Environmental shielding is contrast preservation*

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1 Introduction

In some languages, the phonetic realization of nasal stops depends on their vocalic context. An impressive example of this comes from Karitiâna (Storto 1999):

(1)
a. /m/ → [m] / #_Ṽ, Ṽ_Ṽ, Ṽ_#
b. /m/ → [bm] / V_Ṽ, V_#
c. /m/ → [mb] / #_V, Ṽ_V
d. /m/ → [bmb] / V_V

Herbert (1986:199): this happens "to provide a consonantal shield or buffer to protect vocalic nasality or orality." Following Herbert, we'll call it shielding.

- If /m/ → [m] / #_V, V would likely be nasalized ($^{\tilde{\mathrm{V}}}$V).
  - An important cue to the V-Ṽ contrast: *duration of acoustic nasality*.
  - **Experimental result:** the longer the duration of acoustic nasality in a given V, the more likely that it will be perceived as nasal (e.g. Delattre & Monnot 1968, Whalen & Beddor 1989, refs in Hajek 1997:89-91).
- So /m/ → [mb] / #_V, to keep V-Ṽ maximally distinct.

This project…

1. Develops and formalizes a contrast-based analysis of shielding.
2. Explores its predictions, and shows that they are correct.

2 The typology of shielding

The analysis sketched in §1 makes a very basic typological prediction.

- **Claim:** shielding occurs to help preserve a V-Ṽ contrast.
- **Prediction:** shielding should only occur in systems that have a V-Ṽ contrast.

Herbert (1986:219), following Haudricourt (1970), claims this prediction is right:

> *"…those processes…are perceptually conditioned and never obtain in languages which do not oppose nasal and non-nasal vowels."*

- To test the prediction more thoroughly, I surveyed languages in SAPhon (Michael et al. 2012), a database of inventories in S. American languages.
  - Shielding is a common areal phenomenon of South America.
  - Because it is generally common in the sample, potential *asymmetries* in the languages that exhibit it become more interesting.
- Number of languages surveyed = 188.
  - 361 languages (as of 1/15); 213 with easily accessible online sources.
  - Of these 213, 25 were excluded for various reasons.

The result: with one exception, all languages that display shielding-like behavior license a V-Ṽ contrast. This asymmetry is significant (Fisher's exact, $p < .0001$).

(2) Survey results

	Shielding	No shielding
V only	1	88
V-Ṽ	54	45

Counterexample aside (Ese Ejja; Vuillermet 2012), the picture is clear:

- Languages that allow shielding also license a V-Ṽ contrast.
- Any successful analysis of (2) *must make explicit reference to contrast*.

2.1 A further argument

Predictions of a contrast-based approach:

1. **General:** in a given language, if shielding exists, so should V-Ṽ.
2. **Language-specific:** if a language limits the V-Ṽ contrast to certain positions, it should also limit shielding to those same positions.

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(1) is correct. I believe that (2) is, too. Here's an example:

- In Wari' (Chapakuran; Everett & Kern 1997), nasal vowels (and therefore the V-Ṽ contrast) are limited mostly to stressed, open syllables[1].
- The nasal phonemes /m/ and /n/ fluctuate between fully nasal ([m] and [n]) and postoralized ([mb] and [nd]) syllable-initially, with a "greater tendency towards this fluctuation in stressed syllables" (p. 402).
- **My interpretation:**
  - Both the V-Ṽ contrast and the appearance of postoralized allophones are limited to stressed syllables.
  - Distribution of shielding *parallels* the distribution of the V-Ṽ contrast.
- What we find in Wari' is the language-specific instantiation of the same general principle driving the larger typological asymmetry in §2: *shielding is only necessary when there is something to protect.*

2.2 Setting up the analysis

Desiderata for a successful analysis of shielding:

