will continue to attribute the presence of SCR to the dominant constraints on the shape of prosodic words in this language over MAX-BR, since the present analysis can explain the presence of SCR without resorting to the above constraint.

[19] I consider that the [labial] feature is realized as [p] but not as any other labial consonants, because [p] is the least marked [labial] consonant in Kammu. For the same reason, the [nasal] feature is realized as [n] in [pn]-prefixation. I am grateful to Hidehito Hoshi and Bernard Tranel for bringing this point into my attention.

[20] MAX-IO [lab] and MAX-IO [nas] in (23)-(24) are different from IDENT-IO [lab] and IDENT-IO [nas] in that the former two ensure the realization of the features in question, whereas the latter two prohibit the quality change of the relevant features.

The tableau in (26) validates the constraint ranking in (25). Among the three candidates in (26), the ranking in (25) correctly chooses [pk.la:k] in (a) as the optimal output. First, the most highly ranked MAX-IO [lab] excludes the form [lk.la:k] in (b), since it does not contain an overt realization of the [labial] feature. [pk.la:k] in (a) and [pn.la:k] in (c) tie with respect to MAX-IO [lab] and the choice between them is passed over to the next highly ranked constraint, MAX-BR. [pk.la:k] involves two violations of MAX-BR and is favored over the form [pn.la:k], since [pn.la:k] incurs three violations of MAX-BR. Also crucial here is the ranking between MAX-BR and MAX-IO [nas]. If the ranking were reversed, then [pn.la:k] in (26c) would be chosen as more harmonious, contrary to fact. Thus, (25) yields a correct output.

We still have other candidates to consider. First, let us examine the form [mk.la:k]. The constraint ranking in (25) wrongly selects [mk.la:k] over [pk.la:k] as the optimal output, since the former ties with the latter regarding MAX-IO [lab] and MAX-BR, and crucially satisfies MAX-IO [nas]. Here we need to prevent the [nasal] feature from being realized as [m] in the onset position. The important fact which seems relevant here is that Kammu does not have any minor syllables with nasals in the onset position. This leads us to assuming the following phonotactic constraint.

(27) *ONSET/[nas]: Nasals cannot appear in the onset position of the minor syllable.

The undominated status of the constraint in (27) explains both the ungrammaticality of [mk.la:k], and the absence of minor syllables beginning with nasals in Kammu. The ranking in (28), with the constraint in (27) newly added, enables us to obtain the appropriate form as an output. The problematic form [mk.la:k] is correctly ruled out due to the violation of *ONSET/[nas].

(28) *ONSET/[nas], MAX-IO [lab] >> MAX-BR >> MAX-IO [nas]

However, the revised constraint ranking in (28) still cannot exclude the potential form [km.la:k]. *ONSET/[nas], which plays a crucial role to rule out the form [mk.la:k], does not affect the form [km.la:k], since [km.la:k] has a [nasal] segment in the second position of the minor syllable, not in the onset position. The realization of a nasal consonant in the second position of the minor syllable is independently attested in Kammu, which means that [km.la:k] is not ruled out because of a phonotactic constraint violation. To resolve the problem, we resort to ALIGNMENT in (29). Ranking ALIGN higher than MAX-IO [nas], as in (30), will give us the correct result. Here we further assume that ALIGN and MAX-IO [lab] are undominated, since they never get violated.

(29) ALIGN (Red, R, σ, R): The right edge of the reduplicant must align with the right edge of a syllable. (M & P (1994))

(30) MAX-IO [lab], ALIGN >> MAX-BR >> MAX-IO [nas]

The problematic form [**km**.la:k] is ruled out as a violation of ALIGN and loses to the actual form [p**k**.la:k].

Although ALIGN in (29) guarantees that the reduplicated segment appears in the final position of the minor syllable, it does not answer the third question: why does the syllable-final consonant of the base but not consonants in other positions undergo copying? Even if we reduplicate the onset consonant onto the second position of the minor syllable, the resulting form in (31b) ties with the actual form in (31a) with respect to every relevant constraint observed so far.

(31) Input: /[lab],[nas], RED, la:k/

| | MAX-IO [lab] | ALIGN | MAX-BR | MAX-IO [nas] |
|---|---|---|---|---|
| a. p**k**.la:k | | | ** | * |
| b. pl.la:k | | | ** | * |

To capture the fact that only the syllable-final consonant of the base is reduplicated, we need to resort to RIGHT ANCHOR, which outranks LEFT ANCHOR.[21]

(32) {RIGHT, LEFT}-ANCHOR: Any element at the designated periphery of the base has a correspondent at the designated periphery of the reduplicant. (M & P (1995))

Given that R-ANCHOR plays a crucial role in choosing the actual form [pk.la:k] over [pl.la:k], one might argue that we can obtain the desired result in terms of R-ANCHOR, without invoking ALIGN. However, we still need ALIGN to exclude the potential candidate [p.**k**la:k]. If we simply replace ALIGN in (30) by R-ANCHOR, we obtain the ranking MAX-IO [lab], R-ANCHOR >> MAX-BR >> MAX-IO [nas]. The two candidates [p**k**.la:k] and [p.**k**la:k] tie with each other regarding relevant constraints, especially regarding R-ANCHOR, since the consonant at the right edge of the base correctly has a correspondent at the right of the reduplicant. What is crucial here is that the form [p.**k**la:k] incurs a violation of ALIGN, although it does not violate R-ANCHOR. This indicates that we need to keep ALIGN together with RIGHT ANCHOR as high-ranking constraints to correctly choose the actual form [pk.la:k] over [p.kla:k]. To recap, R-ANCHOR is responsible for reduplicating only the syllable-final consonant of the base in causative formation and ALIGN is responsible for the location of the reduplicant.

