Shupamem Nasal Place Assimilation in Feature Geometry

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1. Introduction

Shupamem is one of the Grassfield Bantu Language of the Niger-Kordofanian family spoken by over one million people in Cameroon. The considerable interest in the language has almost focused solely on structural phonology (Boom 1977) and morphosyntax (Nchare, 2005). However, the language is also interesting for its syllable structure in that nasal place assimilation is a very striking property which has yet not been investigated. This paper has two goals. The first is to cast NPA in Feature Geometry and motivate some ideas developed in Padgett (1995a) on the status of the notion *feature class* in phonological theory. The second is to explore the phenomenon of NPA in an Optimality Theory perspective. These goals are brought together in an exploration of facts involving assimilation in *Voicing*, *Place* and *Stricture* in the data under investigation. I will flesh out the total assimilation with complex segments in the sense that all the articulators of the complex segment spreads under a general process of place assimilation. The main questions I am addressing in this study are the following:

(i) Can a Standard Feature Geometrical Approach solely be adequate to the analysis of NPA? (ii) Is *Padgett's Nasal/Continuant Marking Condition* (Padgett: 1994) relevant to Shupamem? (iii) How should the basic generalizations about place features be well understood in relation to NPA?

I argue that consonant clusters are least marked when the consonants involved share place, voicing, and continuancy. I will first discuss the feature geometry and later introduce and ranking constraints to account for these three processes. It seems more important for consonants in clusters to share features than it was to preserve underlying contrasts, but only as long as that agreement could come without altering the feature make-up of any obstruents involved.

NPA is a regular phonological process of Shupamem which entails that nasals assimilate in place with the following segment without any restriction at all. However, post-nasal voicing is neutralized for certain segments and portrays the general property of faithfulnees and markedness constraints ranking in the language. In section 2 of this paper, I will present the relevant data from Shupamem and other languages as far as NPA is concerned. Section 3 discusses the feature geometry of different segments of the data. Next in section 4, I propose an OT analysis to explain how NPA and voicing assimilation are constrained and conclude with some closing remarks in section 5.

2. The Data

NPA behaves in a very curious way in the morphophonology of Shupamem as illustrated in (1). As an aid to the reader, verb roots are underlined to highlight the various segment changes after NPA.

2. 1 NPA before Plosives (stops)

The infinitive marker in Shupamem is a prefix /iN-/ added to the verbal root which always transmits its initial onset feature to the nasal coda of the infinitive. The imperative mood just uses the verbal root without any inflection as shown in (1) illustrating the contrast between the infinitive and the imperative.

(1) *Infinitive*	*Imperative*	*Gloss*
a. *Labial stops voicing after NPA*		
imbam	pam	'to hold'
imbun	pun	'to struggle'
b. *Coronal stops voicing neutralization after NPA*		
intane	*tane*	*'to welcome'*
intume	tume	'to withdraw'
c. Dorsal stops voicing neutralization after NPA		
iŋki	ki	'to search'
iŋkupʃə	kupʃə	'to change'
d. *Complex segment NPA and voicing neutralization*		
iŋmkpaʔʃə	kpaʔʃə	'to mix'
iŋmkpɨ́	kpɨ́	'to die'
e. *Gemination after NPA*		
(ii) immaʔ	maʔ	'to throw'
(i) inna	naa	'to cook
(iii) iɲɲi	ɲi	'to enter'
(iv) iŋŋaʔ	ŋaʔ	'to open'

One observation is immediately apparent from (1): the coronal nasal in coda position of the infinitive affixed to the verbal root assimilates in place in a very regular way with the following segment. The interesting case is the total assimilation attested in (1d) where both the labial and the velar assimilate in place with the homorganic nasal. The nasal also agrees in place with the following nasal resulting in a kind of gemination as shown in (1e). However, only the labial undergoes a voicing assimilation after the application of NPA as shown in (1a). All other segments occurring in the same context preserve their voiceless quality. We argue that voicing assimilation after NPA is limited to labial plosives in Shupamem because no contrast in voicing is attested in post-nasal context with labial plosives. We will return to this in section 4 devoted to our constraint based approach to voicing assimilation. A fundamental claim about OT is that Shupamem differs principally in the ranking it imposes on constraints. The pattern in (1) is entirely irregular in that we would have expected to have an automatic voicing assimilation for all post-nasal segments. In many languages, when a nasal-final prefix is attached to a stem, a stem-initial voiceless obstruent becomes voiced (e. g. KpeIle (Welmers 1973**),** Kikuyu (Armstrong 1967).

(2) Kpelle

/N-polu/	[mbolu]	'my bag'
/N-tia/	[ndia]	'my taboo'
/N-kɔɔ/	[ŋgɔɔ]	'my foot'
/N-fela/	[mvela]	'my wages'
/N-jua/	[nʒua]	'my nose'

In (2), [voice] appears to be spreading from the nasal to the stem-initial obstruents. In contrast to these languages**,** the phonological inertness of [voice for sonorants - including nasals - is well-documented in the literature (see Kiparsky 1982,1985, Itô & Mester 1986).

Clements and Sagey (1986) cited the examples in (2) to motivate the independence of Place and [continuent] while Padgett (1994) argued for the Place dependence to account for the asymmetry in nasal assimilation to stops and fricatives. Based on the contrast between (1) and (2), one might wonder why voicing assimilation is blocked for some segments in Shupamem and not in Kpelle. In order to address such questions, we shall first study the phonotactics of Shupamem using synchronic evidence to construct a model of syllable. When the syllable structure is understood, it will then be possible to understand a variety of segmental phenomena that arise in the infinitive constructions.

2.2 NPA before Fricatives

NPA obtains within words in Shupamem across all places, giving forms like the following.

(3) *Infinitive*	*Imperative*	*Gloss*
a. iɱfa	fa	'give'
b. insam	sam	'spread'
c. indaane	lanane	'to forget'
d. inzaane	raane	'be careful'
e. iɲʒune	yune	'to buy'
f. iŋgaane	ɣaane	'to frighten'
g. iŋg^{w}one	wone	'to go'

Assimilation involves at the least all of the major articulator features required for Shupamem, [labial], [coronal], and [dorsal], and so the generalization is over the category Place. The question here is about how we can account for postnasal changes and voicing neutralization in a feature geometrical approach. Before we answer this question, it should be very useful to survey the phonemic system in Shupamem under which NPA obtains. All cases involve a strict adjacency of a nasal consonant to the triggering consonant.

