

“Antihomorganicity” in Apinayé and Hayu: Evidence for closure duration as a phonotactic variable

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Abstract

The goal of this thesis is to motivate and examine the consequences of a constraint prohibiting geminate-length supralaryngeal closures at the same place of articulation. Evidence for this constraint is attested in Apinayé and Hayu, two languages which allow heterorganic consonant clusters across a syllable boundary while heterosyllabic homorganic consonant sequences are subject to patterns of simplification that, in their various instantiations, reduce closure length at a given point of articulation. Evidence for a ban on long closures comes from two sources: First, I show how other conceivable analyses such as syllable-based explanations and both formal and functional similarity accounts fail to provide adequate solutions for the phenomenon considered. Second, I make use of the apparent exceptions to the constraint by showing that their gestural composition is such that they are able to undergo articulatory *compression*, meaning that certain clusters are able to be pronounced with a shorter duration while maintaining perceptual recoverability cues, thereby avoiding violation of the long closure constraint. I conclude with a discussion of these findings and their implications for phonological theory.

* This thesis is dedicated to my teachers: Larry Hyman, Keith Johnson, Sharon Inkelas, and Andrew Garrett. Two short years ago, I didn't even know what a phoneme was -- this work is as much their effort as it is mine. I especially thank Larry Hyman for providing me with the data for this analysis and for the wonderful introduction to research in linguistics.

Any faults or errors in this work are of course mine. Comments are welcome and can be addressed to: iancoffman@alum.berkeley.edu.

1. Introduction

Since its inception, generative phonological theory has been concerned with the processes and patterns associated with adjacency, both narrowly in the sense of individual phonological features and broadly with considerations of entire segments or syllables, for example. The structural descriptions of *SPE*-style¹ rules were formulated with locality and adjacency as essential notions, and even still in the representations of the Autosegmental era, such as those of nonconcatenative morphology, considerations of adjacency were upheld despite the apparently nonlocal nature of the phenomena with tools such as tier autonomy (Hayes 1986) and the Obligatory Contour Principle (Goldsmith 1974, Odden 1986, see also section 2.2.2 in this work). More recently with the rise of Optimality Theory (Prince and Smolensky 1993, hereafter OT), this trend is continued as constraints frequently refer to the well-formedness of sequences created by adjacent segments, even though adjacency is not a crucial component of the theory.

It is obvious then that the preoccupation with adjacency in phonological research is warranted; in fact, it is the subject of an independent line of research: the constraints and principles governing the optimal sequencing of segments are collectively referred to as *phonotactics*. Recently, much research in this area has been concerned with the role of phonetic influence in consonantal phonotactics in investigations of, for example, consonantal phonotactics in general (Blevins 2003, Kochetov 2002), positional neutralization of aspiration and place features (Steriade 1997, 1999, 2001), and perceptual distinctness as a factor in patterns of consonant deletion in clusters (Côté 2000, 2004). Research in this line has shown that certain generalizations and typological regularities are missed without consideration of the phonetic grounding of certain phonological processes. Further, in some cases the proposed explanations are often formulated so as to apply independently, that is, not as processes associated with the syllable or any other ‘abstract’ notion.

This thesis is intended to give equal weight to both possible phonetic influence and abstract grammatical structure. However, as will be shown, a consideration of both factors often leads to a description that relies on one more than the other. This is the case in the present work, where inadequacies in formal domains such as the syllable and identity-based accounts show the need for a largely phonetically-based solution.

¹ *SPE: The Sound Pattern of English* (Chomsky & Halle 1968).

Accordingly, the primary goal of this thesis is to motivate and examine the consequences of a constraint prohibiting long closures at the same place of articulation. Satisfaction of such a constraint is attested in Hayu and Apinayé, where there is a ban on heterosyllabic homorganic consonant sequences while heterorganic clusters in the same position are tolerated. Although on the surface it looks as though the attested forms can be attributed to a general ban on homorganicity, I will show that the situation is much more complex and cannot be accounted for by previous approaches to similar phenomena such as coda conditions, the Obligatory Contour Principle, and other similarity accounts. Further evidence for the constraint is provided by the nature of the apparent exceptions to the ban – I argue that some homorganic clusters are tolerated because they are such that their phonetic composition allows them to *compress* so that they can be pronounced with shorter duration while maintaining cues for perceptual recoverability. A sample of data from each of the languages analyzed in this work is given below in (1).²

- (1) a. Apinayé
 /tep + pič/ → te:pič ‘just fish’
 /tep + meč/ → te:meč ‘good fish’
 /tep + vər/ → te:vər ‘to fish’
- b. Hayu
 /puk + koŋ/ → puxkoŋ ‘he aroused you’
 /dip + poŋ/ → dixpoŋ ‘he pinned you in wrestling’
 /dip + nom/ → diʔnom ‘he’ll pin you in wrestling’

In each of these languages, an underlying consonant sequence that would create a long homorganic closure is simplified. As mentioned above, not all consonant clusters with identical places of articulation are simplified in both Apinayé and Hayu, shown in (2). According to the analysis outlined here, these heterosyllabic clusters are compressible.

² Data are from: (1a): Burgess and Ham (1968); (1b): Michailovsky & Mazaudon (1973).

- (2) a. Apinayé
 /tom + pič/ → to:mpič 'just frekle'
 /meŋ + ža/ → me:ŋža 'this honey'
- b. Hayu
 /sel + to/ → selto 'thin out a crop for it!'
 /sel + no/ → selno 'I thin out a crop for you'

Although the analysis presented in this thesis is intended to be framework-neutral, I am partial to Steriade's (1997, 1999) Licensing by Cue framework in holding that positions of phonological contrast are preferably those in which there exist sufficient perceptual cues for the listener to distinguish between segments, where in others, contrasts are frequently neutralized. This is applied specifically in accounting for the nature of the repairs by which Apinayé and Hayu remedy their illegal consonant sequences. Further, I utilize several aspects of Articulatory Phonology (Browman & Goldstein 1986, 1989, 1992, Goldstein & Fowler 2003), particularly the gestural score as a means of representing gestural timing and overlap. A constraint-based framework such as OT is occasionally alluded to, but I refrain from providing a formal analysis along this line. Subsequent sections will describe these ideas in more detail.

1.1 Organization of thesis

This thesis is organized as follows. In section 2, I overview the relevant theoretical concepts that are necessary for a satisfactory analysis of the data to be presented. Section 3 outlines the analysis proposed to account for the data, namely, that the dissimilation patterns seen in Apinayé and Hayu are most profitably analyzed as resulting from a ban on long closure durations. Section 4 describes the idea of consonant cluster compressibility and how it applies to the languages examined. Finally, in section 5, I conclude with a few critical remarks as well as an identification of some important residual issues raised by the analysis.

2. Theoretical groundwork

This section provides a brief overview of the relevant outcomes of previous research pertaining to this analysis. The patterns attested in Apinayé and Hayu have potential explanations that pervade several diverse areas of phonological theory, so a short introduction to the appropriate

concepts is helpful in facilitating discussion in later sections. I begin with an overview of syllable theory and gemination, most of which has its roots in Autosegmental Phonology. Then, I will discuss the results of more recent research concerned with phonetic influence in phonological patterning. Finally, section 2.4 provides an intermediate conclusion, expanding on the applicability of the previous research to the present analysis.

2.1 Syllables and branching structures

The simplification patterns seen in Apinayé and Hayu are most elegantly described in terms of syllable contact; that is, we say that the coda consonant of one syllable simplifies when it is homorganic to a consonant in the following syllable's onset. Stating rules or patterns as functions of syllable position captures important generalizations that are otherwise missed by referring only to segmental context. As a well-known example, obstruents in German devoice when they precede another non-sonorant or a word boundary. Without the syllable as a descriptive unit, a disjunctive structural description must be utilized, i.e., {__ C, __ #}. As Blevins (1995:209) points out, this is undesirable on the grounds that consonants and word boundaries do not comprise a natural class. By appealing to syllable position, however, the rule of final obstruent devoicing can be stated as targeting only those consonants occurring in coda position, reducing the number of environments to one, namely __]_σ. Since the syllable has proven to be such a useful concept in phonological theory and is certainly applicable to the present situation, I will now overview some relevant aspects of the related theory.