Before we go onto the next subsection, a brief mention of the forms resulting from [p]- and [pn]-prefixation is in order. First, let us examine the forms [p.la:k] and [pla:k], obtained by [p]-prefixation. In [p.la:k], [p] forms a minor

[21] L-ANCHOR plays no crucial role in Kammu. Assuming that L-ANCHOR is inactive, I ignore it in the discussion to follow.



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syllable by itself, and in [pla:k], [p] is incorporated into the syllable of the base. Both of them lose to the actual form [pk.la;k], since they involves more serious violation of MAX-BR. Here we have seen that MAX-BR plays a crucial role in ruling out a [p]-prefixation output.

Another potential candidate, [pn.la:k], produced by [pn]-prefixation requires a slightly more complicated argument. We need to consider two different candidates [pn.la:k] and [p$\mathbf{n}_1$.la:k$_1$] for the same surface sequence of segments. The segment [n] in [pn.la:k] is an overt realization of the feature [nasal] and [pn.la:k] thus does not involve a correspondent of the base, yielding severe violation of MAX-BR. On the other hand, [n] in [p$\mathbf{n}_1$.la:k$_1$] is a correspondent of the syllable-final consonant of the base, and at the same time manifests the feature [nasal]. Since [p$\mathbf{n}_1$.la:k$_1$] involves only two violations of MAX-BR, it is wrongly chosen as optimal.

We have two potential ways to exclude [p$\mathbf{n}_1$.la:k$_1$]. One is to resort to prohibiting coalescence, and the other is to take IDENT-BR into consideration. Restricting coalescence is not plausible in Kammu, since there are several instances of coalescence in causative formation.[22] In contrast, referring to IDENT-BR is more desirable, since reduplicated elements exactly match their correspondents in the base in their quality, and the values of the features of the reduplicant never undergo any change in causative formation. Here we assume IDENT-BR in (33) and place it in undominated position in the constraint ranking in (34), since it is not violable in any instances of causative formation.

(33) IDENT-BR: Reduplicant correspondents of a base [$\alpha$ F] segments are also [$\alpha$ F]. (M & P (1995))

(34) MAX-IO[lab], IDENT-BR >> MAX-BR >> MAX-IO [nas]

Given the constraint ranking in (34), the problematic form [p$n_1$.la:k$_1$] is ruled out as a violation of IDENT-BR, since the reduplicant [n] and its correspondent [k] in the base differ from each other in their feature values. Thus, it follows from the ranking in (34) that [pC]-prefixation rather than [pn]-prefixation provides us with the correct optimal form.

To sum up the discussion in this subsection, the ranking (I) IAMBIC FT >> MAX-BR provides an answer to the question as to why we have single consonant reduplication instead of total reduplication. The ranking (II) *ONSET/[nas], IAMBIC FT, MAX-IO [lab] >> MAX-BR >> MAX-IO[nas] explains why the prespecified feature [labial] and a reduplicative affix are overtly realized on the surface in [pC]-prefixation, but not the [nasal] feature. The reason why [pC]-prefixation reduplicates the syllable-final consonant of the base onto the syllable-final position of the minor syllable derives from the constraints (III) ALIGN (Red, R, $\sigma$, R), R-ANCHOR >> MAX-BR. Lastly, the constraint ranking (IV) IDENT-BR,

[22] See section 4.3 for relevant discussion.

MAX-IO [lab] >> MAX-BR >> MAX-IO [nas] accounts for why the reduplicant never undergoes quality change in [pC]-prefixation.

### 4.2 [p]-prefixation and [pn]-prefixation

In this subsection, we are concerned with the examples in which [p]- and [pn]-prefixation are preferred to [pC]-prefixation. [p]- and [pn]-prefixation take place basically when [pC]-prefixation is not applicable due to independent constraints. The choice between [p]- and [pn]-prefixation is made in terms of the ranking between *STRUCTURE and MAX-IO [nas], as presented below.

We begin with [p]-prefixation. As we observed in section 2, the prefix [p-] takes a simple syllable as its base and yields a simple syllable beginning with a consonant cluster or a sesqui-syllabic word with a toneless minor syllable. The relevant examples are repeated below, for convenience.

| | | | | | | |
|---|---|---|---|---|---|---|
| (35) (=(6)) | a. rəh (`) | 'to rise' | prəh (´) | luh (´) | 'to have a hole' | pluh (´) |
| | b. ŋo:m (`) | 'to weigh down' | p.ŋo:m (´ ´) | cra:p (´) | 'to get stuck' | p.cra:p (´´) |
| | c. ka: (`) | 'to climb' | p.ka: (`) | cɨa (´) | 'seed' | p.cɨa (´) |

Let us first consider why no reduplicant can occur on the surface in the causative form for the base verb [ka:] in (35c). The constraint ranking proposed in the previous section chooses the optimal form [p.ka:].

(36) MAX-IO [lab], IAMBIC-FT, R-ANCHOR >> MAX-BR >> MAX-IO [nas]

If the candidate involves the copy of a vowel, the rightmost segment of the base, as in [pa:.ka:], it incurs a violation of IAMBIC FOOT, which restricts the well-formed foot structure in Kammu. The form [p.ka:], in contrast, fulfills the requirement of IAMBIC FOOT and wins over [pa:.ka:]. Why then can we not reduplicate a consonant from the base, yielding the form [pk.ka:]? What is fatal about the form [pk.ka:] is a violation of R-ANCHOR. Since [pk.ka:] involves a copy of a consonant located in the left edge of the base, it violates the undominated constraint R-ANCHOR, and hence loses to the [p]-prefixed form [p.ka:]. What we obtain from the above discussion is that if the base verb ends with a vowel, the causative form cannot contain an overt realization of the reduplicative affix, because of the undominated constraints IAMBIC FOOT and R-ANCHOR.