2.3 Segmental Inventory

This section gives an overview of the inventory of the consonantal and vocalic system along with some of the phonologically conditioned segmental alternations which affect them.

2.3 1 Consonants

Shupamem has six series of phonemic consonants with six places of articulation as shown in (4).

(4) Consonant system

	Labial	Labio Dental	Alveolar	postalviolar	Velars	labiovelars	glottal
Nasal	/m/	/ɱ/	/n/	/ɲ/	/ŋ/		
Stop	/p/ /pʷ/	/t/			/k/	/kp/ /gb/	/ʔ/
Fricatives		/f/ /v/	/s /	/ʃ/	/ ɤ/		
Trill			/r/				
Glides				/y/		/w/	
Lateral			/l/				

All these segments are phonemes and one objective of this study is to explain their alternations and distributional properties in term of syllable structures. The only consonant cluster attested in the language has the form (N)C where N is the homorganic nasal and C any consonant types (plosives, fricatives, liquids, nasals, or glides). Let us summarize the contrast between Shupamem syllable structure and English as in (5).

(5) English vs Shupamem syllable structure

Constituent Language	Onset	Rhyme	
		Nucleus	Coda
English	(C) (C) (C)	V	(C) (C) (C)
Shupamem	C	V	(C)

Shupamem is a language with a strict CV(C) syllable structure and epenthesizes vowels in borrowed materials to avoid clusters or banned consonants in coda position. In addition, as shown in (5), Shupamem tends to prefer opened syllables, a preference that can be captured in a constraint against syllable codas.

2. 3. 2 Vocalic System

Although we only represent ten vowels in this system, vowel length is contrastive in Shupamem, it is very common in the language to contrast vowel length in each word to obtain a difference in meaning. This is always true for the tonal system where each variation in tone entails a difference in meaning. We will not go into details of autosegemental facts here; we reserve that discussion for a separate research topic.

(6) vocalic system

	Front	Central	Back
High	/i/ /ʉ/	/ɨ/	/u/
Mid-high	/e/	/ə/	/o/
Mid-low	/ɛ/		/ɔ/
Low		/a/	

2. 3. 3 Segmental Alternations

Since a number of segmental alternations affect the transcription and may cause confusion, they will be quickly dispensed with here. Consider first the consonantal alternations shown in (7).

(7)

Infinitive	*Imperative*	*Gloss*
imbiʔ	piʔ	‘to remove’
indoʔ	lɔʔ	‘to leave’
iɲʒɨ́	yɨ́	‘to eat’
inzaane	rane	‘to be careful’
iŋgaane	ɤaane	‘to frighten’
iŋgwone	wone	‘to leave’

We should not treat the patterns in (7) as lenition of voiced stops as Hyman (1972:22) did for Fefe another grassfield Bantu language in the same family with Shupamem. Rather, I take the opposite approach following Odden’s (1996:90) analysis of Kinatuumbi which steps up /p/l/w/ phonemes with rules for voicing of the labial stop, delateralisation of l, and post nasal hardening of /w/ and /ɤ/ to /g/. I repeat those rules in (8).

(8). a. labial voicing: /p/ > b/N__

b. delateralization: /l/ > [d]/N__

c. despirantization: / ɤ/ > [gw]/N__

d. postnasal hardening: /r/ > [z]/N__

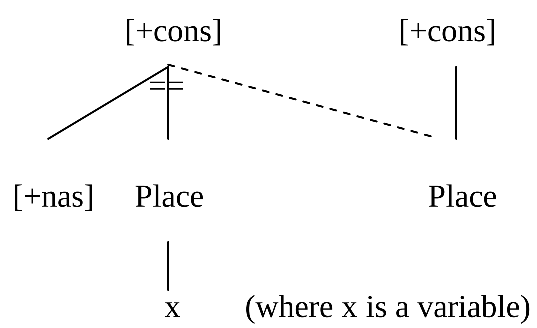
/w/ > [g]/N__

/y/ > [ʒ]/N__

Each of the rules in (8) is assimilatory in nature and will be crucial to explain why post-nasal voicing is blocked for certain basic segments in Shupamem. Rule (8a) involves the spreading of [+voice] of the nasal to the following segment, while the rest of all the rules involve the spreading [-cont]. A rule like (9d) merits further comments.

Based on the rules in (8), adapting Padgett' (1994) model feature geometry approach, it follows that (9) should be the general NPA rule for Shupamem. The segment following the nasal will share it place feature with the homorganic nasal. Recall that the infinitive prefix in Shupamem has a coronal nasal which always assimilates in place with the following segment as shown in (9). This rule applies both across word boundaries and within words. Whenever nasals occur before other consonants within words or across morpheme boundaries, they are homorganic.

(9) Homorganic Nasal Assimilation



(9) also holds for a language like Nchufie, another Grassfield Bantu language spoken in Cameroon. In this language, NPA is displayed exactly in the same way as in Shupamem. The following data show assimilation of Nchufie where the nasal assimilates in place with the following stem-initial consonants, lengthening its preceding vowel.

(10) Nchufie NPA (a = 3rd person pronoun, N = past tense marker]

(i) /a + N + tuŋ/ > [a:tunŋ] 'he kicked'

(ii) /a + N + pe:/ > [a:mbe:] ‘hebroke’

(iii) /a + N + ka/ > [a:ŋka] ‘he ran’

(iv) /a + N + niNi/ > [a:niŋi] ‘ he cooked’

(v) /a + N + fa:/ > [a:ɱfa:] ‘he worked’

(vi) /a + N + ɤwe/ > [a:ŋgwe] ‘he laughed’

(vii) /a + N + liɛ/ > [a:ndiɛ] ‘he slept’

(viii) /a + N + yiɛ/ > [a:nʒiɛ] ‘he said’

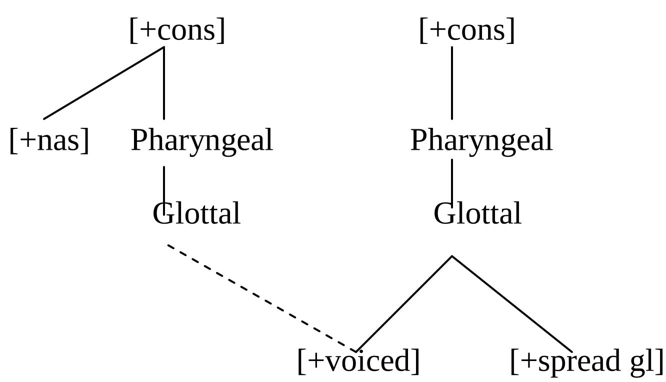
(ix) /a + N + wu/ > [a:ŋgu] ‘he is short’

As can be seen in (10), assimilation outputs display different characteristics depending on the type of the trigger consonant exactly in the same way as illustrated in Shupamem. When coronal, labial and velar stops are trigger, simple place assimilation results (10 i-iii), but when a voiceless labial stop triggers assimilation, it becomes voiced (10ii). If fricative /ɤ/, liquid /l/ and glides /y,w/ trigger assimilation, they undergo post-nasal hardening, becoming their homorganic stops.

