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Tonal Phenomena in Oapan Nahuatl

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1 Introduction

In an unpublished article on tone and tonogenesis in Oapan Nahuatl, Amith (2007) describes several tonal phenomena of theoretical interest. Specifically, he describes a series of complex interactions between the tonal and stress systems of this language[1]. According to Amith, there are two distinct sources of tone in Oapan Nahuatl: a reduplication pattern that introduces a high tone in the derived form, and a synchronic alternation between high tone and [h]. In addition, the language marks phrasal stress, and its acoustic correlates are high F0 and increased duration (Guion et al.). Thus, the distribution of tonal elements cannot be accounted for by making reference to the phonology alone, as it is also determined by the morphology.

The goal of this paper is to provide a rule-based of the tonal phenomena in Oapan Nahuatl. More specifically, the paper proceeds as follows: section 2 provides the necessary background information about Oapan Nahuatl. Section 3 comprises a brief description of the relevant tonal phenomena. In section 4 I introduce a rule-based analysis of the distribution and interactions of tone and stress. The rules are then put together into a cyclic model of the grammar. Finally section 5 concludes the paper with a discussion of the shortcomings of the rule-based analysis. An alternative constraint-based account of the phenomena is briefly sketched.

2 The Language

Modern Nahuatl is a Uto-Aztecan language spoken mainly in Central Mexico. This highly polysynthetic or agglutinating language is not generally a tonal language.

[1] The paper is based almost entirely on the descriptions and the data provided in Amith (2007).

However, the variety I am concerned with in this paper has recently been claimed to have developed tone (Amith, 2007).

Oapan Nahuatl is the dialect spoken by the inhabitants of San Agustín Oapan, a rural village in the Mexican state of Guerrero[2]. Interestingly, this and another variety of Nahuatl spoken in the neighboring village of Ameyaltepec, have developed tone. In these languages, tonal elements originate from the loss of a coda /h/. Specifically in Ameyaltepec Nahuatl, the distribution of tone is fairly simple: the resulting high tone always appears on the syllable preceding that with underlying /h/. In case there is no preceding syllable, the high tone fails to appear. However, as will be described below, the distribution of tonal elements in Oapan Nahuatl is fairly intricate. Not only does it come from the loss of /h/, but also originates from a reduplication pattern. Furthermore, tone and stress interact with one another.

3 Description of Oapan Nahuatl Tonal Phenomena[3]

In this section I describe the distribution of tone and stress in Oapan Nahuatl. Following the organization of Amith (2007), the description will be divided into subsections according to the source of the tonal element. Note that, for the sake of clarity, phrasal stress is ignored in subsections 3.1 and 3.2.

3.1 Reduplication

Oapan Nahuatl has multiple reduplication patterns. One of these gives rise to a high tone in the reduplicated form. The phonological shape of the base determines the shape of the

[2] I spent the summer of 2007 in San Agustín Oapan, studying this variety of Nahuatl under the instruction of Jonathan Amith. I lived with a host family, and had extensive contact with the people in the village. Thus, I can say from experience that the descriptions and forms provided in Amith (2007) are accurate.

[3] The parses and glosses are taken from Amith (2007). For a list of the abbreviations, refer to endnote (16) of that paper.

reduplicant as well as the placement of the high tone on the derived form. Specifically, five different sub-patterns emerge.

Sub-pattern one arises when the stem begins with a short vowel.[4] In the reduplicated form, this vowel is lengthened and carries a high tone. This pattern is illustrated by the following forms, where (2) is the result of reduplication. The first segment of the verb *ita* 'to see' is a short vowel; thus, in the reduplicated form it becomes long and carries a high tone.

(1) mitsita
ø - mits - ita - ø
3sgS-2sgO-to.see-pres.sg
'he sees me'

(2) mitsí:ta
ø - mits - RED - ita - ø
3sgS-2sgO-redpl-to.see-pres.sg
'he looks at me'

The second sub-pattern arises when the stem begins with a long vowel. In this particular case, this vowel is assigned the high tone in the reduplicated form. Compare examples (3) and (4), where the latter is a reduplicated form. Given that there are no other overt differences between the two, the high tone carries all the morphological information. In other words, the forms in (3) and (4) differ only in terms of tone:

(3) a:polakih
ø - a:polaki - h
3sgS-to.submerge.onself-pres.pl
'they submerge themselves'

(4) á:polakih
ø - RED - a:polaki - h
3sgS-redpl-to.submerge.onself-pres.pl
'they repeatedly submerge themselves'

[4] Nahuatl has contrastive vowel length. CVV syllables are heavy, whereas CV and CVC syllables are light.