The constraint ranking provided in the previous section, however, is not sufficient to predict the correct causative forms in (35a) and (35b). For example, the [pC]-prefixed form [ph.luh] is incorrectly chosen over the actual form [pluh], since the former involves less violations of MAX-BR. We need a constraint which properly excludes the unwanted candidate [ph.luh]. The important observation here is that the based in (35a, b) end with glottals or labials. If we apply [pC]-

prefixation to the examples ending with glottals or labials, the resulting forms will be excluded by the phonotactic constraints given below.

(37) *NUCLEUS/[laryngeal]: [laryngeal] segments cannot appear in the nucleus position of the syllable.

(38) *LAB-LAB: A syllable cannot contain two adjacent labial segments. [23]

(37) prevents glottals from occupying the nucleus position. (38) is necessary to explain the failure of copying [labial] sounds onto the second position of the minor syllable. (38) excludes sequences such as [pp], [pw], and [pm] from minor syllables. [24]

Suppose that these phonotactic constraints are undominated and outrank MAX-BR, as indicated in (39). This ranking provides us with desired results in producing causative forms for the base [rəh] and [ɲo:m]. The [pC]-prefixed form [ph.rəh] is ruled out as a violation of *NUC/[laryn], although it involves less violation of MAX-BR than the optimal form [prəh]. In a similar way, the [pC]-prefixed form [pm.ɲo:m] is excluded due to the violation of *LAB-LAB, and loses to the actual form [p.ɲo:m].

(39) *NUC/[laryn], *LAB-LAB >> MAX-BR

In both cases, the less harmonious form violates phonotactic constraints and loses to the optimal form, which involves more violations of MAX-BR. This explains why [p]-prefixation is favored over [pC]-prefixation in these cases.

However, we still need to elucidate why [p]-prefixation is preferred to [pn]-prefixation in these cases. We have two points to consider. The first point we need to explain is that [p]-prefixation is chosen over [pn]-prefixation when the base starts with consonants which can form a legitimate consonant cluster with [p] (e.g. [prəh] and [pluh]). The other point is that when the base begins with a non-consonant cluster forming consonant and ends with a consonant which will induce a phonotactic constraint violation with [pC]-prefixation, either [p-]- or [pn]-

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[23] Given the fact that Kammu does not allow a sequence of palatal consonants (e.g. *[cc], *[cs], *[cɲ], and *[cy]), it seems plausible to argue that *PALATAL-PALATAL is active in Kammu. This further leads us to consider that *LABIAL-LABIAL and *PALATAL-PALATAL are subsumed under the family of constraints *PLACE-PLACE, which might in turn be incorporated into the more general constraint regulating the OCP phenomenon. While *LABIAL-LABIAL and *PALATAL-PALATAL are inviolable, *CORONAL-CORONAL and *VELAR-VELAR are violable, and we can observe several examples in which the sequence of coronal consonants or velar consonants forms a minor syllable. This fact suggests the following ranking.

i) *LABIAL-LABIAL, *PALATAL-PALATAL >> MAX-BR >> *CORONAL-CORONAL, *VELAR-VELAR

[24] *LAB-LAB regulates the sequence of consonants. The sequence of a vowel and a consonant falls outside of this constraint.

prefixation is basically applicable, leaving the choice between them to other factors (e.g. [p.ŋo:m] vs. [pn.nʌ:m]).

To deal with the first point, let us assume the following constraints.

(40) a. *STRUCTURE/σ: Do not build a syllable.
b. *STRUCTURE/μ: Do not build a mora. (Cf. Zoll 1993, Hewitt 1995)

The constraint in (40a) guarantees that we syllabify segments into the least number of syllables whenever possible, whereas the constraint in (40b) ensures that a toneless minor syllable (without a mora) is preferred to a tone-bearing minor syllable (with a mora). Suppose here that *STRUC/σ is ranked lower than MAX-BR, as in (41).

(41) *NUC/[laryn], *LAB-LAB >> MAX-BR >> *STRUCTURE/σ >> MAX-IO [nas]

Given a base verb [rəh], all the relevant candidates [prəh], [p.rəh], and [pn.rəh] tie with respect to MAX-BR and the decision is passed over to the next constraint, *STRUC/σ. Both [p.rəh] and [pn.rəh] contain two syllables and hence lose to [prəh], which involves only one syllable.

The justification for the ranking in (41) comes from the example of [pC]-prefixation. If the order of MAX-BR and *STRUC/σ were reversed, then we would obtain the incorrect result: [pla:k] is wrongly chosen over [pk.la:k] for the base [la:k], since the former involves less syllables than the latter. Hence MAX-BR must dominate *STRUC/σ.

Next, let us consider the second type of [p]-prefixation, in which [p] by itself constitutes a minor syllable. The reason why [p] cannot be incorporated into the base in the same way as [prəh] is that possible consonant clusters are restricted in Kammu, as depicted in (42).

(42) *C-CLUSTER: No consonant clusters in the onset position of the major syllable are allowed except for the following: [pl, pr, ph, tr, th, cr, ch, jr, kl, kr, kw, kh, hm, hn, hɲ, hl, hr, hw, hy, kʰw].

(43) *C-CLUSTER >> MAX-BR >> *STRUCTURE/σ >> MAX-IO [nas]

Given the undominated status of (42), the candidate parallel to [prəh] is disallowed for the base /ŋo:m/, since the onset consonant cluster [pŋ] is not permitted in Kammu. Hence, [p.ŋo:m] wins over [pŋo:m].