Fricative hardening and obstruent voicing in Shupamem and Nchufie as well as in other natural languages seem to support the idea that [voice] and continuant together might form a class. But Clements warns us not to draw such a conclusion for two reasons: (1) these features represent independent phonetic dimension; (2) postnasal hardening and post-nasal voicing occur often and quite independently across languages (see Padgett 2002).

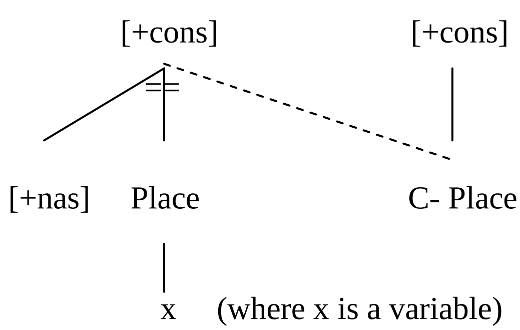
We propose a post-nasal voicing rule adapted from (Kenstowicz 1994) in (11).

(11)



(11) illustrates how the nasal which underlyingly has a voicing property, spreads it to the following segment. This general assumption is problematic for our grammar in that not all the segments are voiced in post-nasal context. Only labials are voiced. How can we account for post-nasal voicing asymmetry? Before answering this question, let us flesh out the feature geometry of the labiovelar NPA. Recall that the Shupemam case is a total assimilation and therefore will have the representation in (12) adapted from Clements and Hume (1993).

(12) *Total Place Assimilation*



Rule (12) says that any nasal preceding consonant in a nasal cluster segment will assimilate totally in place of articulation to that segment. Note that the spreading is from the C-place which will include not only the primary place of articulation, but any secondary one, should it be present. TNA accounts for the examples in (1d). If the representation in (12) is correct, it follows that place should be a candidate, for example, since there are diverse kinds of complex segments having more than one place feature. And indeed partial assimilation to such segments occurs widely: Kpelle [ŋmgbiŋ] 'myself' (Kenstowicz, 1994), versus Kɔɔni [tiŋgbaŋ] 'floor' (Cahill 1995). Padgett (1995a, 2001) presents many cases and provides an analysis that parallels that for Turkish in most respects.

3. Capturing feature classes

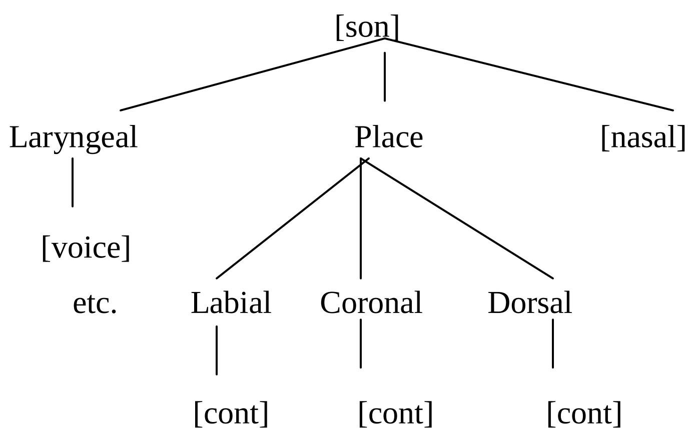
This paper assumes understanding of Padgett's (1994) model of feature geometry which locates stricture independently of Place. I will argue along the same line with Padgett in this section that the existence of nasal place assimilation to fricatives in Shupamem as well as in Kpelle motivates the location of [cont] under Place as shown in

(13). I will attempt to discuss the feature geometry of NPA with fricative and stops to show how we might solve the problem related to complex segments and stricture specification.

3.1 Stricture and nasal place assimilation

If we assume the asymmetry in voicing in post-nasal context both for fricatives and plosives (stops), it follows that [voice] can not be grouped with place feature as shown in (13).

(13)



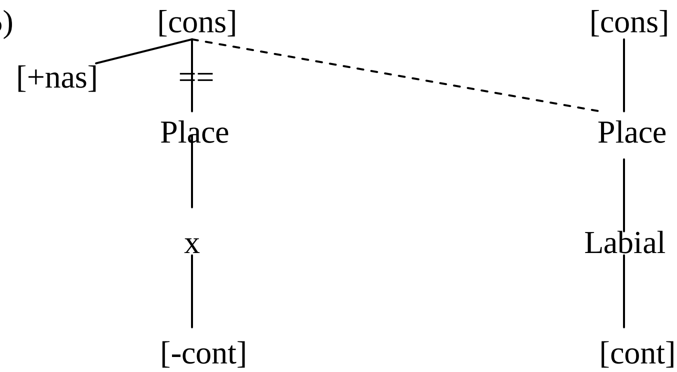
(From Padgett, 1994)

The cases we have examined in the preceding section show that the nasal assimilates in place both to fricatives and stops in Shupamem. In our discussion of the infinitive prefix *iN*-, we argue that the nasal before f/v is labiodental [ɱ] and that / f, v, s, ʃ] are exempt from hardening and voicing after nasal place assimilation. Based on this evidence, we conclude that the nasal is [+cont] before all labiodental in Shupamem as well as in Spanich (See Harris, 1969, 1984 detailed discussions). Place assimilation with labiodental will operate as shown below:

(14) *Infinitive*	*Imperative*	*Gloss*
a. iɱvɛ	vɛ	‘to catch’
iɱfɛ	fɛ	‘to burn’
iɱfute	fute	‘to lie’
iɱvure	vure	‘to erase’

Following Padgett (1994), we propose the following rule for nasal place assimilation with labiodentals:

(15)



(where x is a variable)

(15) shows that the nasal which is initially [-cont] becomes [+cont] when it precedes a labiodental. The behavior of the fricative in post-nasal context is very complex. The hardest process is hardening. How can we represent it in feature geometry?