Sub-pattern three emerges when the stem begins with a consonant and the syllable that precedes it contains a short vowel.[5] Here, the vowel in the preceding syllable is lengthened and assigned the high tone in the derived form. Examples (5) and (6) illustrate this subpattern. Note that none of the segments from the base are actually copied — instead, the vowel in the prefix is lengthened and assigned high tone.

(5) mitste:mowa
ø - mits - te:mowa - ø
3sgS-2sgO-to.look.for-pres.sg
'he looks for you'

(6) mí:tste:mowa
ø - mits - RED - te:mowa - ø
3sgS-2sgO-redpl-to.look.for-pres.sg
'he repeatedly looks for you'

The fourth sub-pattern arises when the stem begins with a consonant and the syllable that precedes the stem contains a long vowel. In the reduplicated form, the reduplicant surfaces as a CV sequence prefixed onto the stem. The high tone falls on the heavy syllable that precedes the reduplicant:

(7) ne:xtemowa
ø -ne:ch- te:mowa - ø
3sgS-1sgO-to.look.for-pres.sg
'he looks for me'

(8) né:xtetemowa
ø -ne:ch- RED - te:mowa - ø
3sgS-1sgO-redpl-to.look.for-pres.sg
'he repeatedly looks for me'

In the examples above, the object marker contains an underlying long vowel. Given that the stem begins with a consonant, a light syllable is prefixed onto the stem, and the high tone appears on the long vowel of the object marker.

[5] Aspectual markers and subject and object markers constitute the prefixes that may precede the verb stem.

Finally, when the stem begins with a consonant and there is no preceding syllable, the reduplicant surfaces as a CV sequence prefixed onto the stem. The high tone lands on the reduplicant's vowel. Examples (9) and (10) illustrate the fifth subpattern:

(9) ki:sah
ø - ki:sa - h
3plS-to.emerge-pres.pl
'they emerge'

(10) kíki:sah
ø - RED - ki:sa - h
3plS-redpl-to.emerge-pres.pl
'they wander around'

In Oapan Nahuatl and Modern Nahuatl in general, reduplication is highly productive. According to Amith, all the verb stems in the language may manifest reduplication, as well as all adjectival constructions. The reduplication pattern described above is, correspondingly, commonly used. The semantic effect of reduplication is usually intensification or repetition of the action described by the verb stem, although there are some cases in which the derived meaning is idiosyncratic.

3.2 Phrase-Internal /h/

Another source of tone in Oapan Nahuatl is the synchronic alternation of [h] and high tone. In this language, [h] and high tone are allophones of /h/, which only appears in coda position. When /h/ occurs phrase-finally, it surfaces as [h]:

(11) kikwah
ø - ki - kwa - h
3plS-3sgO-to.eat-pres.pl
'they eat it'

On the other hand, when /h/ occurs phrase-internally, it surfaces as a high tone[6]. The landing site of the high tone depends on the phonological shape of the stem in which it originated and the presence of other adjacent high tones.

When the underlying /h/ is in a non-initial syllable of the stem, the high tone is realized on the syllable that immediately precedes that with underlying /h/.

(12) kipólotokeh
ø - ki - poloh - tokeh
3plS-3sgO-to.lose-durative.pres.sg
'they are losing it'

However, if the underlying /h/ is in the first syllable of the stem, the high tone is realized on this syllable:

(13) pátiseh
ø - pahti - seh
3plS-to.get.better-fut.pl
'they will get better'

(14) kitlápalowa
ø - ki -tlahpalowa- ø
3sgS-3sgO-to.greet-pres.sg
'he greets him/her'

When a stem-initial syllable with underlying /h/ is immediately preceded by a heavy syllable, the high tone appears outside the stem, on the preceding heavy:

(15) nó:chmatlapahli
ø - no:ch-mahtlapal-li
3sgS-cactus- wing -abs.pres.sg
'it is an *Opuntia bensonii* (a type of cactus)'

This fact —that is, that high tones seemingly prefer to appear within the morphological constituent in which they originated— will prove important in the upcoming analyses.

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[6] The loss of a glottal segment is often cited as a conditioning environment for the historical development of lexical tone. See Gage (1985), Manaster-Ramer (1986), and Kingston (2005).