Although we succeed in excluding the form [pŋo:m] in terms of *C-CLUSTER, the constraint ranking in (41) wrongly chooses the [pn]-prefixed form [pn.ŋo:m] as optimal: [p]-prefixed form [p.ŋo:m] loses to [pn.ŋo:m] with respect to MAX-IO [nas], although the two forms have an equal number of violations regarding MAX-BR and *STRUC/σ. How can we choose the [p]-prefixed form over the [pn]-prefixed form? Here the other *STRUCTURE constraint comes into





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play. Suppose that *STRUC/μ is added to the constraint ranking in (41). We obtain the ranking in (44).

(44) *LAB-LAB, *NUC/[laryn] >> MAX-BR >> *STRUCTURE/σ, *STRUCTURE/μ >> MAX-IO [nas]

The crucial ranking is the one between *STRUC/μ and MAX-IO [nas]. The form [p.ŋo:m] contains two moras and the other form [pn.ŋo:m] involves one more mora, inducing a severer violation of *STRUC/μ. As a result, [p.ŋo:m] is chosen, as desired.

The constraint ranking in (44) also provides us with an actual form for the examples in (35c), where the base verb ends with a vowel: [ka:]. The form [p.ka:] violates *STRUC/μ less than [pn.ka:] and hence wins against [pn.ka:]. If this ranking between *STRUC/μ and MAX-IO [nas] is reversed, the resulting ranking will choose [pn.ŋo:m] and [pn.ka:] as optimal. In fact, this reversed ranking is at work when we get [pn]-prefixed forms.

Let us take a brief look at the basic data of [pn]-prefixation, repeated below.

| | | | | | | |
|---|---|---|---|---|---|---|
| (45)(=(7)) | a. mah (`) | 'to eat' | pn.mah (´`) | kleʔ (`) | 'husband' | pn.kleʔ (´`) |
| | b. tɨ:m (`) | 'to believe' | pn.tɨ:m (´`) | nʌ:m (`) | 'happy' | pn.nʌ:m (´`) |

Just as in the case of [p]-prefixation, the base verbs of [pn]-prefixation end with segments which cannot occur in the second position of the minor syllable. The constraint ranking in (46) will provide us with the correct result for the base /mah/. Among the relevant candidates [ph.mah], [p,mah], and [pn.mah], the [pC]-prefixed form [ph.mah] is ruled out as a violation of *NUC/[laryn].

(46) *NUC/[laryn], *LAB-LAB >> MAX-BR >> *STRUC/σ >> MAX-IO [nas] >> *STRUC/μ
re-ranking

What plays a crucial role in choosing the [pn]-prefixed form over [p]-prefixed form is the ranking of MAX-IO [nas] placed higher than *STRUC/μ, which I argue is obtained through re-ranking. To conclude, the choice between [p]-prefixation and [pn]-prefixation depends upon the ranking between MAX-IO [nas] and *Struc/μ. If MAX-IO [nas] is highly ranked, then [pn]-prefixation takes place and if the ranking is reversed, the [p]-prefixed form emerges. The reason why these two types of prefixation do not freely alternate is arguably because the choice between them has been lexicalized.[25]

[25] More precisely, I consider that there is an unmarked constraint hierarchy, and that some lexical items are marked as assessed by a slightly different constraint ranking. See Prince and Smolensky 1993, Tranel 1996, and Inkelas, Orgun and Zoll 1996 for related discussion.





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### 4.3 [m]-infixation: Coalescence of [lab] and [nas] Features

[m]-infixation basically applies to sesqui-syllabic words with a toneless minor syllable and yields sesqui-syllabic words with a tone-bearing minor syllable. The relevant data are partially repeated below.

(47)(=(8)) k.ses (´) 'to fall' km.ses (` ´) t.lu:y (´) 'to hang' tm.lu:y (´ `)

We can regard the infix [m] as resulting from coalescing the [labial] and [nasal] features of the causative morpheme, which are substantiated as separate segments in [pn]-prefixation. We attempt to clarify the properties of [m]-infixation by addressing the following questions: (i) why does infixation rather than prefixation take place; (ii) why do other types of causative formation not apply to the bases in (47)?

The answer to the first question straightforwardly follows from the ranking established above. If [m] is prefixed to the base /ses/, then the resulting form [mk.ses] will violate a phonotactic constraint *ONSET/[nas], which is undominated as shown in (48).

(48) *ONSET/[nas], MAX-IO [lab] >> MAX-BR >> MAX-IO [nas]

Thus, we obtain infixation [km.ses] rather than prefixation due to the constraint *ONSET/[nas].

The answers to the second question are also provided by the ranking obtained in the previous discussion. First, let us consider [pC]-prefixation.

(49) IAMBIC FT, MAX-IO [lab] >> MAX-BR >> MAX-IO [nas]

Among the potential outputs created by [pC]-prefixation, [k.ps.ses] and [ps.k.ses] are ruled out as a violation of IAMBIC FOOT, although they incur less violations than the optimal output regarding MAX-BR.[26] Similarly, the form [ks.ses] violates MAX-BR less severely than the actual form [km.ses] but lacks the overt realization of the labial feature. As a result, the [m]-infixed form survives as optimal. From this example, we can conclude that IAMBIC FOOT and MAX-IO [lab] play crucial roles in preventing [pC]-prefixation from applying to sesqui-syllabic bases.