3.2 Hardening

We have shown so far that hardening of fricatives like /l, r, ɣ, j and w/ is a common phonological process in Shupamem. Nasal-fricatives clusters are completely different from nasal-affricates clusters as argued in Steriade (1991). How can we represent the hardening rules repeated in (16) in feature geometry?

(16) Sonorant *Hardening Rules*

a. /l/ > [d]/N__

b. / ɣ/ > [g]/N__

c. /r/ > [z]/N__

d. /w/ > [g^w]/N__

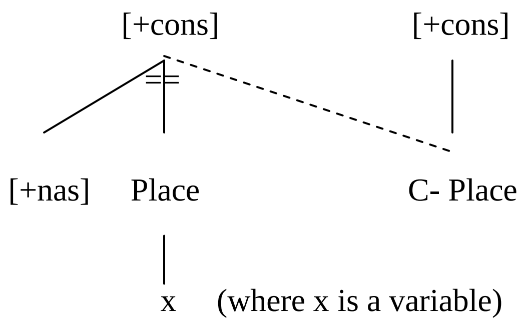
e. /y/ > [ʒ]/N__

The rules in (16) are a serious problem to the standard feature geometry theory as advocated by Padgett (1994:487). Although all the segments in (16) are sonorant, the only thing we can say is that when a nasal is adjacent to a sonorant, the sonorant is hardened and assimilates in place with the nasal. The minimal hardening as argued by Padgett involves insertion of [-cont]. Why is hardening seemingly blocked with labiodentals? What principles block the voicing spreading rule on certain segments, if any? We will give some principles answers to these questions in the next section.

3.3 Labiovelars Feature Three

NPA before labiovelars like *kp* and *gb* produces a labiovelar nasal ŋm in Shupamem as well as in Kpelle. If we assume that [gb] is a single segment as in Padgett (2002), it follows that the Place node of the labiovelar spreads to the preceding nasal as shown in (17).

(17)



(17) shows that in spreading just the Place node, we will easily obtain the homorganic sequence of a doubly articulated nasal followed by the doubly articulated stop *ŋmgb* or *ŋmkp* as exemplified in (18).

(18)

Infinitive	*Imperative*	*Gloss*
iŋmkpɛn	kpɛn	'to force'
iŋmgbɛn	kpɛn	'to march'
iŋmkpɨ	kpɨ	'to die'
iŋmgbɨ	gbɨ	'to fall'

3. 4 Vocalic-Place Feature vs C-Place Feature Distinction for Labiovelars

Since the introduction of feature geometry (Clements 1985, McCarthy 1988), four major innovations in the theory have been proposed:

1. *Unified Feature Theory*, which employs a single set of Place features for both consonants and vowels (Clements 1989);

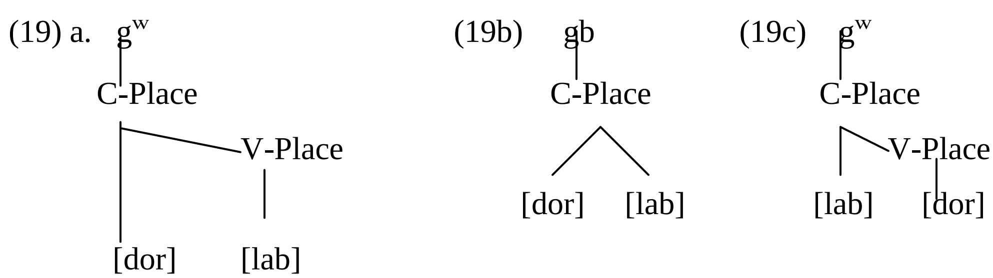
2. *Vowel-Place Theory*, which maintains that vocalic and consonantal Place features are segregated (Clements 1989, 1991, 1993, Ni Chiosain and Padgett 1993, Clements and Hume 1995);

3. *Partial Spreading,* which allows spreading of two or more features that are not exhaustively dominated by a common node (Sagey 1987, Halle 1995, Padgett 1995);

4. *Strict Locality,* which prohibits spreading from skipping segments (Ni Chiosain and Padgett 1993, 1997, Gafos 1998, Flemming 1995).

Hall, Vaux and Wolfe (2000) acknowledged that no consensus has been reached concerning which of these innovations should be incorporated into the theory of feature geometry.

We face the same dilemma when it comes to represent the labialized velar after hardening a labial glide in post-nasal context. How could we represent hardening rule like (16d)? If the *Vowel-Place Theory* is right, it follows that a derived labialized velar segment like [g^w] has to be represented with to separate Place Features: a C-Place Feature dominating a V-Place feature as in (19a) as opposed to (19b). However, the labiovelar could also be represented as in (19c).



(19) encodes a clear distinction within the feature tree itself: the primary articulator is dominated by the C-Place node (19b) and (19c), whereas the secondary articulation is dominated by the V-Place node. This distinction will be very crucial to define our constraint against complex segment. However, the representation in (19c) never surfaces as an optimal candidate in our grammar. The selection between dorsal and labial as target place for NPA will remain an open question for the present discussion. The rule defined in (17) still hold with a minor difference that we do have to specify a V-Place for segments with secondary articulation.

Many questions remain unanswered although we have tried to give a detailed account of NPA using feature geometry. How can we get around the puzzling problem about post-nasal voicing neutralization and hardening rule blocking of some fricatives in nasal+fricative clusters?

4. An OT Account of Post-nasal Voicing Asymmetry

In what follows, I propose a particular way to account for post-nasal voicing asymmetry attested in Shupamem. Since I presuppose Optimality Theory, what is crucially needed is a means to obtain phonetically-motivated constraints which will make the right prediction about the optimal candidates of our UG. As others have noted, Optimality Theory, with its emphasis on directly incorporating principles of markedness, can serve as part of the bridge. Discussing the postnasal voicing and phonotactic closedness Kiss (2005: 17) argued that the most important phonological facts concerning nasals, place assimilations, and the voicing of postnasal obstruents are the following:

i. In place assimilations, in C_1C_2, C_1 tends to assimilate the features of C_2.

ii. *Nasals* are the most common targets for place assimilation (including static place agreement).

iii. The target of nasal place assimilation is frequently restricted to *coronals*.

iv. Obstruents following nasals prefer to be *voiced*.