Finally, high tones also appear outside the stem with forms that meet the following conditions: (a) the underlying /h/ is in the stem-initial syllable, and (b) the stem has two syllables or less. Two examples are given below. Compare these forms with the one in (14), where the stem is trisyllabic and consequently fails to meet one of the aforementioned conditions.

(16) nípa'tís
ni - pahti - s
1sgS-to.get.better-fut.sg
'I will get better'

(17) nopán yekos
no - pan ø - yehko - s
1sgPoss-locative 3sgS-to.arrive.here-fut.sg
'he will arrive here'

3.3 Phrasal Stress

The final source of tone in Oapan Nahuatl is phrasal stress. An acoustic study by Guion et al. found that duration and high F0 are the acoustic correlates of phrasal stress in the language.[7] It generally falls on the penultimate syllable of the last word in a phrase.

(18) nihkwa:s xo'nákatl
ni - k - kwa:- s xonaka-tl
1sgS-3sgO-to.eat-fut.sg onion-abs
'I will eát onions'

If the penultimate syllable in the last word of a phrase is heavy, stress obligatorily falls on it. If the penult is light, on the other hand, stress may fall in other syllables to avoid clashing with adjacent tone-bearing syllables. Consider the examples below: in (19), stress falls on the heavy penult even though there is an adjacent high tone. In (20), however, the penult is light and the syllable preceding it contains a high tone. Stress falls on the final syllable of the last word, thus avoiding clash.

[7] For this reason, phrasal stress is marked with a stress diacritic (') and a high tone diacritic (´) in this paper.

(19) pá'pá:ki
ø -RED - pa:ki- ø
3sgS-redpl-to.be.happy-pres.sg
'he is happy with excitement'

(20) néne'mí
ø - RED - nemi - ø
3sgS-redpl-to.live-pres.sg
'he walks'

Finally, there exists one documented case where phrasal stress falls on the antepenultimate syllable. According to Amith, this occurs when there is a high tone docked on the final syllable of the last word in a phrase, and the penultimate syllable is light. This is illustrated in the following:

(21) 'ó:niké:w
o: - ni - k - RED - e:w - ø
compl-1sgS-3sgO-redpl-to.store.away-perfv.sg
'I stored it away'

The verb in (21), *e:wa* 'to store away', only appears in its reduplicated form. In the singular perfective, the final vowel of the verb is dropped. Thus, the high tone that was introduced by the reduplication process is now on the final syllable of the word, meeting the first condition. Given that the penultimate syllable is light, stress falls on the antepenult.

This section concludes the preliminary description of the tonal phenomena in Oapan Nahuatl. The following section comprises the rule-based analysis of tone and stress.

4 Rule-Based Analysis of Oapan Nahuatl Tone and Stress

In this section of the paper I introduce a rule-based analysis of the previously described phenomena. Again, phrasal stress is ignored in sections 4.1 and 4.2 for the sake of clarity.

4.1 Reduplication

As seen in section 3.1, there is a reduplication pattern in Oapan Nahuatl that gives rise to high tone. Following the proposal by McCarthy & Prince (1998), where reduplication is analyzed as affixation of a prosodic template, reduplication in Oapan Nahuatl consists of prefixation of a light syllable. Additionally, a high tone (H) is linked to it. The rule is formalized as follows:

(22) Reduplication rule
Copy and prefix a light syllable and link a high tone to this syllable.

The Reduplication rule in isolation is only able to produce the right results with stems that begin with a consonant and there are no other syllables preceding the stem. In this case, a light syllable is copied and prefixed, and a high tone appears on the reduplicant's vowel. See the last column of Table 1 for a sample derivation.

In order to account for the sub-patterns that emerge with vowel-initial stems, two cleanup rules are necessary. The first rule, formalized in (23), makes a long vowel out of two adjacent identical vowels. The second rule constitutes a prohibition of super-long vowels. These are stated below:

(23) Super-long simplification rule
A super-long vowel surfaces as a long vowel.

(24) Long vowel rule
A sequence of two identical vowels constitutes a long vowel.

Finally, there is another rule that unlinks an H from a short vowel and re-links it to an immediately preceding long vowel. This rule accounts for the subpattern that emerges with consonant-initial stems preceded by a long vowel. The rule is formalized in (25):

(25) H attraction rule
A high tone shifts to a preceding heavy syllable if it isn't already linked to one.