Before we proceed to examining [p]-prefixed forms and [pn]-prefixed forms, there is another candidate we need to consider regarding [pC]-prefixation:

---

[26] Note that we need to exclude the candidates where [k.ps.ses] and [ps.k.ses] are parsed k.[ps.ses]/ps.[k.ses] ([...] indicates a foot), respectively. Since these candidates satisfy IAMBIC FOOT, the proposed constraint ranking alone cannot provide a correct result. We need to ensure that the word consists of an iambic foot and nothing more. Here I assume, following Bernard Tranel (p.c.), that a high-ranking constraint PARSE-SYLLABLE prohibiting unfooted syllables is operative to exclude the unwanted candidates.

[ps.ses]. The candidate [ps.ses] is wrongly chosen as optimal against the ranking in (49) over the actual form [km.ses] since [ps.ses] incurs less violations of MAX-BR, although it fails to realize one segment originally present in the input. The problem here lies in the absence of MAX-IO with respect to the root in the ranking. Since MAX-IO with respect to the root is never sacrificed to satisfy MAX-BR, MAX-IO must dominate MAX-BR. With this necessary modification, we obtain (50).

(50) IAMBIC FT, MAX-IO[lab] >> MAX-IO >> MAX-BR >> MAX-IO[nas]

The modified ranking in (50) correctly predicts the [m]-infixed form as optimal. The candidate with a reduplicated consonant in [ps.ses] loses to the [m]-infixed form [km.ses] since [ps.ses] violates the highly ranked constrain MAX-IO.

The ranking in (50) also excludes the [p]-prefixed form and the [pn]-prefixed form, and explains why the candidate with coalescence in [km.ses] is most harmonious. The [pn]-prefixed form [pn.ses] which realizes both [labial] and [nasal] as separate segments, involves a fatal violation of MAX-IO, and the [p]-prefixed form [pk.ses], which preserves the segments of the base in the input, is ruled out because of the violation of MAX-IO[nas]. The [m]-infixed form [km.ses] successfully retains the segments of the base in the input while realizing [labial] and [nasal] on the surface. Hence [km.ses] is optimal.

We have now demonstrated that for the sesqui-syllabic base verbs in (47), given the constraint ranking established in (2) with MAX-IO added, the three types of prefixation yield less harmonious forms and accordingly, the form produced by infixation is chosen as optimal. This result, in turn, suggests that the constraint ranking developed originally to explain that the prefixation patterns is appropriate.

## 5 Summary

In this paper, I have argued that the four types of causative affixes in Kammu are allomorphs of the same morpheme and that their distribution can be explained through interaction of hierarchically ordered constraints. In doing so, I have shown that SCR in causative formation in Kammu can be dealt with without assuming a templatic specification.

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Roots and Correspondence:
Denominal Verbs in Modern Hebrew

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## 1 Introduction

Modern Hebrew exhibits a derivational process known as *Denominal Verb Formation* (DVF) whereby a base form, usually a noun, may become a verb. This process has been analyzed by several researchers (Bat-El 1994, Gafos 1995, Sharvit 1994) but to date a comprehensive, principled account has not been proposed. In this paper, it is my aim to present such a principled account of DVF, within Optimality Theory (Prince & Smolensky 1993). This account crucially relies on the consonantal *root*, arguing against the proposal of Bat-El (1994) that the root plays no role in DVF.

In addition, I propose to capture the well known effects of left-to-right spreading attested throughout Semitic (McCarthy 1979, 1981, et seq.) using a new form of Anchor constraints. These new Anchor constraints will be useful in accounting for cases of consonant doubling, which is attested in a subset of Modern Hebrew denominal verbs. Finally, I show that Bat-El's (1994) arguments against the consonantal root can be recast as reasons to adopt a separate dimension of correspondence relations in the analysis: namely, the dimension of Output-Output Correspondence, following work of, e.g., Benua (1995, 1997) and Burzio (1996).

## 2 Data

All denominal verbs in Modern Hebrew are bisyllabic. However, within this set of verbs there exists an interesting variation. The range of denominal verbs in Modern Hebrew may be divided into two sets: biliteral forms (forms whose bases contain two consonants), and forms with three or more consonants.

### 2.1 Biliteral forms

Biliteral denominal verbs exhibit a variation in possible surface patterns. As seen in (1), consonant doubling involves copying the second base consonant.

(1) $C_1iC_2eC_2$ (consonant doubling)

| | *Base* | *Gloss* | *Denominal verb* | *Gloss* |
|---|---|---|---|---|
| (a) | dam | 'blood' | dimem | 'to bleed' |
| (b) | xad | 'sharp' | xided | 'to sharpen' |
| (c) | mana | 'portion' | minen | 'to apportion' |

Consider now the forms in (2), which involve the epenthesis of the palatal glide [j] as the medial consonant in the related denominal verbs.

(2) $C_1iyeC_2$ (glide epenthesis)

| | *Base* | *Gloss* | *Denominal verb* | *Gloss* |
|---|---|---|---|---|
| (a) | bul | 'stamp' | bijel | 'to stamp' |
| (b) | gis | 'column, corps' | gijes | 'to conscript' |
| (c) | buΣa | 'shame' | bijeΣ | 'to put to shame' |

The final case involving biliteral bases is what I term total reduplication. As shown in (3), here we find two copies of each base consonant in each denominal verb.

(3) $C_1iC_2C_1eC_2$ (total reduplication)

| | *Base* | *Gloss* | *Denominal verb* | *Gloss* |
|---|---|---|---|---|
| (a) | kav | 'line' | kivkev | 'to draw a dotted line' |
| (b) | nim | 'sleepy' | nimnem | 'to doze' |
| (c) | mila | 'word' | milmel | 'to gabble' |

## 2.2 Cluster Transfer Effects (≥3-literal forms)

The second class of denominal verbs have more than three consonants in their related bases. These forms typically involve consonant clusters, which, as pointed out originally by Bat-EL (1994), are usually preserved. This is illustrated below, in (4)-(8). Note that the only exception to the generalization regarding cluster preservation is the form in (4).