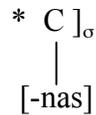
2.1.1 Branching codas

The interaction of adjacent heterosyllabic segments has been an important area of research in syllable theory. Some languages restrict well-formed coda consonants to those that branch to their following onsets (Goldsmith 1990, Ito 1986). This is evident in Japanese, where the only attested coda segments are those that share a place specification with the consonant in the next onset. This is illustrated by the data in (3).

(3)	Japanese		
	shimbun	‘newspaper’	(but *shikbun)
	gambatte	‘good luck’	(but *ganbatte)
	yokatta	‘it was good’	(but *yokapta)
	ippai	‘one flat thing’	(but *itpai)

As seen, the only well formed codas in Japanese are those that share their place features with the following onset consonant (though nasality can occur word-finally in what is referred to as a ‘placeless coda,’ often described phonetically as a nasal glide). To account for these facts, Ito (1986) proposes the use of a *coda condition*, shown in (4), which is a statement of markedness particular to the coda³.

(4) Japanese coda condition (Itô 1986)

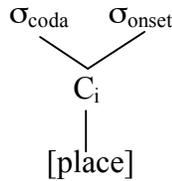


Ito’s coda condition is formulated to disallow all non-nasal consonants from occurring in coda position unless they share a place node with a following onset consonant. Although it is true that geminate stop consonants in the language are linked to the coda, their doubly-associated structure exempts them from the constraint (note the single association line in (4)). Facts such as these provided motivation for the idea that in languages like Japanese, the coda cannot be an independent licenser of place features; rather, it must obtain this specification from the following heterosyllabic consonant (Goldsmith 1990:126). These situations are illustrated schematically in (5).

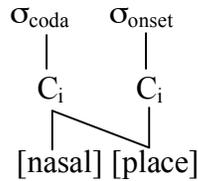
³ Presumably, the existence of restrictions specific to the coda follow naturally from the typological fact that, unlike onset material, coda segments possess a restricted set of possible featural occurrences (if any are allowed at all).

(5) Place licensing (Hyman 2008)

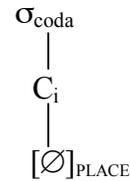
a. geminate C.C



b. homorganic N.T



c. placeless coda



The representations above show a geminate consonant in (a), a homorganic nasal + stop cluster in (b), and (c) illustrates the idea of a placeless coda. Note that in (a-b), a branching structure exists somewhere in the representation, which, as stated above, are necessary for consonants in coda position to be tolerated.

2.1.4 *The Nonsyllable*

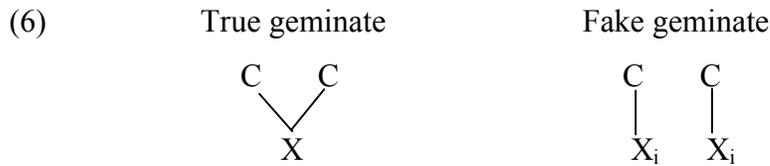
Several recent studies have shown that some patterns of consonantal phonotactics are best viewed as phenomena outside of the syllable domain (Steriade 1997, 1999, Kochetov 2002, Blevins 2003), while some have suggested that the syllable may not be a relevant concept at all (Samuels 2008). The reasoning behind these ideas is that in some cases, phonotactic patterns hold without reference to the syllable; for example, the German final obstruent devoicing case discussed above may be alternatively formulated as a positive licensing condition stating that voiced obstruents are licensed only before sonorants. While I do not overview the work undertaken in this area here, its existence is worth pointing out insofar as it establishes the apprehension some researchers have shown regarding aspects of the syllable in phonological theory.

2.2 *Conditions on adjacency: geminates and the Obligatory Contour Principle*

Geminates are broadly defined as two adjacent identical consonants, resulting in a long pronunciation generally 1.5 to 3 times longer than a singleton counterpart. Since the languages analyzed in this thesis seem to disfavor geminates, or at least geminate-like structures, a discussion is warranted.

2.2.1 “True” vs. “fake” geminates

Phonologists generally agree on two classifications of geminate consonants: *true* and *fake* (or *apparent*) (Hayes 1986, Goldsmith 1990, Schein and Steriade 1986, McCarthy 1986). True geminates are characterized by a single melody multiply linked to two C slots on the timing tier, while fake geminates consist of two adjacent identical melodies linked to their own respective C slots. This is schematized in (6).



The types of geminates attested cross-linguistically are strongly correlated with the environments in which they occur. True geminates are found in word-internal contexts, while fake geminates are almost always the result of a derived environment – morpheme or word concatenation, for example. The difference between these two classifications of geminates has important phonological consequences. True geminates are noteworthy for their exemption from phonological processes that typically apply to singleton segments, a phenomenon known as *geminate inalterability* (Hayes 1986). A frequently cited example of this comes from Tigrinya, a Semitic language in which true geminate consonants fail to undergo a process of postvocalic spirantization (Kenstowicz 1982, Schein 1981), shown in (7).

- (7) Geminate inalterability in Tigrinya
- | | |
|-------------|---------------------------------------|
| a. fäkkär-ä | ‘he boasted’ |
| yə-räkkəb | ‘he finds’ |
| b. mərəx-ka | ‘your calf’ (from /mərak + ka/) |
| bätəx-kum | ‘he cut you (pl)’ (from /bätək + kum) |

The forms in (7a) show that a geminate /kk/ is exempt from postvocalic spirantization, while the data in (7b) show that this process has taken place despite an underlying geminate structure created by morpheme concatenation. The explanation for this can be found by an appeal to the nature of the geminate structures – the data in (7a) contain true geminates, while those in (7b)

have fake /kk/ geminates. In other words, spirantization of the /k/ in the forms in (7b) may apply freely since the geminate is singly linked.

Several explanations have been proposed to account for such phenomena. The formal account of Autosegmental Phonology holds that any process affecting one half of a true geminate violates the *conjunctivity condition*⁴ and therefore does not occur (Goldsmith 1990:82). A more functional treatment of inalterability with respect to lenition phenomena is found in Kirchner (2000), where it is argued that the reason /kk/ clusters never completely spirantize to a [xx] sequence is due to the latter's articulatorily demanding nature; that is, maintaining the precise approximation necessary for a fricative is difficult to accomplish over long durations. Further, it is suggested that half-spirantized (true) geminates such as [xk] are unattested because of their similarly increased effort cost, as again, fricatives require the kind of isometric tension which is unnecessary for the production of stops (536).⁵

2.2.2 *The Obligatory Contour Principle*

The Obligatory Contour Principle, formulated below in (8), is a strict statement of the occurrence of possible adjacent elements. The OCP was originally formulated to account for tonal patterns but has since been extended to explain patterns in the co-occurrence of features and even entire segments.

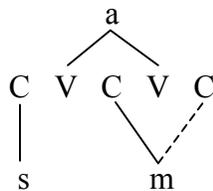
- (8) Obligatory Contour Principle (McCarthy 1986)
 On some tier, adjacent identical elements are prohibited.

⁴ The conjunctivity condition essentially holds that association lines must be interpreted as exhaustive (a statement which is identical to Hayes' (1986) *linking constraint*). This means that the number of linkages an autosegment has in a structural description must match the number of linkages borne by the autosegment to which the rule is meant to apply. Thus, in Tigrinya, the postvocalic spirantization rule's structural description refers to a singly-linked structure and therefore cannot apply to a doubly-associated (true) geminate. See also Schein and Steriade (1986) for their explanation involving the *uniform applicability condition*, a principle similar to Goldsmith's conjunctivity condition and Hayes' linking constraint.