The rules in (23), (24), and (25) need not be ordered with respect to each other. However, they must all apply after the Reduplication rule. Consider the derivations in Table 1:

input	/ø-mits-ita-ø/	/ø-a:polaki-h/	/ø-mits-te:mowa-ø/	/ø-ne:ch-te:mowa-ø/	/ø-ki:sa-h/
Redpl	ø-mits-i-ita-ø | H	ø-a-a:polaki-h | H	ø-mits-te-te:mowa-ø | H	ø-ne:ch-te-te:mowa-ø | H	ø-ki-ki:sa-h | H
Super-long	---	ø-a:polaki-h | H	---	---	---
Long vowel	ø-mits-i:ta-ø | H	---	---	---	---
H-attract	---	---	---	ø-ne:ch-te-te:mowa-ø | H	---
output	mitsí:ta 'he looks at me'	á:polakih 'they repeatedly submerge themselves'	*mitstéte:mowa 'he repeatedly looks for you'	né:chtetemowa 'he repeatedly looks for me'	kíki:sah 'they wande around'

Table 1

Notice that the output of the third derivation is ungrammatical. As it was defined in (22), the Reduplication rule cannot account for the third subpattern, which emerges when the stem begins with a consonant and the syllable that precedes the stem contains a short vowel. To reiterate, in this particular case the vowel in the syllable that precedes the stem is lengthened and assigned a high tone; no segments are actually copied. Thus, the rule in (22) is incomplete, as it cannot account for this residual case. The final version of the Reduplication rule is stated below:

(26) Reduplication rule
   a. When the stem has an onset and the preceding syllable contains a short vowel, lengthen and link an H to this vowel.
   b. Elsewhere, copy and prefix the initial light syllable of the stem and link an H to its nucleus.

The rule is now able to produce the attested form, as seen in Table 2:

input	/ø-mits-te:mowa-ø/
Redpl	ø-mi:ts-te:mowa-ø | H
Super-long	---
Long	---
H attract	---
output	mí:ste:mowa 'he repeatedly looks for you'

Table 2

It is important to note that the Reduplication rule above assumes that inflectional morphology is present in the input. That is, inflectional morphology is part of the input to a derivational rule. Consider, however, the semantic effect of reduplication. It is aspectual, seeing that the action or state expressed by the verb is intensified or repeated. This is consistent with the relative ordering of other aspectual markers in the language. For example, take the morpheme *o:* in the form in (21), which marks a completed action. This morpheme appears in front of the subject and object markers, on the left of the verb stem. In this case also, the inflection must be present before the introduction of aspectual *o:*. Bearing this in mind, the presence of inflectional morphology in the input to the Reduplication rule is not incredibly controversial.

4.2 Phrase-Internal /h/

Recall that, in Oapan Nahuatl, an underlying /h/ surfaces as [h] phrase-finally, and as a high tone phrase-internally. Consider the following forms and the ultimate landing site of the high tones. In 0 and (28), the high tone appears on the syllable that immediately precedes that with underlying /h/. Taking these forms into account, we could hypothesize that high tones always appear on the syllable that precedes that with underlying /h/.

(27) kipólotokeh
ø - ki - poloh - tokeh
3plS-3sgO-to.lose-durative.pres.sg
'they are losing it'

(28) i:kámoyo
ø - i: - kamoh - yo
3sgS-3sgPoss-sweet.potato-poss.pres.sg
'it is its sweet potato (of the plant)'

However, consider the next three forms. These contradict the hypothesis that high tones always appear on the syllable that precedes that with underlying /h/, since the high tones appear on the same syllable with underlying /h/. In (29), there is no preceding syllable; thus, the only available landing site for the high tone is the syllable with underlying /h/. Nevertheless, this is not the case in examples (30) and (31). Instead, these forms show that word-internal boundaries play an important role in the distribution of the high tones. More specifically, high tones will remain within the morphological constituent in which they originated.

(29) pátiseh
ø - pahti - seh
3plS-to.get.better-fut.pl
'they will get better'

(30) tla:katlátowa
ø -tla:ka-tlahtowa- ø
3sgS-man-to.speak-pres.sg
'he speaks in a man's voice'

(31) kitópowia
ø - ki - topowia - ø
3sgS-3sgO-to.cause.skin.eruption-pres.sg
'he causes a skin eruption on him'

Now, consider examples (32) and (33). There seems to be an exception to the above stipulation. That is, high tones that should otherwise stay in the first syllable of the stem actually dock on a preceding heavy syllable, crossing the morphological boundary.