Shupamem NPA facts sharply contrast with this broad picture for two reasons: (i) Voicing assimilation of stops after NPA is limited to labials exclusively; (ii) postnasal fricative hardening is inert on certain segments although applying on a wide range of sonorants. How can we account for this couple of asymmetries? If we assume the constraint based approach to be correct, it follows that the issue of '*blocking* versus *repair*' problem is solely viewed as an artifact of Optimality Theory, which sees constraints as hierarchically ranked to favor the optimal candidates. The first task will be to define the family of markedness vs faithfulness constraints and their hierarchy in the language. Let us start with the labial stops.

4. 1 Labial voicing in post-nasal context

Our discussion of NPA in the previous section showed that when a voiceless labial stop triggers assimilation, it becomes voiced (1a) for Shupamem and (10ii) for Nchuffie. The common constraint in action in those examples is ***NC** after Kager (1995**)** which forbids a voiceless segment to be adjacent to the homorganic nasal preceding it. Shupamem will use a post-nasal voicing rule to avoid the violation of this constraint by its labial segments as shown in (20).

(20)	Infinitive	Imperative	Gloss
	i**<u>mb</u>**am	**p**am	‘to hold’
	i**<u>mb</u>**ɛn	**p**ɛn	‘to hate’
	i**<u>mb</u>**one	**p**one	to assemble’

For our grammar to be robust, we need a more general constraint than *NC which could fails to account for cases where voicing assimilation is not the direct effect of NPA. That is why we will adopt Pulleyblank’s idea of *Identical Cluster Constraint* which demands that consonant clusters agree on a certain (parametrized) feature. Labial plosives are always voiced in Shupamem. The general constraints responsible for labial voicing in post-nasal context are (21) and (22).

(21) **ICC [Voice]**: Consonants in a cluster should share the same value for voicing.

(22) **Ident [Voice]:** Corresponding segments in the input and the output should have same value for voicing.

(23) Labial voicing

/iN-pam/ > imbam	ICC[VOICE]	IDENT-[VOICE]
a. inpam	* !	
☛ b. imbam		*

From (23) we can infer that ICC [Voice] dominates Ident-[Voice]. Our optimal candidate violates Ident-[Voice] ranked beneath and satisfies the highest constraint while our suboptimal candidate has a fatally marked on the highest constrain.

The ranking in (23) says nothing about place, candidates like *inbam* and *iNbam* might also win as our optimal candidate (23b). We need an additional constraints say *Ident[POA*] and NPA to rule out those suboptimal candidates. Those constraints are defined as in (24).

(24). **Ident[POA]:** Corresponding segments in the input and the output should have the same place of articulation.

(25) **NPA**: In very sequence NC, every *Place* linked to C is linked to N, and vice versa. (Padgett 2002:5)

NPA plays the same role as *ICC [Place]* which requires that consonants in a cluster should share a common place of articulation. The first consonant in the cluster is the nasal and spread its voicing value to the second consonant.

(26) **NPA >> IDENT**[POA]

/iN-pam/ > imbam	NPA	IDENT[POA]
a. inpam	*!	
☛ b. imbam		*!
c. iŋbam	*!	*!

The NPA constraint demands that the homorganic nasal agrees in place with the following segment. In (26), [labial] is targeted as a *Place* feature and only the optimal candidate (26b) satisfies that constraint. *IDENT[POA*] plays the same role as Padgett's (1995a,b) *Have Place* constraint which is that 'every segment must have some *Place*. We have shown so far that nasal assimilation is total with labiovelars and gives rise to a homorganic sequence of a doubly articulated nasal followed by the doubly articulated stop. Having the contrast in voicing between labiovelars underlyingly in Shupamem the same ranking in (26) could hold depending on the status of our inputs. In this case, we need a higher-ranked constraint ruling out the doubly articulated nasal in one of the segmental markedness as defined in (27) following Padgett (1995).

(27). ***COMPSEG**: Consonants may not have > 1 place specification

By 'consonant' we mean a segment with any consonantal constriction in the oral cavity.

(28) NPA >>CompSeg

/iN-kpɛn/ > iŋkpɛn	NPA	*COMPSEG
a. iŋkpɛn	*!	*
☛ b. iŋmkpɛn		**!
c. inkpɛn	**!	*

Only the fully assimilated candidate (28b) can emerge as optimal when NPA is higher ranked than COMPSEG. Although we do have evidence that NPA with complex segment is total in Shupamem, a language like Kpelle with partial assimilation will have the reversed ranking to account for an output like *ŋgbi* ‘myself’. Now, let us consider the voiced labiovelar as our input, the same ranking argument in (28) will hold as shown in (29). /Kpa/ is inert to ICC [voice] because there is a contrast in voicing for labiovelar segments in Shupamem. We do have this evidence from minimal pairs like gbaʔ ‘throw away’ vs kpaʔ ‘to mix’; *kpi* ‘to die’ vs *gbi* ‘to fail’ etc.

(29) NPA and voiced labiovelars

/iN-gbɛn/ > iŋgbɛn	NPA	*COMPSEG
a. iŋgbɛn	*!	*
☛ b. iŋmgbɛn		**!
c. ingbɛn	**!	*

Based on our mini grammar developed in what precedes, we can infer the following rankings in a Hasse Diagram as the following. The summary tableau is given in (31)

(30). *ICC[Voice]* *NPA*

Ident[Voice] *Ident[POA]* **CompSeg*

(31)The summary tableau of NPA

/iN-pam/ > imbam	ICC[VOICE]	NPA	IDENT[POA]	*COMPSEG	IDENT[VOICE]
a. inpam	*!	*!			
b. impam	*!			*	
c. inbam		*!	*	*	*
☛ d. imbam			*	**	*

4. 2 Post-Nasal Voicing Neutralization

Before explaining the voicing asymmetry in post-nasal context, let us recapitulate the contrast in voicing assimilation as shown in (32) and (33). Voiced plosives are traditionally forbidden segments in Shupamem. However, a postnasal hardening of a fricative might surface as a voiced plosive. The hardening rule is apparently triggered by NPA which creates a context where the [voice] feature of the homorganic nasal spreads to the following fricative segment undergoing a hardening rule as shown in (32).