⁵ In his analysis, Kirchner briefly discusses a possible connection between his effort-based analysis and geminate linkage. It is unclear to me why a language like Tigrinya would tolerate both geminates and the presumably more difficult half-spirantized geminates as a function of their environments (tauto- vs. heteromorphic). To account for this, Kirchner suggests a high-ranking IDENTITY constraint requiring faithfulness to the root, which according to the effort based approach, a final stop should spirantize (as it does).

OCP related effects apart from tone were first applied to radical consonants in the representations of Semitic templatic morphology (McCarthy 1981). Here, observed directionality effects in the co-occurrence of consonants in Arabic words could be explained by a restriction on adjacent identical consonants coupled with autosegmental spreading, shown in (9).

(9) *samam*, 'poison' (from √sm)



It is well-established that the underlying representation of *samam* is /sm/; because of the left-to right spreading rule, the /m/ is linked to the final two consonants by its spreading to fill an unassociated C-slot. It is this fact that lead researchers to believe that underlying identical consonants were prohibited, and thus another effect of the OCP was encountered.

2.3 Phonetically-informed phonology: the role of perception and production

Many recent studies have attempted to ground certain aspects of phonology in the properties associated with speech production and perception. This section reviews the relevant outcomes of such research.

2.3.1 Perception and Licensing by Cue

The role of speech perception in phonology has recently been an issue of much interest (Hume & Johnson 2001, Côté 2000, 2004, Steriade 1997, 1999, Kochetov 2002, Hayes, Steriade & Kirchner 2004). These studies have found that perception-related issues can influence the phonology of a language to a dramatic extent. While all of the important work in this area cannot receive a treatment here, I will describe the results of a particularly insightful study, the Licensing by Cue framework proposed by Steriade (1997, 1999). Broadly, Licensing-by-Cue

holds that contrast between segments occurs most in contexts where there exist sufficient perceptual cues for the listener to hear it. Steriade defines Licensing by Cue as follows (1999:4):

(10) Licensing by Cue

The likelihood that distinctive values of the feature F will occur in a given context is a function of the relative perceptibility of the F-contrast in that context.

Steriade convincingly shows that patterns of neutralization involving laryngeal and place features are strongly correlated with the availability of perceptual cues in a given segmental context. Further, she argues that these patterns are best considered without relation to the syllable, a notion she terms *segmental autonomy*.

2.3.2 Production and Articulatory Phonology

In addition to matters of perception, articulatory considerations in the structure of phonological systems have been a recent area of interest. Articulatory Phonology (Browman & Goldstein 1989, 1992, Goldstein & Fowler 2003) holds that the basic units of phonological organization are physiological speech gestures, which are defined as “events that unfold during speech production whose consequences can be observed in the movements of the speech articulators” (Browman & Goldstein 1992:156). In Articulatory Phonology, lexical items contain a set of definitions specifying the relations among gestures in terms of timing; that is, each lexeme consists of both intrinsic fixed times for individual gestures as well as timing relations between gestures, or *phasing*. However, these sources of timing can be variable within various domains, which allows for the overlap and merging of gestures.

Although the intricacies of the Articulatory Phonology program cannot receive complete treatment here (nor is one necessitated), its mention is warranted insofar as it has provided the impetus for many studies involving the role of speech gestures in phonology, such as Byrd (1994), Chitoran et. al (2002), Silverman (1997), Gick et. al (2006), etc. The present study makes use of ideas that have emerged from research in this area, namely the functional independence of articulatory subsystems and the gestural score as a means of representing gestural timing and overlap.

2.4 *Intermediate conclusion*

This section has described previous research in areas relevant to the analysis presented in this thesis. As a preliminary note, the concepts overviewed in the first two sections will be applied mainly in showing how these types of analyses fail to account for the Apinayé and Hayu pattern, while the latter two concepts will be used to motivate the central claim of this analysis.

3. Closure duration as a phonotactic variable

In this section, I will show how the patterns attested in Apinayé and Hayu are most accurately accounted for as resulting from a constraint banning long closure durations at the same place of articulation. Sections 3.1 and 3.2 provide an overview of the two languages examined. Section 3.3 shows how other conceivable approaches cannot account for the patterns encountered. Finally, in section 3.4 I show how the long closure constraint is the most appropriate analysis of the data.

3.1 *Apinayé*

Apinayé is an Amazonian language spoken by the roughly 800 members of the Apinayé tribe in Brazil. Although heterorganic consonant sequences are tolerated across a syllable boundary in Apinayé, homorganic clusters in the same position are simplified via the deletion pattern illustrated in (10).^{6,7}

- (11) a. Stop before a homorganic stop: /tɛp + pič/ → tɛ:pič ‘just fish’
 b. Stop before a homorganic nasal: /pɛp + mɛč/ → pɛ:mɛč ‘good fish’
 c. Nasal before a homorganic nasal: /om + mɛč/ → o:mɛč ‘a massa boa’
 d. /p/ and /m/ before /v/: /tɛp + vɔr/ → tɛ:vɔr ‘to fish’
 e. /r/ before /r/: /pur + rač/ → pu:rač ‘big field’
 f. /č/ before /ž/: /moč + ža/ → mo:ža ‘this cow’

⁶ The format in which these data are presented is from Hyman (2008); they originally come from Burgess and Ham (1968) and Ham (1967).

⁷ Note also that /k/ deletes causing compensatory lengthening of the preceding vowel when it precedes any consonant except /r/ and /ʔ/, as in /kok + pič/ → ko:pič ‘just wind.’ While this cannot be attributed to homorganicity exclusively, it is worth mentioning since it fits with the other patterns of deletion.

As seen, homorganic consonant sequences resulting from morpheme concatenation are simplified via deletion of C1, causing compensatory lengthening of the preceding vowel. In other words, Apinayé seems to require that its heterosyllabic consonants be non-branching (Hyman 2008), contrasting sharply with the situations attested in languages such as Japanese and Italian (cf. section 2.1.1 above). However, as mentioned, the Japanese pattern is accounted for by requiring that the coda share some place specification with its following onset. In this language, it is clear that this is not the case.

Apinayé's inventory of possible coda consonants is /p, t, č, m, n, ɲ, v, r, ž/. These consonants are attested in the coda word-medially as well as word finally, so we know that the language tolerates sequences of heterorganic consonants across a syllable boundary. Note, however, that not all consonant clusters are subject to these simplification patterns, shown in (12).

- (12) /tom + pič/ → to:mpič 'just frekle'
 /meɲ + ža/ → me:ɲža 'this honey'

While the tolerated nasal + stop clusters are not transcribed as prenasalized stops, note that compensatory lengthening of the preceding vowel still occurs in the phonetic forms. Also of potential relevance are the facts that nasal + stop clusters are attested word-initially, and nasal stops become prenasal preceding an oral vowel, as in /ma/ → [mba] 'liver.'

3.2 *Hayu*

Hayu, a Himalayan language spoken in Nepal, is similar to Apinayé in that it disallows sequences of heterosyllabic homorganic consonant sequences while allowing heterorganic consonant clusters across syllable boundaries, as seen below in (13) (Michailovsky & Mazaudon 1974).