(data from Bat-El 1994)

| (4) | *Base* | *Gloss* | *Denominal verb* | *Gloss* |
|---|---|---|---|---|
| | blof | 'bluff' | bilef | 'to bluff' |

| (5) | *Base* | *Gloss* | *Denominal verb* | *Gloss* |
|---|---|---|---|---|
| | faks | 'facsimile' | fikses | 'to send a fax' |

| (6) | *Base* | *Gloss* | *Denominal verb* | *Gloss* |
|---|---|---|---|---|
| (a) | praklit | 'lawyer' | priklet | 'to practice law' |
| (b) | Σravrav | 'plumber' | Σrivrev | 'to plumb' |



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| (7) | *Base* | *Gloss* | *Denominal verb* | *Gloss* |
|---|---|---|---|---|
| (a) | guΣpanka | 'seal' | giΣpenk | 'to seal' |
| (b) | nostalgia | 'nostalgia' | nistelg | 'to be nostalgic' |

| (8) | *Base* | *Gloss* | *Denominal verb* | *Gloss* |
|---|---|---|---|---|
| (a) | transfer | 'transfer' | trinsfer | 'to transfer' |
| (b) | streptiz | 'striptease' | striptez | 'to perform a striptease' |

Bat-El (1994) notes that in Modern Hebrew, these verbs could have surfaced with clusters that differ from those in their bases if such clusters do not violate the Sonority Sequencing Principle (SSP); e.g., *[pirklet] instead of [priklet]; but such forms are never attested; consonant clusters are always preserved (except for (4)). These facts are taken by Bat-El as evidence against the consonantal root, a unit traditionally given morphemic status in all Semitic languages. Bat-El argues, however, that if DVF simply involved extraction of root consonants from a base noun, information regarding adjacency of consonants in the base is lost. Cluster preservation, for Bat-El, therefore, suggests that no consonantal root is extracted, and that the base forms themselves serve as the inputs to DVF. Rather than adopt this approach, I claim that DVF is dependent on the consonantal root. My OT analysis will account for cluster preservation through a high-ranking Output-Output Correspondence constraint on CONTIGUITY.

## 3 OT Analysis

In this section I present my OT-based analysis of DVF. I will first provide an account of consonant doubling, through the use of special Anchor constraints I dub "Strong-Anchor". These constraints explain why it is always the right consonant that gets copied (a phenomenon that is widespread throughout the Semitic language family).

### 3.1 Consonant doubling

In order to satisfy constraints on the shape of stems in Hebrew, denominal verbs may opt for a range of patterns. The first of these that we have seen is consonant doubling. However, if we start with a base noun that has two consonants, and we are compelled to double one of these, it is only the rightmost consonant that may double. In order to account for this I propose a new set of Anchor constraints, based on McCarthy & Prince's (1995) original conception of Anchoring, which is presented below in (9), along with a table illustrating its satisfaction and violation.



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(9) ANCHOR-L(EFT)

$[(x = \text{Edge}(S_1, L)) \ \& \ (y = \text{Edge}(S_2, L))] \rightarrow [x\Re y]$

where "$x\Re y$" means "x and y are in a correspondence relation."

| ANCHOR-L satisfied: | ANCHOR-L violated: |
|---|---|
| $S_1$: $[_L\ \mathbf{b}_1\ a_2\ d_3\ u_4\ p_5\ i_6\ ]_R$ | $S_1$: $[_L\ \mathbf{b}_1\ a_2\ d_3\ u_4\ p_5\ i_6\ ]_R$ |
| $S_2$: $[_L\ \mathbf{b}_1\ a_2\ d_3\ u_4\ p_5\ i_6\ ]_R$ | $S_2$: $[_L\ a_2\ \mathbf{b}_1\ d_3\ u_4\ p_5\ i_6\ ]_R$ |

I propose a new set of Anchoring constraints, which have stronger prohibitions than normal Anchoring. I term this new constraint STRONG-ANCHOR. Its definition is given in (10), and is followed by an illustrative table.

(10) S(TRONG)-ANCHOR- L(EFT)

$[(x = \text{Edge}(S_1, L)) \ \& \ (x\Re y)] \rightarrow [y = \text{Edge}(S_2, L)]$

| S-ANCHOR-L satisfied: | S-ANCHOR-L violated: |
|---|---|
| $S_1$: $[_L\ \mathbf{b}_1\ a_2\ d_3\ u_4\ p_5\ i_6\ ]_R$ | $S_1$: $[_L\ \mathbf{b}_1\ a_2\ d_3\ u_4\ p_5\ i_6\ ]_R$ |
| $S_2$: $[_L\ \mathbf{b}_1\ a_2\ d_3\ u_4\ p_5\ i_6\ ]_R$ | $S_2$: $[_L\ \mathbf{b}_1\ a_2\ \mathbf{b}_1\ d_3\ u_4\ p_5\ i_6\ ]_R$ |

(10) states that for an input-initial element, *every* correspondent of that element must be initial in the output. Doubling of input-initial elements is prohibited by S-ANCHOR-L. Let's now reconsider the Hebrew data, where we have seen that in the cases of consonant doubling, the rightmost consonant doubles. This is evidence that in addition to S-ANCHOR-L, we also need a (violable) constraint prohibiting input-final elements from doubling:

(11) S-ANCHOR-R(IGHT)

$[(x = \text{Edge}(S_1, R)) \ \& \ (x\Re y)] \rightarrow [y = \text{Edge}(S_2, R)]$

(11) is the mirror image of (10) in that it refers to right edges instead of left edges. The ranking in (12), which I propose is universal throughout Semitic, will force doubling of the rightmost consonant whenever doubling is forced.