- Shielding must be motivated *by a desire to keep V and Ṽ distinct*.
  - Markedness constraints like *NV (no oral vowels preceded by nasal stops) are not the right constraints to motivate shielding.
  - *NV does not care whether or not V and Ṽ contrast: it predicts that shielding should happen regardless. This is not an accurate prediction, so we probably don't want *NV and others like it in CON.[2]
  - We need constraints that explicitly reference contrast. If we do not have them, the analysis cannot make the right predictions.
- Phonology must be able to see the output of the phonetic grammar.
  - Presumably, the duration and extent of coarticulatory nasality is something that is controlled by a language's phonetic grammar.
  - For shielding to be motivated, the phonological grammar must see that vowels in nasal environments acquire some degree of nasality.
  - Just one of many arguments that phonology must be able to "see" phonetics (e.g. Jun 1995, Steriade 1997, Flemming 2002 *et seq.*).

[1]Everett & Kern note one exception (p. 409): a stressless /ã$^{\tilde{\imath}}$/ in [kã$^{\tilde{\imath}}$na'tʃiʔ].
[2]This raises a question: if *NV doesn't trigger nasal harmony, then what does? More later...

I'll assume the architecture of the phonological grammar outlined in Flemming (2008), which has both of the characteristics we need for a successful analysis.

(3)

'Rich Base'
↓ — *Inventory selection*
Input
↓ — *Phonetic realization*
Realized Input
↓ — *Phonotactics*
Output

In Flemming's model, the phonological grammar has several levels (p. 9):

- **Inventory selection**: determines the inventory of contrasting segment types.
- **Phonetic realization**: derives the coordination of articulatory gestures used to realize (sequences of) sounds, as well as their perceptual consequences.
- **Phonotactics**: places limits on possible sequence of sounds.

In what follows, we'll be working at the level of the Realized Input (RI).

- This level *follows* phonetic realization, but *precedes* phonotactics.
- Phonotactic constraints are evaluated against fully phonetically specified inputs. This allows the language's phonology to see its phonetics.

Families of constraints active here that are relevant to us (see Flemming 2008):

- **Distinctiveness constraints**: constraints penalizing contrasts that are insufficiently distinct (i.e. MINDIST constraints).
- **Other markedness constraints**: output constraints (e.g. *CONTOUR).
- **Faithfulness constraints**: constraints on IO mappings (e.g. IDENT).

3 Basic analysis

To start, we'll develop an analysis of the Karitiâna pattern in (1). Reminder:

(4) a. /m/ → [m] / #_Ṽ, Ṽ_Ṽ, Ṽ_#
b. /m/ → [bm] / V_Ṽ, V_#
c. /m/ → [mb] / #_V, Ṽ_V
d. /m/ → [bmb] / V_V

Relevant constraints:

- All over (esp. (4d)), there is a clear preference for nasal consonants in the input to remain at least partially so in the output:

  (5) IDENT[±nas]-C: one * for each output consonant whose specification for [±nasal] is different than that of its input correspondent.[3]

- It is also the case that there is a clear preference for input oral and nasal vowels to remain as such in the output (V-Ṽ is never neutralized).

  (6) IDENT[±nas]-V: one * for each output vowel whose specification for [±nasal] is different than that of its input correspondent.

- There also needs to be a constraint that disprefers nasal contours.
  - *Likely:* a small family of constraints disprefer nasal contours.

    (7) a. *NC: one * for each NC sequence in the output.
    b. *CN: one * for each CN sequence in the output.
    c. *CNC: one * for each CNC sequence in the output.

  - But for the time being, I'll just refer to them as *CONTOUR.

- And finally, we'll need a MINDIST constraint to motivate shielding.
  - MINDIST constraints evaluate *acoustic differences among forms*, and penalize pairs that are insufficiently distinct.
  - We might imagine, that in Karitiâna, there is a MINDIST constraint on the V-Ṽ contrast requiring Vs and Ṽs to be maximally distinct.
    - > Satisfying pair: fully oral vowel (8a), fully nasal vowel (8c)
    - > Violating pair: nasalized oral vowel (8b), fully nasal vowel (8c)

(8) a. Fully oral vowel:

V

b. Nasalized oral vowel ($^{\tilde{V}}V$ or $V^{\tilde{V}}$):

50%	V

V	50%

c. Fully nasal vowel (Ṽ):

100%

[3]It's necessary for this constraint to assign different degrees of violation, so that [bmb] (where part of /m/ becomes [-nasal]) is preferred to [b] (where all of /m/ becomes [-nasal]).