(13)	Root	‘they ... you sg.’	‘...it!’	‘I ... you sg.’	‘he ... us’	‘he ... me’	
	/pʊt/	pʊtme	pʊxtʊ	pʊʔno	pʊtkok	pʊtŋo	‘thin out a crop for’
	/pʊk/	pʊkme	pʊkto	pʊkno	pʊxkok	pʊʔŋo	‘arouse’
	/pɪŋ/	pɪŋme	pɪŋto	pɪŋno	pɪ:kok	pɪŋo	‘send’
	/dɪp/	dɪʔme	dɪpto	dɪpno	dɪxpok	dɪʔmo	‘pin in wrestling’
	/mʊm/	mʊme	mʊmto	mʊmno	mʊ:pok	mʊmo	‘offer food to’
	/tʃʊn/	tʃʊnme	tʃʊ:to	tʃʊno	tʃʊnkok	tʃʊnmo	‘wash dishes for’

In the data presented above, it can be seen that homorganic consonant sequences across a syllable boundary are simplified. A stop before a homorganic stop alternates with either [x] after back vowels or [ç] after front vowels (generalized to [x] in (13)). An oral stop before a nasal becomes a glottal stop, an apparent case of stability as coda stops are realized as glottalized and unreleased. A nasal before a homorganic stop deletes, causing compensatory lengthening of the preceding vowel which bears stable nasality as well. Finally, a nasal before a homorganic nasal simply deletes. These patterns are summarized in (14).⁸

(14)	CVT _i + T _i V	→	CV[x ~ ç].T _i V
	CVT _i + N _i V	→	CV[ʔ].N _i V
	CVN _i + N _i V	→	CV.NV
	CVN _i + T _i V	→	CV[ʔ].C _i V

It should be noted that the allophones resulting from the demand on simplification only occur in the coda as a result of this process. Similar to Apinayé, Hayu tolerates heterorganic consonant clusters across a syllable boundary, as shown by the table of partial word-medial attestations in (15).

⁸ These data are again presented in the format originally found in Hyman (2008)

(15) Attested word-medial consonant combinations in Hayu (partial)⁹

C ₁ ↓ C ₂ →	p	t	k	m	n	ŋ
p	(xp)	pt	--		pn	--
t	--	(xt)	tk	tm	(ʔn)	--
k	kp	kt	--	km	kn	(ʔŋ)
ʔ/x	xp	xt	xk	ʔ _m	ʔ _n	ʔ _ŋ
m	(mp)	mt	--	(m)	--	--
n	np	(nt)	nk	nm	(n)	nŋ
ŋ	ŋp	ŋt	(nk)	ŋm	ŋn	(ŋ)
n	np	nt	nk	--	--	--

In the table above, unattested word-medial consonant combinations are indicated by blank spaces; sequences in parentheses indicate combinations that are unattested because they are sites of simplification. The final C₁ listed, *n*, represents nasality on the preceding vowel. Labial + velar sequences are unattested because of a separate constraint that bans such sequences. Note that this explains the patterns seen in forms such as /dip + kok/ → dixpok; the result of the *labial + velar constraint is a sequence of two labial segments which are then subject to the dissimilation process described above. These simplification patterns are attested morpheme-internally as well, shown by the data in (16).

(16) Word-internal simplification in Hayu

/kattu/	→	kaxtu	‘nut’
/sakka/	→	saxka	‘barley’

We know that the underlying representations above contain geminated sequences since, from the phonetic forms, underlying C₁ is recoverable via the nature of the allophony, with its [-continuant] specification given unambiguously by [x] and its place given by C₂. If these underlying sequences are true geminates¹⁰, then the principle of geminate inalterability predicts

⁹ Table reproduced and slightly modified from Michailovsky & Mazaudon (1973:146)

¹⁰ Note also that we see stable glottalization (from the syllable-final stops) in the morpheme-internal forms, as in /natnum/ → na^ʔnum ‘rain’ and /tsotla/ → tso^ʔla ‘child.’ Since the glottalization rule targets the syllable coda which, because of Hayu’s maximal coda shape,

that simplification should fail to apply. Therefore it seems that these morpheme-internal clusters are singly-linked.

Importantly, as is the case in Apinayé, there are exceptions to the general ban on homorganicity, shown in (17).

- (17) a. /sel + to/ → selto ‘thin out a crop for it!’
 /sel + no/ → selno ‘I thin out a crop for you’
 b. /puk + kok/ → puxkok ‘he pins us in wrestling’

The cases in (17a) result from the fact that heterosyllabic /IC/ clusters never undergo simplification. Although I have been unable to find supporting data, this presumably means that /ll/ would be the language's only geminate consonant. The data in (17b) show a heterosyllabic homorganic sequence resulting from simplification. Finally, the data in (18a) show that exceptions to the nasal + stop simplification pattern are attested in reduplicated forms, while (18b) shows an 'anomalous combination' (Michailovsky & Mazaudon 1973:150).

- (18) a. /pem-peremu/ → pemperemu ‘round’
 /plom-plom/ → plomplom ‘tasteless’
 /kaŋkaŋ/ → kaŋkaŋ ‘vertical’
 b. /um+be/ → umbe ‘now’

3.3 *Conceivable approaches*

The elimination of heterosyllabic homorganic sequences has a variety of possible explanations. As far as I am aware, no previous attempts have been made at providing an analysis of this phenomenon, so I bear the responsibility of providing and critiquing conceivable analyses apart from the proposed ban on long closure durations. Accordingly, previous research on similar problems can be divided into the following two areas: syllable-based accounts, as in Ito (1986)

necessarily refers to a singly-linked consonant in its structural description, it follows that its successful application implies a non-branching geminate structure.

and Goldsmith's (1990) coda conditions, and similarity-based accounts, utilizing the OCP or considerations of perceptual distinctness. In this section I will show how analyses from both of these areas cannot account for the patterns attested in these languages.

Apinayé and Hayu share a striking commonality in that they seem to require their coda consonants to be *non-branching*. This situation contrasts sharply from that of languages such as Japanese, where the only allowable codas are those that branch to a following onset consonant (cf. section 2.1.1 above.). It is evident that the problem presented by Apinayé and Hayu is outside of the scope of gemination as total identity since non-identical homorganic sequences are subject to simplification. We can, however, take the facts available in the languages to offer a solution based on certain properties of the syllable. Following Ito's idea of the coda constraint, we might attempt to construct a similar account for the languages analyzed in this work. Temporarily leaving aside the exceptions described above, the constraint in (19) may be proposed to account for the fact that the attested heterosyllabic consonant sequences are those that do not share a common place node (generalized here as 'o').

$$(19) \quad * \begin{array}{c} C]_{\sigma} \quad o[C \\ \diagdown \quad \diagup \\ o \end{array}$$

This constraint would prohibit a branching node across a syllable boundary. However, such a formulation subsumes the notion of a coda constraint as it must refer to the onset of a second syllable; in other words, it is not clear how the constraint proposed above can be said to apply primarily to the coda. This is a problem if we assume, as discussed in earlier sections, that the motivation for a constraint referring exclusively to the coda comes from its generally marked status relative to onsets. Considering this, we are led to the conclusion that the facts of Apinayé and Hayu cannot be stated in terms of a negative coda constraint. We achieve slightly greater success, however, in following Chung (1991) by positing a positive, conditional constraint on the coda, formulated for Apinayé and Hayu in (20).

$$(20) \quad \begin{array}{c} \text{IF} \quad C]_{\sigma} \\ \hline \text{THEN} \quad o \end{array}$$

The constraint above can be paraphrased as “if a consonant occurs in the syllable coda, then it must be singly-linked.” We avoid the problem presented by the negative condition as the structural description in (20) can now refer exclusively to the coda. The problem with this approach, however, will become a familiar one: there is no formulation of this constraint that could exempt certain clusters, i.e., the tolerated homorganic sequences. Since it is not always the case that heterosyllabic sequences are banned from what appears to be the sharing of a common place node, coda conditions are simply not informative enough for a complete account of the markedness of homorganic sequences.

Aside from syllable-based approaches, many previous solutions to similar phenomena have relied on similarity-based accounts; that is, many languages place restrictions on the co-occurrence of segments based on their similarity to one another. Since it is reasonable to suspect that similarity may be the driving force behind the patterns of simplification, following this line of reasoning may yield positive results. The strictest form that similarity avoidance can take is found in the Obligatory Contour Principle, restated in (21).

- (21) Obligatory Contour Principle (after Hayes 1986)
 On some tier, adjacent identical elements are prohibited

Considering this, we might formulate a constraint such as the one shown below in (22), which bans adjacent segments with identical place specifications. Note also the single linkages borne by each place feature; this is meant to account for the fact that Apinayé and Hayu seem to require that their consonants be non-branching, as discussed above. If this is the case, as argued, then this principle must be reflected in a constraint formulated in terms of the OCP.