(12) *Ranking prohibiting initial consonant doubling and compelling final consonant doubling:*

S-ANCHOR-L » S-ANCHOR-R

### 3.2 What is in the input?

Of course, a crucial issue here is the input to denominal verb formation in Modern Hebrew. My claim is that the consonantal root of the base is taken as the input, as



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opposed to the entire base. This approach is motivated mainly by the existence of polysyllabic bases, such as [mana] 'portion' above, where the base is a CVCV sequence and the resulting verb ([minen] 'to apportion') is identical in shape to the verbs whose bases are CVC. Thus, the input consists of the consonants, as well as the verbal morphology, which consists of the vowels /i e/.

Another issue that arises in connection to the input is the bisyllabic nature of all denominal verbs. How are we to arrive at this bisyllabic output in every case? Is it truly a coincidence that the verbal morphology contributes two vowels to the input, and that the output in every case is two syllables? Previous researchers have attributed such effects to templates, whose existence has recently been questioned in general (e.g., Prince 1997, Spaelti 1997) and for Semitic (Bat-El 1994). We will see that in my analyses below the bisyllabic output is unavoidable, given the constraints appealed to. Further work is necessary to determine exactly which principles are at work in setting prosodic restrictions in DVF.

### 3.3 Other constraints

The analysis requires the use of the following constraints:

(13) INTEGRITY (McCarthy & Prince 1995)
No element of the input has multiple correspondents in the output.
("No copying/doubling")

(14) MAX-IO
Every element of the input has a correspondent in the output.
("No deletion")

(15) DEP-IO
Every element of the output has a correspondent in the input.
("No epenthesis")

(16) ONSET (Prince & Smolensky 1993)
Every syllable has an onset.

(17) REALIZE-M(ORPHEME) (Gnanadesikan 1997, Rose 1997, after Samek-Lodovici 1993)
Any morpheme in the input must have some realization in the output.

In (18) I illustrate the analysis of a case of consonant doubling, showing the use of two of the above constraints.

(18) [dimem] 'to bleed from base [dam] 'blood'

| d m + i e | REALIZE-M | MAX-IO |
|---|---|---|
| a. dam | *! | ** |
| ☞ b. dimem | | |

(19) shows a tableau motivating the ranking ANCHOR-R » INTEGRITY:

(19)

| d m + i e | ANCHOR-R | INTEGRITY |
|---|---|---|
| a. dime | *! | |
| ☞ b. dimem | | * |

Next, we see the interaction of these two constraints with the STRONG-ANCHOR constraints.

(20) ANCHOR-R, S-ANCHOR-L » S-ANCHOR-R, INTEGRITY

| d m + i e | ANCHOR-R | S-ANCHOR-L | S-ANCHOR-R | INTEGRITY |
|---|---|---|---|---|
| a. didem | | *! | | * |
| ☞ b. dimem | | | * | * |

As seen in (20), the crucial ranking between S-ANCHOR-L and S-ANCHOR-R guarantees that if doubling must take place, only root-final consonants are doubled. Why is it so imporant to refer to *root* elements here? Suppose that instead of the root, we took as input to the denominal verb the entire base form. Let us take, for instance, the form [minen] 'to apportion', whose base is [mana] 'portion'. The following tableau illustrates the problem:

(21) wrong prediction with full base [mana] as input:

| mana + i e | ANCHOR-R | S-ANCHOR-L | S-ANCHOR-R | INTEGRITY |
|---|---|---|---|---|
| ☞ a. minen | *! | | | * |
| b. mimen | *! | * | | * |
| c. mimena | | *! | | * |
| d. mamanine | *! | * | * | ** |
| ❽ e. mananinena | | | * | ***** |



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We make the right prediction, however, when just the root is taken as the input:

(22) correct prediction with root /m n/ as input:

[minen] 'to apportion' from [mana] 'portion'

| m n + i e | ANCHOR-R | S-ANCHOR-L | S-ANCHOR-R | INTEGRITY |
|---|---|---|---|---|
| ☞ a. minen | | | * | * |
| b. mimen | | *! | | * |
| c. mimena | *! | * | | * |
| d. mamanine | *! | * | * | * |
| e. mananinena | *! | | * | *** |

Returning now to [dimem], let us consider other potential candidates and how these are ruled out by ONSET and DEP-IO:

(23) ONSET, DEP-IO: undominated

| d m + i e | ONSET | DEP-IO | S-ANCHOR-R | INTEGRITY |
|---|---|---|---|---|
| a. diem | *! | | | |
| b. dijem | | *! | | |
| ☞ c. dimem | | | * | * |

Interestingly, the analysis presented here is *contra* Gafos (1995) and Sharvit (1994) in that no reduplicative morpheme is involved in consonant doubling or in glide epenthesis. Rather, consonant doubling and glide epenthesis are both seen as ways of fulfilling a bisyllabic template without a true reduplicative morpheme. Such a morpheme will be invoked for total reduplication below, but first, let's examime how the analysis accounts for cases involving glide epenthesis.

### 3.4 Glide Epenthesis

I analyze cases of glide epenthesis as involving constraint reranking. As we saw above, the constraint DEP-IO must be high-ranking in the cases of consonant doubling; specifically, it must at least outrank INTEGRITY. However, in the cases of glide epenthesis, this constraint is low-ranking; specifically, it is outranked by INTEGRITY. This is because in cases where glide epenthesis is attested, it is worse to copy a consonant than to insert phonological material with no input correspondent. (24) illustrates the analysis of such forms.