(32) o:né:chpa'tíh
o: - ø - ne:ch - pahtih - ø
compl-3sgS-1sgO-to.cure-perfv.sg
'he cured me'

(33) nó:chmatlapahli
ø - no:ch-mahtlapal-li
3sgS-cactus- wing -abs.pres.sg
'it is an *Opuntia bensonii* (a type of cactus)'

Finally, examples (34) and (35) show that not only heavy syllables but also light syllables outside the stem may end up carrying a high tone. However, for this to happen two conditions must be met: first, the underlying /h/ must be in the first syllable of the stem; second, the stem must have two syllables or less.

(34) nípa'tís
ni - pahti - s
1sgS-to.get.better-fut.sg
'I will get better'

(35) nopán yekos
no - pan ø - yehko - s
1sgPoss-locative 3sgS-to.arrive.here-fut.sg
'he will arrive here'

Clearly, the placement of high tones that originate from phrase-internal /h/ is quite complicated. However, adopting a metrical analysis of this phenomenon is able to predict the attested forms. Consider the rules introduced below. The rule in (36) must apply before (37) and (38), as the former's output constitutes the input of the latter. However, (36) and (37) need not be ordered with respect to each other.

(36) /h/ footing rule
Initiate a trochee at the right edge of a phrase-internal underlying /h/. Place the left edge of the foot so as to make it maximally trimoraic and maximally binary.

(37) H linking rule
Link a high tone to the head of a foot.

(38) Phrase-internal /h/ rule
/h/ surfaces as [h] phrase-finally. Elsewhere, it deletes.

As they are formulated, these three rules account for the landing sites of high tone in the previous examples, except for (30) and (31). This is because the /h/ footing rule in (36) ignores the significance of morphological boundaries. To accommodate these exceptions, then, the rule must include a stipulation that prohibits building feet across morphological boundaries. This stipulation is to be broken only if (a) the result is an uneven trochee of ($\sigma_{\mu\mu}\sigma_{\mu}$) shape; or (b) the underlying /h/ is in the first syllable of the stem and the stem has two syllables or less. The /h/ footing rule is restated below. Table 3 follows, showing the relevant derivations. Each derivation results in the attested form.

(39) /h/ footing rule
a. Initiate a trochee at the right edge of a phrase-internal underlying /h/. Place the left edge of the foot so as to make it maximally trimoraic and maximally binary.
b. Do not build feet across morphological boundaries unless:
i. The resulting foot is an uneven trochee, or
ii. The underlying /h/ is in the first syllable of the stem and the stem has two syllables or less.

input	/ø-ki-poloh-tokeh/	/ø-pahti-seh /	/ø-no:ch-mahtlapal-li/	/ni-pahti-s/
/h/ footing	ø-ki-(poloh)-tokeh	ø-(pah)ti-seh	ø-(no:ch-mah)tlapal-li	(ni-pah)ti-s
H link	ø-ki-(poloh)-tokeh | H	ø-(pah)ti-seh | H	ø-(no:ch-mah)tlapal-li | H	(ni-pah)ti-s | H
/h/ rule	ø-ki-(polo)-tokeh | H	ø-(pa)ti-seh | H	ø-(no:ch-ma)tlapal-li | H	(ni-pa)ti-s | H
output	kipólotokeh 'they are losing it'	pátiseh 'they will get better'	nó:chmatlapahli 'it is an *Opuntia bensonii*'	nípatis 'I will get better'

Table 3

Recall that the rule in (39) applies at the phrasal level —that is, it is part of the postlexical phonology. Additionally, note that this rule assumes that word-internal structure is still accessible at this point in the grammar. It is true that there are other ways

to make the boundary between a base and the inflectional morphology available to a postlexical rule. For instance, we could assume that the inflectional morphology is not part of the word. Instead, we could take the subject, object, possessive, and aspectual markers to be clitics, adjoined rather than prefixed. This assumption, however, is problematic given the analysis of reduplication proposed in section 4.1. More specifically, this analysis is not consistent with the Reduplication rule in (26). Rule (26) requires that the inflectional morphology be present in its input[8]. However, cliticization is commonly considered a postlexical operation, given that clitics tend to attach to phrases (see Peperkamp, 1997; and Vigário, 1999). Bearing this in mind, if we take the aforementioned inflectional markers to be clitics rather than prefixes, these markers would not be part of the input to the Reduplication rule. For the sake of uniformity, then, I assume that word-internal structure is still accessible to the postlexical phonology.