- (22) * C C
 | |
 [α place] [α place]

Of course, the most obvious problem with this approach is that, again, it cannot account for the fact that not all homorganic consonant clusters are simplified via the patterns described above. A second, related problem is that the OCP is unable to account for the observed directional asymmetries. The tolerated homorganic sequences in Apinayé and Hayu have an interesting characteristic: when the syntagmatic ordering of the consonants C1 and C2 is reversed, the

cluster is not tolerated. Considering this, it can be useful to think of the patterns of these languages not as a general ban on homorganicity, but rather a ban on homorganicity in a somehow marked syntagmatic order. Therefore, we find that an OCP-based account referring to place features cannot explain all of the patterns we seek to describe. We can, however, propose that the OCP applies within a different domain, namely that of the feature [continuant] (assuming the ban on identical place still holds), which would result in a constraint such as the one below in (23)

$$(23) \quad \begin{array}{cc} *C & C \\ | & | \\ [-\text{cont}] & [-\text{cont}] \end{array}$$

Utilizing this formulation of an OCP constraint is somewhat more valuable since we are now dealing with a binary feature, further constraining its domain of applicability; that is, there are now only two options for a sequence that is not subject to dissimilation, which is reflected by syntagmatic ordering. Taking this approach to the OCP also seems reasonable insofar as the attested heterosyllabic homorganic sequences appear in Hayu to be exclusively of the type [+cont][-cont], shown again in (24).

(24)	/sel + to/	→	selto	‘thin out a crop for it!’
	/sel + no/	→	selno	‘I thin out a crop for you’
	/puk + kok/	→	puxkok	‘he pins us in wrestling’

However, we still find that the OCP is unable to account for the fact that some homorganic sequences seem to only be banned when the segments are ordered linearly in a specific direction. In other words, for a complete description of these patterns, a constraint or principle would need to be informed of precedence relations, which, as we have seen, is not possible with the OCP as a constraint on similarity. The *[-cont][-cont] constraint cannot hold as well for two reasons: first, as seen in Apinayé, nasal + stop clusters are not simplified, and second, /l/ seems to function as [-continuant] in Hayu – see below for more discussion. Considering these facts, it would be beneficial to find some principle more informative than the OCP.

Such a case is found as a similarity approach that subsumes the OCP is offered in Côté (2004), where similarity is ranked on a perception-based implicational hierarchy, and languages

select a certain point on this scale that stipulates the degree of similarity they tolerate. She argues for this by examining cases of stop deletion patterns, showing that the greater degree of similarity two adjacent segments possess, the more likely one of the two is to delete. Regarding the function of the implicational hierarchy, if a language shows in one way or another that adjacent stops, for example, are disfavored because their similarity, then it is necessarily the case that segments contrasting in more features than [continuant] are less marked and may not be subject to deletion. Although similarity is computed in terms of phonological features, Côté suggests that the motivation for the patterns of stop deletion described in her paper is perceptual salience.

Considering this, we might want to posit that segments contrasting in more features than place are acceptable in Apinayé and Hayu. However, this analysis quickly runs into a problem since homorganic clusters such as [mp] and [ln] are found in the languages considered here. However, Côté's (2004) discussion is valuable insofar as it highlights the fact that perception may play a role in determining simplification patterns of consonant deletion, which I will discuss below.

To summarize the results of this discussion so far, I have provided evidence that syllable- and similarity-based accounts including the OCP cannot account for the observed patterns of homorganic consonant simplification in Apinayé and Hayu. I have shown that the coda condition is not an applicable concept, and I have also established that the OCP cannot be utilized in this analysis because of its inability to account for the directional asymmetries observed in both Apinayé and Hayu. I will now shift focus to these asymmetries by showing how a perception-based similarity approach still cannot provide an explanation for the phenomenon encountered in these languages. I will then show how the only reasonable analysis is that of a ban on long closure durations, utilizing a phonetically natural yet phonologically unnatural segment class. To begin, the directional asymmetries in the attestations of homorganic sequences are summarized in (25)

(25) Summary of directional asymmetries

<u>Hayu</u>	<u>Apinaye</u>
*[nl] [ln]	*[TN] [NT]
*[tl] [lt]	
*[TN] *[NT] ~ [NT] ¹¹	

These asymmetries illustrate where similarity-based accounts fail. That is, the problem of exempting certain clusters by virtue of their similarity is linked to the fact that in some cases, a cluster C1C2 may be subject to dissimilation, but the same cluster reordered as C2C1 is not. If we assume that perceptual similarity is at the root of these patterns, a more insightful argument can potentially be made. Considering homorganic stop sequences, for example, there is some support for the idea that the dissimilation patterns are meant to maximize perceptual cues. For example, /tt/ → [xt] in Hayu may serve to increase perceptibility since, rather than two sounds which rely on transitional cues (as is the case for stops), there is now only one, namely C2. Since this stop is prevocalic, its release burst is salient, and the importance of the transition between the fricative and the stop is negligible since the primary cue to the perception of fricatives, high frequency aperiodic noise, is intrinsic to the segment. However, since geminate stops contain two transitional cues just as singleton stops do, it is unclear why one would be less perceptually salient than the other. The inadequacy of a perception-based account is shown most dramatically by Hayu's [ln] ~ [nl] asymmetry since sequences of nasals and laterals have low contrast in terms of perceptual salience. In fact, Seo (2001) argues that this fact provides motivation for an assimilation process in Korean whereby nasal + lateral sequences in either ordering both surface as either [ll] or [mn]. A perceptually-motivated account of the dissimilation patterns of Apinayé and Hayu seems untenable when considering that in Hayu, for example, /nl/ sequences are subject to simplification while sequences like [tk] which are perhaps even more perceptually impoverished are tolerated.

3.4 A ban on long closure durations

To provide evidence for a phonotactic constraint disallowing long closures, we must first examine what is meant by *closure*. The term 'closure' is most frequently applied to stops and

¹¹ Markedness indicated as variable since NT clusters are attested in reduplicated forms, cf. above.

affricates since these sounds are articulated with complete lingual-palatal or bilabial closure (that is, a completely efficient seal is formed between active and passive articulators), resulting in their characteristic blockage, buildup, and eventual release of oral airflow. In this sense, then, ‘closure’ is a cover term for the separate events of active-passive articulator contact and airflow blockage, as supralaryngeal articulators and the glottis are independently controllable and do not, a priori, require any such descriptive conflation. For the purposes of the analysis presented here we will need to provide a phonologically relevant distinction between these two events when describing a closure.

Most phoneticians (and languages) would agree that a glottalized and unreleased /t/ still counts as a lingual-palatal stop even though, unlike a plain stop, there is no airflow buildup or release involved. Following this line of reasoning, I use the term ‘closure’ to refer to any *contact* between articulators. This includes sounds for which closure forms an inefficient seal (in terms of airflow) such as /l/ and certain fricatives. I will refer to closures that may potentially block airflow as *efficient* closures, while I follow standard tradition in referring to closures made by /l/ as *transverse* (Catford 2001:71). Ultimately, I will use this idea to show that to account for the data examined in this work, a phonologically unnatural yet phonetically-motivated class consisting of these ‘contact’ segments needs to be an available concept.

A similar treatment can be given to the event of a stop *release*. As its name implies, this is when a stop releases its blocked airflow, usually causing an audible burst. Again separating supralaryngeal articulator contact and laryngeal behavior, I define ‘release’ as the event of an articulator’s withdrawal from contact, regardless of whether or not airflow is released.