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(24) Glide epenthesis

[bijel] 'to stamp' from [bul] 'stamp'

| b l + i e | ONSET | S-ANCHOR-L | ANCHOR-R | INTEGRITY | S-ANCHOR-R | DEP-IO |
|---|---|---|---|---|---|---|
| a. bile | | | *! | | * | |
| b. bilel | | | | *! | * | |
| c. bibel | | *! | | * | | |
| d. biel | *! | | | | | |
| ☞ e. bijel | | | | | | * |

Again, with the *base* as input instead of the root, we would make the wrong prediction when it comes to CVCV bases: there would be no reason for the epenthetic glide to appear were the entire base (including its vowel) to serve as input to DVF.

### 3.5 Total Reduplication

I now turn to cases of total reduplication. My claim here is that such forms involve an actual reduplicative morpheme (Bar-Adon 1978, Gesenius 1910, Rose 1997), in contrast to the analysis of consonant doubling and glide-epenthesis forms. The morphological content contributed by the reduplicative morpheme (RED) signifies repetitive, frequentative, or durative action. The correspondence-theoretic constraint in (25) accounts for the reduplication of *both* root consonants in such forms:

(25) MAX-BR (McCarthy & Prince 1995)
Every element of the base has a correspondent in the reduplicant.
(undominated)

The following tableau illustrates the analysis.

(26) Total reduplication

[kivkev] 'to draw a dotted line' from [kav] 'line'

| k v + RED + I e | MAX-BR | REALIZE-M | S-ANCHOR-L | S-ANCHOR-R | INTEGRITY | DEP-IO |
|---|---|---|---|---|---|---|
| a. kivev | *! | | | * | | |
| b. kijev | *!* | * | | | | * |
| ☞ c. kivkev | | | * | * | ** | |

As above, if we take the base instead of the root as input, we make the wrong prediction about CVCV bases.

### 3.6 Cluster Transfer Effects

Let us now turn to the effects of cluster preservation. Such data (given in (4) - (8) above) led Bat-El (1994) to adopt a Stem Modification analysis of denominal verbs in Modern Hebrew, whereby the base is taken as input to denominal verb formation. I propose that such cases can also be fruitfully analyzed with *roots* as inputs; the cluster transfer effects are in fact the result of Output-Output Correspondence (e.g., Benua 1995, 1997; Burzio 1996):

(27) O(UTPUT)O(UTPUT)-CONT(IGUITY)
Correspondents that are contiguous in the base are contiguous in the output; likewise, correspondents that are not contiguous in the base are not contiguous in the output.

Another constraint is also also important (and violable):

(28) *COMPLEX (Prince & Smolensky 1993)
Syllable margins (i.e. onsets and codas) do not contain more than one segment.

The following tableaux illustrate the analysis:

(29) [.flir.tet.] 'to flirt' from [.flirt.] 'flirt'

| f l r t + i e<br>related output:<br>[flirt] | ANCHOR-R | OO-CONT | *COMPLEX | S-ANCHOR-R | INTEGRITY |
|---|---|---|---|---|---|
| a. filret | | *!** | | | |
| b. flirte | *! | | * | | |
| ☞ c. flirtet | | | * | * | * |

As (29) shows, consonant clusters are robustly preserved, even at the expense of violating the constraint INTEGRITY. That is, consonant clusters are preserved even if this entails that doubling must also take place. Another example of the same type, showing the high-ranking status of our output-based constraint OO-CONT is shown in (30):



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(30) [.fik.ses.] 'to send a fax' from [.faks.] 'facsimile'

| f k s + i e related output: [faks] | ANCHOR-R | OO-CONT | *COMPLEX | S-ANCHOR-R | INTEGRITY |
|---|---|---|---|---|---|
| a. fikes | | *! | | | |
| b. fikse | *! | | | | |
| ☞ c. fikses | | | | * | * |

The remainder of cases involving cluster preservation all have so many consonants that doubling never takes place. Our analysis straightforwardly accounts for such cases, as illustrated in (31):

(31) [.pri.klet.] 'to practice law' from [.pra.klit.] 'lawyer'

| p r k l t + i e related output: [praklit] | OO-CONT | *COMPLEX | S-ANCHOR-R | INTEGRITY |
|---|---|---|---|---|
| a. pirklet | *!* | * | | |
| ☞ b. priklet | | * | | |

We encounter a problem, however, when we consider the CCVC bases. Recall that such cases were the only exception to the generalization that consonant clusters are preserved from base to denominal verb. (32) illustrates the problem.

(32) [.bi.lef.] 'to bluff' from [.blof.] 'bluff'

| b l f + i e related output: [blof] | OO-CONT | *COMPLEX | S-ANCHOR-R | INTEGRITY |
|---|---|---|---|---|
| ❽ a. blifef | | * | * | * |
| ☞ b. bilef | * | | | |

Under this ranking, the cluster-preserving candidate (a) will emerge the winner, even though (b) is the actual output. One suggestion is that some other constraint (as yet unformalized) mandates that onset consonants in the base must each be their own onset in the resulting denominal verb. For now, I leave this question open to future research.

## 4 Conclusion

To sum up, I have provided an OT account of Modern Hebrew denominal verb formation. The most important point is that we have seen that the input to denominal verbs consists of base consonants (i.e. the consonantal *root*) only.





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Variation between two of the biliteral patterns (those not involving a reduplicative morpheme) is explained by constraint reranking.

Finally, we have seen that the third pattern involves a reduplicative morpheme and the undominated constraint MAX-BR. Consonant cluster transfer effects are thus captured through high-ranking OO-Correspondence, and we are left with an analysis that does not abandon the consonantal root.

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