4.3 Phrasal Stress

Let us turn to a simpler tonal phenomenon in Oapan Nahuatl. Given that phrasal stress is generally penultimate in the language, and that it obligatorily falls on a heavy penult that is followed by a light syllable, the phrasal stress rule is formalized as follows:

(40) Stress footing rule
Initiate a trochee at the right edge of a phrase. Locate the left edge of the foot so as to make it maximally trimoraic and maximally disyllabic.

In addition to this rule, another one is needed to account for the appearance of a high tone on the head syllable of a stress foot. The H linking rule that was stated in (37) produces the attested forms; thus, it must also have as input the outputs of the Stress footing rule. The H linking rule is restated below:

[8] Otherwise, the subpattern that emerges when reduplicating consonant-initial stems that are preceded by a light syllable could not be accounted for.

(41) H linking rule
Link a high tone to the head of a stress foot.

An important result of the rule in (40) is that it will build uneven trochees where possible, similarly to the /h/ footing rule in (39). Feet of shapes ($\sigma_{\mu\mu}\sigma_{\mu}$), ($\sigma_{\mu}\sigma_{\mu}$), and ($\sigma_{\mu}$) are exemplified in the following forms.[9]

(42) pá'pá:ki
ø -RED - pa:ki- ø
3sgS-redpl-to.be.happy-pres.sg
'he is happy with excitement'

(43) típa'tíseh
ti - pahti - seh
1plS-to.get.better-fut.pl
'they will get better'

(44) néne'mí
ø - RED - nemi - ø
3sgS-redpl-to.live-pres.sg
'he walks'

In (42) the Stress footing rule builds an uneven trochee. Given that feet are left-headed, a high tone is linked to the left-most syllable in the foot. In (43), the stress foot is composed of two light syllables. Again, a high tone is linked to head of this foot. Finally, in (44) the stress foot is a degenerate foot consisting of a single light syllable. Why is the

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[9] There is one form in Amith's paper that contradicts this rule:

- nókwe'tówa:n
ø - no -kwehtom- wa:n
3plS-1sgPoss-pillow-al.poss.pres.pl
'they are my pillows'

Given this example, it would seem that stress feet in Oapan Nahuatl were syllabic trochees. However, it is the only form I could find with this stress pattern. Furthermore, the following example is consistent with my analysis, and contradicts the form above:

- nikoni:s 'á:tl
ni - k - oni: - s a:-tl
1sgS-3sgO-to.drink-fut.sg water-abs
'I will drink water'

Here, the stress foot constitutes a single heavy syllable, showing that the stress system is quantity sensitive. If the system were syllabic, we would expect stress and the associated high tone to fall on the penultimate syllable of the phrase, resulting in the ungrammatical **niko'ní:s a:tl.*

Stress footing rule unable to build a disyllabic foot in this case? This problem will be addressed in the following section.

4.4 Rule Ordering and Residual Problems

To completely elucidate the nature of the interaction between tone and stress in Oapan Nahuatl, a rule that builds feet from tone-bearing syllables is necessary.

(45) H footing rule
Initiate a trochee at the left edge of an H-bearing syllable. Locate the right edge of the foot so as to make it maximally trimoraic and maximally disyllabic.

This rule needs to apply after the Reduplication rule, since the latter introduces a high tone in the reduplicated forms. Importantly, the H footing rule must apply before the /h/ footing and Stress footing rules to account for the forms below.

(46) néne'mí
ø - RED - nemi - ø
3sgS-redpl-to.live-pres.sg
'he walks'

(47) ní:ne'mí
ni - RED - nemi - ø
1sgS-redpl-to.live-pres.sg
'I walk'