The behavior of airflow can, however, evidence the extent to which an articulation can be classified as a closure, even though as described above it is not a necessary component. For example, as will be shown, /s/ behaves as though it contributes to closure length in Hayu. Although in this case laryngeal behavior is not a significant factor, the appreciable buildup of airflow characteristic of /s/ relative to other fricatives helps explain its contribution to closure duration, insofar as airflow buildup implies a ‘stronger’ constriction, i.e., more forceful contact between articulators.¹² The status of /l/ as a closure contributing segment, however, is largely

¹² This phonetically-based distinction is necessary to separate /s/ from /x/, which does not appear to contribute to closure duration. Phonologically speaking, Mielke (2005) finds that in a small number of languages, fricatives pattern as [-continuant]. If, however, there were a

phonologically motivated (aside from the fact that apical contact does occur on the alveolar ridge), which will be shown below.

I will now describe how the simplification patterns encountered in this work are most profitably analyzed as resulting from a ban on geminate-length closure durations. As a preliminary note, the terms 'geminate-length' and 'long' are used arbitrarily throughout the analysis (though see section 4 for more discussion); these measures simply represent durations that are anywhere from 1.5 to 3 times longer than that of a singleton segment.

I begin with a preliminary note on the role of articulation in the long closure constraint. In his (2008) paper on phonological universals, Hyman briefly considers these data and arrives at the generalization that “stop closures may not be followed by a homorganic release.” Building from this, a conceivable analysis, then, is to view the LCC as a cover term for numerous processes consisting perhaps of similarity avoidance coupled with this release statement. Since this generalization neatly accounts for the directionality aspect, we can rule out an explanation relying on a strict interpretation of the OCP. However, this approach becomes complicated when considering that all coda stops are preglottalized and unreleased, and I question the extent to which the offset of a /t/ in a /tʰ/ cluster can be considered a release, especially since lingua-palatal contact is not fully broken (and in this case, the glottalization of the stop would not allow for an appreciable release of airflow). If a preglottalized stop cannot be released into the same place of articulation, then it would follow that no homorganic sound can be released in the same position. If the idea of a release is at all relevant, its effects would be unseen as releases are then identical for C1 /tʰ/ and /t/ since because of the homorganicity, there are no phonologically significant release phases. Thus we find that there is no reason to appeal to stop releases as a factor contributing to the antihomorganicity effects seen in Hayu and Apinayé.

I will now remark on the status of standard phonological features in regard to the present analysis. It seems reasonable to assume that the specification of /l/ as either [+continuant] or [-

situation that necessitated a divide within the class of fricatives (such as in Hayu, possibly, though see below), I suspect that /s/ would pattern with [-cont] segments while /x/ would pattern with [+cont] segments. Evidence for this comes from the properties of /s/ described above, whereby buildup of airflow may be used as an indication of the extent to which a fricative is ‘stop-like.’ Again, though, keep in mind that airflow is not a crucial factor of closure segments in Apinayé and Hayu, and accordingly I will not utilize a feature-based analysis.

continuant] is responsible for its behavior with respect to the simplification patterns, but this line of reasoning does not hold for long: if this were the case, it would seem that /l/ patterns as both specifications depending on its position in a consonant cluster. Recall that /l+C/ clusters are tolerated across syllable boundaries in Hayu but /C+l/ clusters are not. If the tolerability of the former is attributed to its [+cont] status (since it is then like [x] where [xC] clusters are tolerated, c.f. above), then the appeal to /l/'s continuancy status may be reasonable. However, in situations where potential /C+l/ clusters arise, they are subject to simplification, indicating that a C₂ /l/ contributes to closure length just as any other [-cont] segment does. What we are confronted with then is a positional asymmetry; that is, /l/ appears to function as [+continuant] when it is C₁ in a consonant cluster and as [-continuant] when it is C₂. I avoid this complication by not utilizing the feature [continuant] and rely on the phonetically natural class [contact], which I will now describe.

It has been alluded to in earlier sections that segments which contribute to closure duration comprise a phonetically-motivated yet phonologically unnatural class, which I call [contact]. [+contact] segments are stops, affricates, coronal lateral liquids, and strident fricatives (/s/, in this case). These segments can be grouped together because of their stronger forcefulness of contact between articulators relative to other sounds (cf. footnote 12 on page 23). All others are [-contact]. It is still the case, however, that two adjacent [+contact] segments should a priori fail to occur, but since there are exceptions, we must posit a mechanism to account for this, which I undertake in the next section.¹³

To summarize, I have shown that the dissimilation patterns attested in the present analysis are best viewed as resulting from a phonotactic constraint militating against long closure durations, which are now defined as adjacent [+contact] segments. Note that a long duration seems to be defined only by articulator contact, needing no reference to airflow or other factors. Arguments in this section point to this fact as the only significant generalization to be made, especially since similarity accounts and feature-based generalizations cannot explain the directional asymmetries. Next, I provide a preliminary account of the mechanism by which some [+contact] clusters are able to surface.

¹³ Note that we could plausibly state that /l/'s are exclusively [-continuant], but insofar as the feature [continuant] implies airflow, which is unnecessary, utilizing this feature only provides complications.

4. Satisfying the long closure constraint: consonant cluster compressibility

3.1 Overview

It is a central claim of this thesis that the tolerated heterosyllabic homorganic consonant sequences are intrinsically different from those that are simplified. In this section it is argued that the exempt clusters are *compressible*, meaning that the two segments may be pronounced with shorter duration while maintaining perceptual recoverability cues and are thereby no longer banned by the long closure constraint. The clusters that are simplified cannot be compressed, so they must simplify.

The term “compressibility” has had a brief treatment in the literature. Steriade (2008) utilizes it to refer to consonant clusters that are shorter in duration, such as stop + liquid clusters in her account of an interlude theory of weight in the classical meters of Greek.^{14,15} In addition, Chitoran et al. (2002) propose that obstruent sequences in Georgian are more likely to exhibit a greater degree of articulatory overlap when recoverability cues are not threatened, such as in word-medial environments. The notion of compressibility developed here is different in a number of important ways. First, compressibility is a term better applied to the nature of a cluster’s gestural organization rather than its duration, although it is still certainly the case that gestural compressibility is correlated with phonetic duration; Steriade’s utilization of compressibility, as I understand it, relies on features universally intrinsic to a consonant cluster; in my view, compressible clusters are those that *can* be pronounced with shorter duration, meaning that it may not be the case that the compressible clusters I describe are pronounced in the same way cross-linguistically. Further, it is reasonable to suspect that this sort of ability is only realized when it is externally motivated, i.e., by the long closure constraint.

3.1.1 Compressibility

¹⁴ Steriade cites McCrary (2007) for the data leading to the durational measurements.

¹⁵ I credit Steriade for the idea of compressibility as a phonologically relevant feature of consonant clusters. My only source of information on this topic, however, is from attending a talk she gave at the CUNY Conference on the Syllable in January of 2008. Therefore, any reference I make to this information is based on necessarily limited exposure to it.

This section will provide a preliminary account of the mechanism by which certain clusters are able to compress in the languages analyzed here. Clusters that are able to compress can be pronounced with a shorter duration while maintaining perceptual recoverability cues. I propose that there are two primary criteria used in determining a cluster's ability to compress: articulatory subsystem mismatch and C1 release cue preservation. Regarding the former, segments in a consonant cluster have an articulatory subsystem mismatch if each utilizes different, independently controllable articulators. For example, homorganic nasal + stop clusters share a closure gesture, but the segments differ in their use of the velic gesture for nasality. As for C1 release cue preservation, which will be used to account for certain cases of directionality, clusters are more likely to compress if C2 does not obscure release cues for C1 (Chitoran et al. 2002). Words containing compressible clusters in Apinayé and Hayu are repeated in (27).