(32).	*Infinitive*	*Imperative*	*Gloss*
	a. iN-laa > indaa	laa	‘to close’
	b. iN-ɣaa >iŋgaa	ɣaa	‘ to frighten’
	c. iN-rii > inzii	rii	‘to choose’
	d. iN-yaane > inʒaane	yaane	‘to dry’

(33)	*Infinitive*	*Imperative*	*Gloss*
	a. iN-taa > intaa	taa	‘to count’
	b. iN-kaa > iŋkaa	kaa	‘to fry’
	c. iN-si > insii	sii	‘to burry’
	d. iN-ʃaane > iɲʃane	ʃaane	‘to collide’

(32) and (33) are archetypical minimal pairs that our grammar preserve systematically by imposing on postnasal segments certain constraints which prevent extra voicing rules which might overlap with a *transderivational* surface output.

I have shown so far that coronal and dorsal stops are inert to voicing assimilation after NPA. How can we get around this puzzle having in mind the intuitive idea that the nasal naturally spread its voicing property to the following segment? One way of solving this problem could be defining some parochial markedness constraints like *d; *g and *b and determine their ranking hierarchy vis-à-vis the faithfulness constraint.

If we take **ICC [Voice] >> Ident[Voice]** for granted, it follows that the only ranking argument we need to know is *d , *g or *b with the highest ranked constraint ICC*[Voice]*.

(34) **d >> ICC[Voice]*

/iN-taa/ > intaa	* d	IDENT-[VOICE]
a. indaa	* !	
☛ b. intaa		*

The ranking in (34) is straightforward in that the optimal candidate only fails on the lowest ranking constraint. If this conclusion is right, it follows that ***g** will also outrank **ICC [Voice].** In that case, the optimal candidate (35) will be parsed faithfully without any activation of voicing assimilation.

(35).*g >>ICC [Voice] >> Ident[Voice]

/iN-kaa/ > ingaa	*g	ICC[VOICE]	IDENT-[VOICE]
☛ a. iŋkaa		* !	
b. iŋgaa	*!		*

Let us now reconsider our solely segment undergoing a voicing assimilation in the language. Whether *b outranks *Ident[voice]* or is dominated by *Ident[voice]* will not matter. The only undominated constraint is *ICC[Voice]*. In this case, the Hasse Diagram will have the following structure.

(36) ICC[Voice]

Ident[Voice] *b

(37) ICC [Voice] >> Ident[Voice] ; ***b**

/iN-pam/ > inbam	ICC[VOICE]	IDENT-[VOICE]	*b
a. iNpam	*!		
☛ b. imbam		*	*

4. 3 Post-nasal hardening

Post-nasal hardening is very common in Shupamem as well as in other natural languages. In a language like Kiyuyu (Clements 1985:244) when a nasal consonant precedes a fricative, the fricative is hardened to a stop (See also Padgett 1991 for more detailed discussion):

(38) a.βur-a > m-bur-eetɛ ‘lop off’

b. ɣor-a > ŋ-gor-eetɛ ‘buy’

c. reh-a > n-deh-eetɛ ‘pay’

d. Sin-a > ndʒin-eetɛ 'burn'

Based on the examples in (38), it is not obvious whether fricatives and nonnasal sonorants can trigger assimilation, since the nasal may undergo assimilation after post-nasal hardening; then this will be a case of stop trigger. However, in Shupamem as well as in Nchufie, at least some fricatives, f and s, trigger assimilation, while not subject to post-nasal hardening. The nasal in the output is always homorganic to the following fricative which may be hardening or not as shown in (39). This reveals two puzzling questions for our theory in accounting for nasal-fricative clusters: (1) Why is hardening not applied to all fricatives? (2) What blocks the nasal voicing spreading on certain fricatives?

(39). *Post-nasal hardening and some exceptions*

		Infinitive	*Imperative*	*Gloss*
(i)	a.	in-laa > indaa	laa	'to close'
	b.	in-ɤaa > iŋgaa	ɤaa	'to frighten'
	c.	in-rii > inzii	rii	'to choose'
	d.	in-yune > iɲʒune	yune	'to buy'
(ii)	a.	in-sii > insii	sii	'to burry'
	b.	in-fii > iɱfii	fii	'to sell'
	c.	in-ʃu > iɲʃu	ʃu	'to stay'
(iii)		in-vii > iɱvii	vi	'to catch'

The data in (39) reveals that post-nasal voicing is in fact paradigmatically conditioned. If any overapplication of a post-nasal voicing rule might result in neutralizing another derived word say *derived post-hardening words*, the post-nasal voicing will simply be blocked to preserve them in our grammar. The reverse is also true. If post-nasal hardening of a fricative might neutralize a *basic or underlying word* in the grammar, it simply fails to apply to keep that word faithfully as a minimal pair to the basic word of the grammar. Let us summarize these observations in what we call *Transderivational Correspondence* between words in our grammar.

(40). *Tranderivational Correspondence*

(a)
- /N + p/ → *[mp], [mb]
- /N + β/ → [mp], *[mb]

(1) /p/ > [b]

(2) /p/ > [p] (not attested)

(b)
- /N + l/ → *[nt], [nd]
- /N + t/ → [nt], *[nd]

(1) /l/ > [d] to preserve [nt] in (2).

(2) /t/ > [t] to preserve [nd] in (1).

(c)
- /N + r/ → *[ns], [nz]
- /N + s/ → [ns, *[nz]

(1) /r/ > [z] to preserve [ns] in (2).

(2) /s/ > [s] to preserve [nz] in (1).

(d)
- /N + ɣ/ → *[ŋk], [ŋgw]
- /N + k/ → [ŋk], *[ŋg]

(1) /ɣ/ > [gw] to preserve [ŋk] with obstruent voicing.

(2) /k/ > [k] to preserve [ŋg] in fricative hardening.

(e)
/N + ɣ/ *[ŋk] [ŋg] (1) /ɣ/ > [g] to preserve [ŋk] with obstruent voicing.
/N + w/ [ŋgʷ] *[ŋg] (2) /w/ > [gʷ] to preserve [ŋg] in fricative hardening.

(40) interestingly shows that the reason why the labial plosives always undergo a voicing assimilation is that there is no voicing contrast between the labial plosives(40a) which block a transderivation with any labial fricative. The status other segments is sharply different in that they obviously exhibit a voicing contrast in post-nasal context.