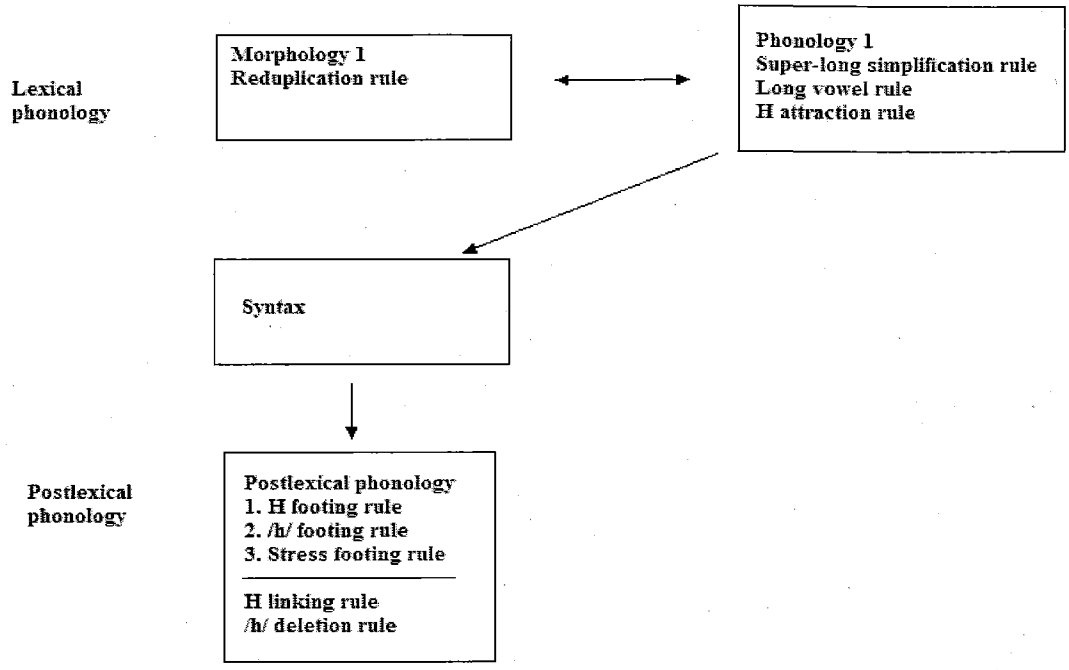
(48) 'ó:niké:w
o: - ni - k - RED - e:w - ø
compl-1sgS-3sgO-redpl-to.store.away-perfv.sg
'I stored it away'

(49) kí:tekí 'xó:chitl
ø - ki -RED- teki -h xo:chi-tl
3plS-3sgO-redpl-to.pick-pres.pl flower-abs
'they pick flowers'

Consider examples (46) through (48). If the H footing rule applies before the Stress rule, the correct results are predicted. That is, in order to explain the appearance of stress on a light ultimate syllable as in (46) and (47), the input to the Stress rule must already

include unalterable metrical structure. In (48), furthermore, the metrical structure that results from the H footing rule occupies the right edge of the phrase. As a result, the stress rule builds the stress foot on the rightmost available material —the remaining unfooted syllables. Finally, example (49) shows that the H footing rule applies before the /h/ footing rule as well. Since the H footing rule preferably builds uneven trochees, the penultimate syllable in */kí:tekih/* is footed with the reduplicant. Thus, when the /h/ footing rule applies, the only footable syllable left is the ultimate syllable of the word. The high tone, then, falls on this syllable. The crucial assumption is that metrical structure that is present in the input to a rule cannot be altered or crossed by new metrical structure.

To summarize, the entire analysis is put into a cyclic model of the grammar as follows. Two distinct domains are needed: the lexical and the postlexical domain. The Reduplication rule is part of morphology associated with the first level. Then, the lexical phonology comprises the cleanup rules in (23) and (24), as well as the H attraction rule in (25). To reiterate, these rules need not be ordered with respect to each other. The output of the lexical phonology goes through the syntax, and the output of the syntax becomes the input to the postlexical phonology. In at this point, all the metrical structure is introduced. The first rule that applies is the H footing rule. The output of this rule constitutes the input to the /h/ footing rule. Finally, the output of the /h/ footing rule constitutes the input to the stress footing rule. The H linking rule initially introduced in (37) applies after both /h/ footing and Stress footing, since this is the rule that links a high tone to the head of a toneless foot. Finally, the /h/ deletion rule must apply after the /h/ footing rule, yet need not be ordered with respect to the rest of the rules. The following diagram illustrates the rule ordering and domains.



5 Setbacks of the Rule-Based Analysis and the Potential of OT

Languages that have active tonal and stress systems are not common. However, Oapan Nahuatl is an example of the rare instances in which the tone and stress systems interact extensively. More specifically, there is a two-sided relationship between tonal structure and metrical structure. On the one hand, the distribution of tone is metrically constrained: high tones are consistently linked to the head of feet. Conversely, metrical structure depends upon the distribution of tone: high tones are introduced by reduplication, and their landing syllable is then necessarily footed.