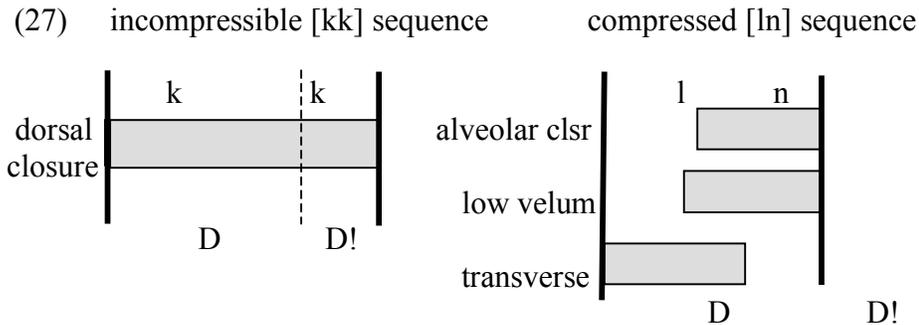
- (27) a. Apinayé
 /tom + pič/ → to:mpič 'just frekle'
 /meŋ + ža/ → me:ŋža 'this honey'
- b. Hayu
 /sel + to/ → selto 'thin out a crop for it!'
 /sel + no/ → selno 'I thin out a crop for you'

The Apinayé words showing tolerated nasal + stop sequences in (27a) illustrate the roles of both articulatory subsystem mismatch and C1 release preservation. While in each of these clusters the segments share a closure gesture, the nasal utilizes a velic lowering gesture while the plosive does not. Because of this extra source of information (relative to a stop-stop sequence, for example, which contains perceptual information from only one source, namely the closure gesture), there are sufficient cues for the recoverability of the segments in the cluster even when it is pronounced with shorter duration. Since the primary cues for nasality in a nasal segment are not obscured by a C2 stop masking its release, the clusters meet the release preservation criterion as well.

The tolerated homorganic /l+C/ sequences shown by the Hayu words in (27b) can be treated in a similar fashion. Since sonorants do not possess phonologically relevant release phases, no C2 segment is in danger of masking their recoverability cues. I note here that while

sonorants in general typically have longer durations than other consonant types, there is no quality intrinsic to these sounds that demands such length.¹⁶ Thus, it is reasonable to posit that sonorants may be pronounced with a (reasonably) short duration without perceptual consequence. Of course, for both of these languages there is a directionality aspect that cannot be predicted from the compressibility criteria alone; I will address this problem in later sections.

To illustrate these ideas, the gestural scores below in (27) illustrate an incompressible [kk] sequence and a compressed [ln] sequence, respectively.

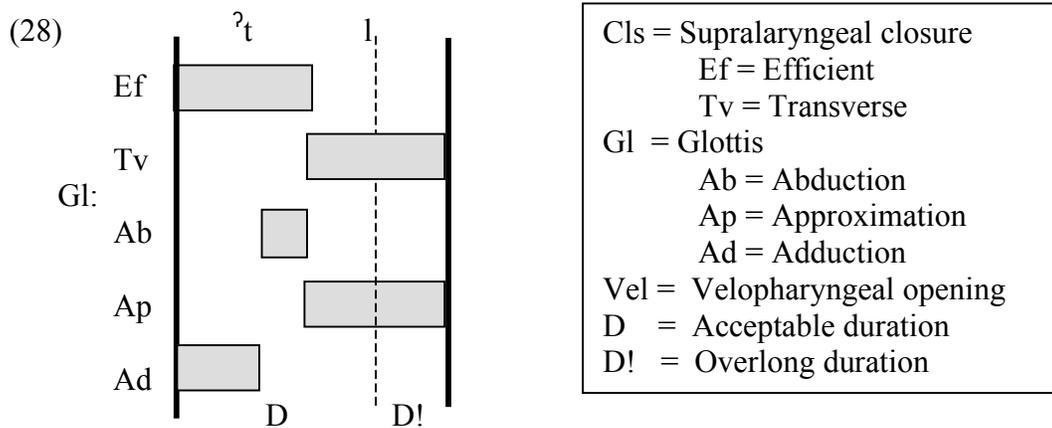


Compressing a [kk] sequence would result in a shorter duration, but neither Apinayé nor Hayu satisfies the long closure constraint in this way. There are two options that may be used to account for this fact. First, it is possible that these languages treat adjacent homorganic segments as bi-gestural, meaning that they are phonologically composed of two identical gestures rather than one long gesture¹⁷. If this is the case, then we can apply the C1 release preservation criterion: in a [kk] sequence, C2 [k] masks the release cues of C1 [k]. The second option relies on speakers' linguistic competence – speakers may have implicit knowledge of the perceptual recoverability cues associated with particular segment sequences that is referenced in determining which clusters may compress. Since a [kk] sequence does not meet the articulatory mismatch criterion, the effect on perceptual cues between a compressed and non-compressed sequence is negligible.

¹⁶ This cannot be said of oral stops, for example. Their relatively short durations follow from the fact that equalization of subglottal and oral air pressure happens quickly for physiological reasons.

¹⁷ As established above, the simplification patterns of Hayu and Apinayé seem to indicate that homorganic clusters do not share a single place node. If we imagine that a branching place structure in some sense licenses an otherwise phonetically marked sequence, then it follows that a two identical stops would require some sort of repair. This analysis raises other issues which will be addressed below.

The [ln] sequence, on the other hand, is compressible since gestural overlap still allows for recoverability of perceptual cues. In particular, the ‘low velum’ gesture may occur simultaneously with the transverse /l/ closure. Even with the cluster’s short duration, all perceptual information is sufficiently cued. Before moving on, the legend in (28) provides an explanation of the gestural scores used throughout this section.



In the gestural score above, from top to bottom, we have the following articulatory subsystems: supralaryngeal (lingua-palatal and labial) closures (efficient and transverse), glottal states (abduction – voiceless, approximation - voiced, and adduction – no airflow), and finally, though not included above, velopharyngeal opening. The time dimension is represented below the score with “D” and “D!,” separated by a dashed line, marking allowable and overlong closure durations, respectively. Note that these units are arbitrary. No attempt has been made to correlate them with any concrete measure such as milliseconds, for example, nor is asserted here that D corresponds to the length of a typical singleton segment. D is simply the underlying total duration minus D!, which equals an allowable closure duration. It is reasonable to suspect, however, that D corresponds roughly to the duration of a singleton segment but may vary somewhat depending on the particulars of the cluster. I will now detail the ways in which particular consonant sequences are able to compress in Apinayé and Hayu.

3.2 Application

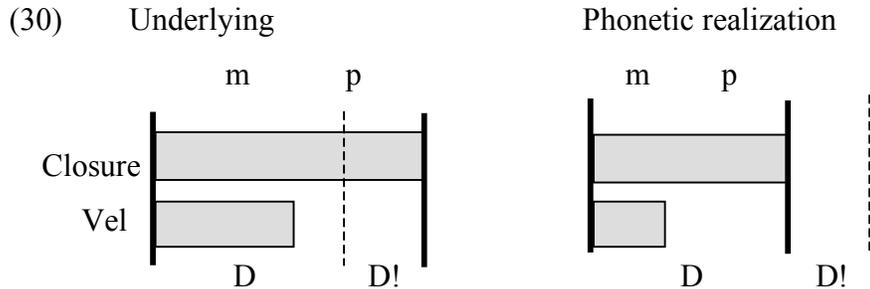
This section provides a preliminary account of the nature of consonant cluster compressibility in Apinayé and Hayu. First, the exceptions to the simplification pattern of Apinayé are considered, then, those in Hayu receive a similar treatment.

3.2.1 Apinayé

In Apinayé, nasal + stop clusters are not subject to simplification when all other homorganic sequences are, repeated in (29).

- (29) /tom + pič/ → to:mpič 'just frekle'
 /meŋ + ža/ → me:ŋža 'this honey'

As mentioned above, nasal + stop sequences meet both criteria for compressibility: articulatory subsystem mismatch and C1 release preservation. Gestural scores illustrating the compressibility process are given in (30).



The compressibility of nasal + stop sequences in Apinayé is also evidenced by the compensatory lengthening which occurs on the preceding vowel (cf. above); that is, the lengthening of the vowel would seem to indicate that the following segment has been made inversely shorter. Note also that compression in this situation may be helped by the fact that the primary articulatory difference between a nasal and a homorganic stop is the state of the velum – when it is lowered, airflow is directed into the nasal cavity. If at any point the velum raises, the necessary result is a released stop consonant, as the resultant influx of intraoral air pressure forces an audible release. Therefore a simple system of physiological implications assures recoverability of both sounds.