We have shown so far that hardening is triggered by NPA. In Shupamem, the nasal also assimilates with the following fricative contra Padgett's (1995) *Nasal/Continuant Marking Condition*. According to this condition, *Nasal+ Fricative Clusters* are disfavored for the following reason. While nasals frequently place-assimilate to a following plosive, they rarely assimilate to a following fricative: e.g. *impossible* but *infamous*, instead of **imfamous*. According to Padgett, this is because place assimilation implies stricture assimilation. Thus, when a nasal assimilates to the place node of the following segment, it will automatically assimilate to the stricture node as well. Accordingly, assimilation to a fricative yields a nasalized fricative, a phonologically highly marked segment. This is the reason why in *Nasal + Fricative* contexts, languages show diverse outputs: no assimilation (English, see above), default place assignment (Polish), or deletion of the nasal (Zoque, Lithuanian).

According to Padgett, these are all strategies to prevent nasalized fricatives. Padgett's *Nasal/Continuant Marking Condition* tends to be irrelevant for Shupamem data in that a nasal always assimilates in place with the following fricative although a hardening rule is also attested in the same context.

4.3.1 Nasal Assimilation to Stricture

We have defined so far a family of *Idenityt* constraints related to *Voiceness* and Place of the segment. Let's now turn to stricture constraint. The NPA constraint is still in action.

(41) **Ident [Sticture**]: corresponding segments in the input and output must agree on the feature [+stricture].

Let us first look at the dorsal fricative hardening after NPA. Recall that we had a rule like the following in (42).

(42) a. *Uvular Fricative and Glide Hardening rules*

a. ɤ > g/N__

b. j > ʒ/N__

A rule like (42) is related to Postnasal Hardening constraint defined as follows.

(43). **P-HardCon**: Any fricative should be hardened after a nasal.

(44) **P-HardCon >> Ident[Strict]**

/iN-ɤam/ > iŋgam	P-HARDCON	IDENT-[STRICT]
a. inɤam	* !	
☛ b. iŋgam		*

The candidate (44a) is ruled out by the fatal violation of the topmost ranked constraint. This ranking argument is straightforward. It also holds for the glide hardening case shown in (45).

(45). Glide hardening

/iN-jam/ > iɲʒam	P-HARDCON	IDENT-[STRICT]
a. injam	* !	
☛ b. iɲʒam		*

Although (45b) is optimal, another candidate like *imʒam* could also be a winner because it would only violate *Ident[Strict]* exactly as (45b). *NPA* will be activated to rule out such a candidate. In this case we will have.

(46) NPA >> Ident[Strict]

/iN-jam/ > iɲʒam	NPA	IDENT-[STRICT]
a. injam	* !	
☛ b. iɲʒam		*
c. imʒam	*!	*

Having established that P-HardCon >> Ident[Stict], we can infer that P-HardCon also dominates ICC[CONT]. This will give us a summary tableau in (47). Why is it that the palatal glide not hardened to a stop? Well, the reason is that there is no palatal stop is Shupamem phonemic system. In any situation where no stop is available for hardening to take place, the fricative will always change to the closest voiced fricative as shown in (45).

(47) *Glide Hardening*.

/iN-jam/ > iɲʒam	P-HardCon	NPA	IDENT-[STICT]
a. injam	*!	*	
☛ b. iɲʒam			*
c. imʒam		*	*

This conclusion seems to support *Padgett's generalisation* although the data in hand obviously has certain counterexamples. Padgett (1994) showed with a large number of examples that natural languages display an asymmetry between stops and fricatives with respect to place assimilation: while coda nasals usually freely assimilate to stops, they do not often assimilate to fricatives. He claimed that this effect could be due to the following principle or constraint:

(48) *Padgett's Generalisation* (PADGETT, Padgett 1994:476)

If [+nas, +cons], then [-cont]

'A nasal consonant cannot be linked to the feature [+continuant]'

Can we extend this conclusion to lateral and another glide?

3.5 Lateral hardening after the nasal

We have also shown so far that the following hardening rules are also attested:

(49). a l > d/N__

b. r > z/N__

c .w> g^w/N__

If our mini-grammar is correct, it follows that the same ranking we have inferred in the previous section will be very consistent in accounting for the hardening rule in (49).

(50) *Delateralisation*

/iN-lam/ > indam	P-HardCon	NPA	IDENT-[STRICT]
a. iNlam	*!	*	
☛ b. indam			*
c. imdam		*	*

(51) /r/ *Hardening Rule*

/iN-ram/ > inzam	P-HardCon	NPA	IDENT-[STRICT]
a. iNram	*!	*!	
☛ b. inzam			*
c. imzam		*!	*

Up to this point, our ranking is still very consistent in that the optimal candidates are always those which satisfy the highest ranked constraint. Only (52b) should be a problem to our grammar in that we have a complex segment say a nasal-labialized velar segment as our winner. The treatment of the labial glide needs more discussions because of its underlying C-Place and V-Place feature as discussed in the section devoted to feature geometry.

(52) /w/ *Hardening Rule*

/iN-wone/ > iŋgwone	P-HardCon	NPA	IDENT-[STRICT]
a. iNwone	*!	*	
? ☛ b. iŋgone			*
c. imgone		*	*
? ☛ d. iŋg^{w}one			*

3.6 Nasal Assimilation with labiovelar glide /w/

In most of the consonant charts accompanying descriptions of languages, [w] is placed either in the labial or velar column, not both. Similarly, Chomsky and Halle (1968) argue that all labiovelars must either be primarily velars with secondary labialization or primarily labials with secondary velarization or, in their terms, must be either [+anterior] or [-anterior]. Which of the places of articulation is primary is determined by phonological evidence, not phonetic evidence. Kaisse (1975) and Anderson (1976) in more recent papers argue the same point. This seems to be a king of puzzle for this analysis. However, I will argue that, given that the labiovelar glide obviously has two place features [+/-anter], a constraint preserving those features will rule out all the competing candidates having just a half of that complex feature. This constraint is defined as in (53). More over, that constraint has to care about the competing complex segment /gb/ as opposed to /g^w/

(53) Ident-F: All underlying phonological features of each segment of the input have to be preserved in the output.

So far, our mini-grammar in (52) chooses two candidates as optimal, (52b) and (52d). In fact, it is the former which is the optimal candidate in that its preserves both [+dor] and [+round] features and therefore satisfies Ident-F as shown in (54). Recall that [g^w] has both C-Place and a V-Place (secondary articulation). If [g] were to be our winner, it will has only one C-Place Feature and therefore fail to preserve the V-Place feature [+round]. In the same token, a candidate like (54e) is ruled out by Ident-F because, even though it has a complex C-Place feature (dorsal and labial), it crucially lacks a V-Place which is a secondary place of articulation feature.