The analysis[10] presented in section 4 successfully accounts for all the data in Amith's descriptive paper[11]. However, it is based on a few controversial assumptions. First, the Reduplication rule in (26) requires that inflectional morphology be present in the input. As was touched upon before, inflection is generally described as appearing outside of

[10] The analysis is an adaptation of Leben's *Tonal Feet* proposal (2001).
[11] The only exception is the form in footnote 9.

derivation. In other words, inflectional morphology is introduced after derivational morphology. Although it remains the focus of heated debates in the field of morphology, the popular view is that this generalization holds. Thus, the formulation of the Reduplication rule in (26) is far from ideal.

Another controversial assumption in the analysis is that word-internal structure is accessible to postlexical rules. According to the theory of Lexical Phonology (Kiparsky, 1982), Bracketing Erasure deletes word-internal structure before a form is submitted to the next level of the phonology. Since I adopt a cyclic model of the grammar like the one built into the theory of Lexical Phonology, the assumption that word-internal structure is available in the postlexical level is contradictory.[12]

Finally, the formulation of the rules in (26) and (39) is inelegant and typologically unfounded. These are restated below.

(50) Reduplication rule
   a. When the stem has an onset and the preceding syllable contains a short vowel, lengthen and link an H to this vowel.
   b. Elsewhere, copy and prefix the initial light syllable of the stem and link an H to its nucleus.

(51) /h/ footing rule
   a. Initiate a trochee at the right edge of a phrase-internal underlying /h/. Place the left edge of the foot so as to make it maximally trimoraic and maximally binary.
   b. Do not build feet across morphological boundaries unless:
      i. The resulting foot is an uneven trochee, or
      ii. The underlying /h/ is in the first syllable of the stem and the stem has two syllables or less.

In (50), stipulation (a) is necessary to account for the residual sub-pattern of reduplication. This sub-pattern is synchronically inconsistent with the rest of the

[12] Refer to section 4.2 for a possible solution to this problem, and the reason why it was not adopted in the analysis.

reduplication sub-patterns. Consequently, a special clause had to be included in the rule to produce the attested forms.

The rule in (51) is even more elaborate. It has no articulatory or phonetic basis, differently from a great number of phonological rules. Furthermore, even though it applies at the postlexical level, the /h/ footing rule makes reference to the shape of the stem and the word-internal structure. The characteristic of the stem to which it refers, finally, is also arbitrary (the number of syllables in the stem). However, this particular formulation is able to account for all the data in Amith.[13]

Various linguists have successfully adopted the framework of Optimality Theory (Prince & Smolensky, 1993; McCarthy & Prince, 1993) in order to account for languages like Oapan Nahuatl, where there is a dynamic relationship between the stress and tonal systems. An analysis put forth by Zec (1999) is particularly relevant to the tonal phenomena at hand. In this analysis, metrical structure plays an active role in the distribution of tone, and the distribution of tone constrains metrical structure as well. These effects are captured by the following constraints:

(52) TONE-TO-FOOT
Align a High tone with the head of a foot.

(53) FOOTSALIENCE
A foot should be associated with tone.

The rest of the analysis is based on general alignment and prosodic constraints, such as FOOTBINARITY, PARSESYLLABLE, and ALIGN-L/R (HEAD, PRWD).

This analysis can potentially be extended to the Oapan Nahuatl phenomena described above. Besides the constraints in (52) and (53), in the data it is clear that there is a preference for uneven trochees. Another apparent driving force is the Obligatory Contour

[13] Not including stipulations i and ii produced ungrammatical forms for nearly half of the derivations.

Principle, which penalizes sequences of identical tones. The relative ranking of general faithfulness, alignment, and prosodic wellformedness constraints should be able to capture the totality of the interactions of tone and stress, as well as the loss of phrase-internal /h/. It is important to note that Optimality Theory does away with the controversial assumptions necessary for the rule-based analysis. In this framework, the morphology and the phonology work in parallel, eliminating the need to order derivational, inflectional, and phonological rules with respect to each other.

Finally, the reduplication pattern that introduces a high tone can be semi-successfully accounted for by adopting the view of Alderete et al. In keeping with this analysis, this reduplication pattern in Oapan Nahuatl can be seen as reduplication with morphological fixed segmentism. The tonal element functions like a normal affix, except that it "overrides" a part of the reduplicant copy. This analysis, however, would not work with the residual sub-pattern captured by stipulation (a) in rule (26).

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