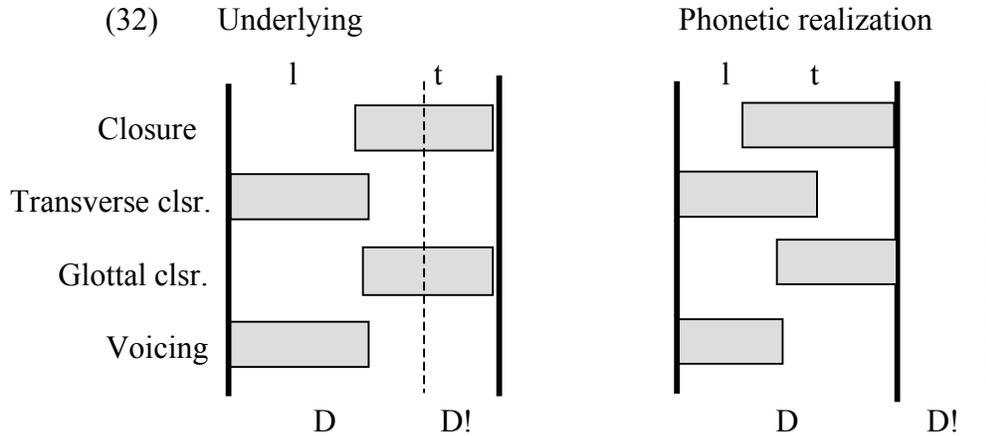
As mentioned above, there is still the issue of directionality. A [pm] cluster meets the criterion of articulatory subsystem mismatch, yet these sequences are simplified rather than compressed. This can be explained by C1 release recoverability: C2 [m] masks the release cues of C1 [p] since the identical place specifications make it impossible for [p] to have a salient release burst. On the other hand, this particular analysis raises another issue: if release cues are one of the main considerations when accounting for the allowable homorganic clusters, then why refer to duration at all? In other words, it may be the case that in Apinayé, homorganic clusters are simplified because in most cases C1 cannot have an audible release. I again cite the fact that the nasal component of compressed clusters in this language is “very short” (Burgess & Ham 1968:15), and the preceding vowel lengthens as though some process of cluster simplification has occurred (and not left completely unaltered).

3.2.2 *Hayu*

Forms in which homorganic sequences are attested in Hayu are repeated below in (31) – recall that all attested homorganic clusters in Hayu contain /lC/ clusters.

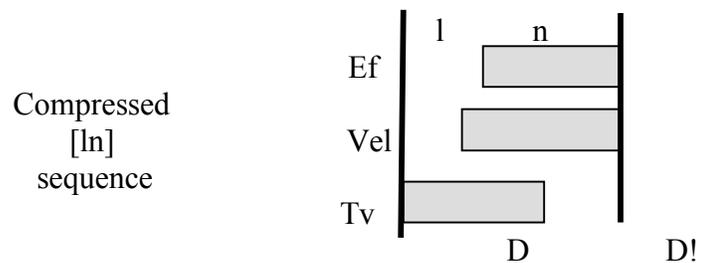
- | | | | | |
|------|------------|---|-------|-----------------------------|
| (31) | /sel + to/ | → | selto | ‘thin out a crop for it!’ |
| | /sel + no/ | → | selno | ‘I thin out a crop for you’ |

An explanation for the compressibility of /lC/ clusters in Hayu is less direct than for the Apinayé case. In the /l/ + oral stop situations, there is no danger of any C2 masking release cues of /l/, and I also point out the transverse closure of /l/ may be treated as a gestural onset to the stop closure. This is illustrated by the gestural scores in (32).



The claim made above makes sense on physiological grounds as well, since a transverse closure can serve as a transition from zero oral occlusion to complete occlusion, such as with a stop. Although the compressibility of this cluster satisfies the ban on long closure durations exclusively, it is also the case that, in this situation, the transverse closure of /l/ allows for airflow to continue; therefore, the stop fulfills its unmarked function by having an audible release. The reverse ordering, /^htl/, is not compressible because considering that the /t/ is glottalized and unreleased since it occurs in the syllable and also keeping in mind the physiological statements made above, /t/ cannot be treated as a suitable gestural onset to /l/ since it fails to participate in the physiologically natural series of implicational relationships described above for [mp] and [lt] clusters. This same logic can be used to account for the expected /ln/ and /ls/ as well; that is, in these cases the transverse closure of the /l/ functions as a gestural onset to its next segment which may thereby reduce the overall duration of the sequence. Note that in the case of /ln/ clusters, there is more opportunity for increased gestural overlap since the velum is active in these sequences, as shown in (33), repeated from (27).

(33)



Finally, recall the “anomalies” present in reduplicated forms and a lexical item from above, shown again in (34).

- | | | | | | |
|------|----|--------------|---|-----------|-------------|
| (34) | a. | /pem-peremu/ | → | pemperemu | 'round' |
| | | /plom-plom/ | → | plomplom | 'tasteless' |
| | | /kaŋkaŋ/ | → | kaŋkaŋ | 'vertical' |
| | b. | /um+be/ | → | umbe | ‘now’ |

Since all of these attested clusters are of the type nasal + stop, it is reasonable to posit that they too undergo the same manner of articulatory compression described for the preserved nasal + stop clusters in Apinayé. It is unclear, however, why compressibility is only seen in reduplicated forms and the lexical item in (34b).

This section was meant to provide a preliminary account of consonant cluster compressibility as it relates to the patterns attested in Apinayé and Hayu. Obviously, there are issues that remain unanswered; for example, a clearer statement of the directionality restrictions, particularly for Hayu, is desirable. Also, although an attempt at an explanation has been made, it is still unclear exactly why all homorganic clusters do not compress rather than simplify. Regardless, as we have seen, the exceptional homorganic clusters are those that seem to lend themselves to duration reduction via articulatory compression, more so than the illegal clusters.

5. Concluding remarks

In this thesis I have shown that the simplification patterns attested in Apinayé and Hayu are most profitably analyzed as resulting from a ban on long closure durations. I have also shown that the tolerated homorganic clusters, i.e., those that are exempt from simplification, are likely shorter in duration due to their compressibility (reduced duration), which may shorten the overall duration of a consonant sequence, satisfying the ban on long closures while maintaining perceptual recoverability cues.

5.1 *A functional account of the long closure constraint*

I will state here that a functional motivation for the long closure constraint is difficult to conceptualize. One possibility is that long homorganic closures are less desirable than singleton

segments due to the prolonged period in which airflow must be blocked (this assumes also that there is some airflow release in heterorganic stop + stop clusters). In any case, the effects of Apinayé and Hayu's general ban on homorganicity are extremely pervasive, as we see the same simplification process applying even morpheme-internally, as in Hayu.

5.2 *The segmenthood of compressed clusters and their relation to the syllable*

An interesting question raised by the present analysis is that of the relation, if any, between compressed consonant sequences and traditional conceptions of segmenthood. The facts established here do not point to a segmental analysis, and where segmenthood breaks down, so in turn do syllable-based analyses. The idea that the processes encountered in this work may occur outside of the syllable finds support as well from section 3, where it was not possible to characterize the patterns with traditional syllable-based approaches.

Another issue brought up in the course of this analysis is the matter of branching place structures. Multiple associations show the need for single associations, and not the other way around (that is, there are no languages consisting of only geminate sounds; if this were the case, then branching structures would be an undeniably necessary concept). From this, it seems reasonable to ask why languages like Apinayé and Hayu that seem to show that doubly-linked structures are nonexistent need make reference to such notions of binarity at all. To say that these languages allow only singly-linked structures may be an unnecessary descriptive complication.

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