(54) Ident-F>> P-HardCon >> NPA>> Ident-[Stict]

/iN-wone/ > iŋgwone	Ident-F	P-HardCon	NPA	IDENT-[STRICT]
a. iNwone	*!	*!	*	
b. iŋgone	*!			*
c. imgone	*!		*	*
☛ d. iŋg^wone				*
e. iŋgbone	*!			*

Many questions remain unanswered about the selection of C-place for labiovelars as far as NPA is concerned. Why is w realized phonetically as b^w or gb after NPA? Up to this point, we do not have any empirical answer to this question. All what we can say is that additional data from Shupamem show that [mb^w] is already a derived segment after the application of NPA on another velarized labial as in the following examples.

(55). *NPA with velarized labial stop.*

Infinitive	*Imperative*	*Gloss*
a. imb^wom	p^wom	'to create'
b. imb^wone	p^wone	'to bore/probe'

Based on this, we may claim that the velar is the target place of assimilation because of being the only available place which does not overlap in meaning with (55b)

To sum up, I argue that the analysis of all fricatives undergoing a *Hardening Rule* seems to support what I will call *Padgett's generalisation* although the data in hand obviously has counterexamples as will be discussed in the next section. Padgett (1994) showed with a large number of examples that natural languages display an asymmetry between stops and fricatives with respect to place assimilation: while coda nasals usually freely assimilate to stops, they do not often assimilate to fricatives. This effect could be due to the following principle or constraint:

(56) *Padgett's Generalisation* (PADGETT, Padgett 1994:476)
If [+nas, +cons], then [-cont]
'A nasal consonant cannot be linked to the feature [+continuant]'

According to Padgett (1994), the constraint PADGETT is phonetically grounded. It can also be held responsible for the independent fact that nasalized fricatives are absent or at least rare in languages of the world, and that fricatives behave as opaque or transparent segments in nasal harmony systems. According to Padgett, languages may respond in several ways to structures that are bound to violate the constraint in (56): in some languages the fricative may harden to a stop as is the case in Shupamem although f and v, s and ʃ are exempt from hardening. In some the nasal may get deleted, etc.

The intuition of the constraint against nasal+fricative cluster proposed here corroborate with *Padgett's Generalisation* with a slight difference that we have tried to restrict it only to segments undergoing hardening as a repair rule. Let us now turn to fricative segments which are inert to the hardening rule after NPA.

3.7 Exceptions to Hardening Rule

Having established a mini-grammar which works for hardening of fricatives, how can we account for the segments which are inert to the *Hardening Constraint*? There seems to be no tendency to voice or harden f, s and ʃ in our grammar. We argue that *v, *z, and * ʒ are the members of markedness constraints family outranking *P-HardCon*. If this assumption is correct, all the exceptions will be accounted for by our mini-grammar as shown in (57), (58) and (59) respectively.

(57) *NPA with s*

/In-suu/ > insuu	*z	P-HardCon	NPA	IDENT-[STRICT]
a. iNsuu		*!	*	

☛ b. insuu		*		
c. inzuu	*!			*

(58) *NPA with f*

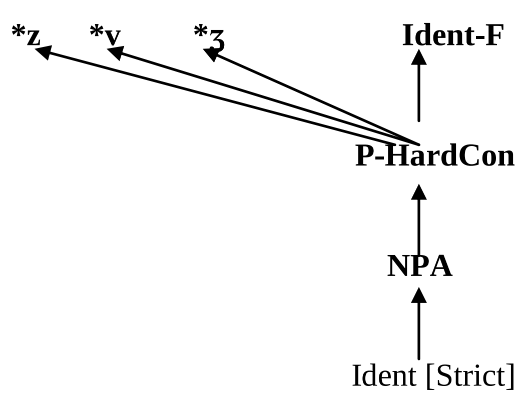
/iN-fa/ > iɱfa	*v	P-HardCon	NPA	IDENT-[STRICT]
a. iNfa		*!	*	
☛ b. iɱfa		*		
c. iɱva	*!			*

(59) NPA with ʃ

/iN-ʃa/ > iɱfa	*ʒ	P-HardCon	NPA	IDENT-[STRICT]
a. iNʃa		*!	*	
☛ b. iɲʃa		*		
c. iɲʒa	*!			*

The Hasse diagram in (60) provides a global picture of our constraints ranking for the hardening rule problem.

(60)



5. Conclusion

In this paper we have discussed NPA properties like voicing asymmetry in the perception of stops and fricatives in post-nasal context and Fricatives hardening as a repaired rule to forbidden nasal-fricative clusters in Shupamem. Previous analyses of these were rule-based and mainly concentrated on the questions of how a feature geometry approach can cast NPA. We employed an approach in which this distinction actually is irrelevant and argued that this system is successfully described using only constraints that are observable also in other languages. In our analysis, Shupamem is a 'normal' language system, based on a handful of constraints that have shown their value also in the analysis of other languages. A standard Feature Geometry approach account cannot deal with postnasal voicing asymmetry and hardening in a most robust way.

In principle, the approach taken here to account for post-nasal voicing asymmetry in Shupamem is applicable elsewhere in linguistics. I have shown that both post-nasal voicing of obstruents and post-nasal hardening are paradigmatically conditioned. If the approach of Optimality Theory is correct, such grammars will do full justice to the amazing intricacy of NPA and some phonotactic rules related to it. If this view of things is right, there are a number of things we should expect to find in the direction of Transderivational Optimization of Shupamem data. Shupamem NPA gives some evidence that we should find a pervasive role for *violable* grammatical constraints, as Optimality Theory claims, since constraints based on functional principles have no *a priori* claim to inviolability as advocated in Hayes (In progress). Very little in what we assumed here need be posited as innate knowledge. In principle, only the procedure for inductive grounding and the mechanisms of Optimality Theory itself need be innate, the rest being learned. But I am not at all *a priori* opposed to positing that parts of grammar and phonology are genetically encoded. This view seems especially cogent in domains of grammar that abound in “projection puzzles” (Baker 1979). However, I do have a suggestion regarding research strategy: arguments for innate principles can only be made *stronger* when inductive alternatives are addressed and refuted.

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