- For present purposes, the following MINDIST constraint will suffice:

  (9) MINDISTV-Ṽ = NASDUR$_{100\%}$: for V-Ṽ to be distinct, V must be fully oral and Ṽ fully nasal. Assign one * for each violating pair.

(10)

$m^{\tilde{a}}a$ mã	NASDUR$_{100\%}$	*CONTOUR
a. $m^{\tilde{a}}a$ mã	*	
b. mba mã		*

- For speakers of languages that lack V-Ṽ, NASDUR$_{100\%}$ is irrelevant.
  - If NASDUR$_{100\%}$ is irrelevant, there's no motivation to shield.
  - Shielding blocked by constraints that disprefer the result.

(11)

$m^{\tilde{a}}a$	NASDUR$_{100\%}$	*CONTOUR
☞ a. $m^{\tilde{a}}a$		
b. mba		*!

Ranking arguments for Karitiâna shielding:

- Desire to keep V-Ṽ distinct licenses contours; NASDUR >> *CONTOUR.
- Nasal contours preferred to [b]; IDENT[±nas]-C >> *CONTOUR.
- Contours preferred to V-Ṽ neutralization; IDENT[±nas]-V >> *CONTOUR.
- This yields the total ranking in (12):

  (12) NASDUR, IDENT[±nas]-C, IDENT[±nas]-V >> *CONTOUR.

Sample tableaux for Karitiâna shielding:

(13)

$m^{\tilde{a}}a$ mã	NASDUR	ID[±NAS]-C	ID[±NAS]-V	*CONTOUR
a. $m^{\tilde{a}}a$ mã	*!			
b. mã mã			*!	
☞ c. mba mã				*
d. ba mã		*!		

- **Question:** in a language where shielding occurs, how does the learner know that the V-Ṽ contrast *would* have been in danger, had shielding *not* occurred?
  - This is an unanswered question.
  - The hope: learners are able to infer what the non-shielding outcome *would* have been, based on variability in the outcome (21/55 report variation), or through knowledge of other coarticulation processes.

A note on phonetic variation

- I have been assuming the existence of coarticulatory nasality.
- Phonetics of coarticulatory nasality vary by language (e.g. Cohn 1990), but there are regularities:
  - In most of the world's languages, oral vowels adjacent to nasal consonants are nasalized to some degree (cf. Chan & Ren 1987 on Miao and some Chinese dialects, Durie 1985 on Acehnese).
  - Oralization of nasal vowels adjacent to oral consonants is rarely mentioned and in the one case I know of where it's described (French, in Cohn 1990), it's temporally brief.
- Given these observations, I make two simplifying assumptions:
  - Oral vowels adjacent to nasal stops are always nasalized.
  - Nasal vowels adjacent to oral stops aren't oralized.[4]
- A full version of the overall theory takes language-specific variation very seriously and builds it into the analysis. But this is not feasible now, because we do not know what the range of variation is.

4 Asymmetries in the typology

Perhaps unsurprisingly, not all languages are Karitiâna.

- Languages differ in unpredictable ways as to which allophones shielding can produce: the only generalization is that [bmb] implies other contours.

(14)

[b]	[mb]	[bm]	[bmb]	Example
✓				Karajá (Ribiero 2001)
✓	✓			Epena (Harms 1984)
✓		✓		Yuhup (Martins 2005)
✓	✓	✓		Arara (da Rocha D'Angelis 2010)
	✓			Tenharim (Sampaio 1998)
		✓		Nadëb (Barbosa 2005)
	✓	✓		Amundava (Sampaio 1998)
	✓	✓	✓	Kaingáng (Cavalcante 1987)

[4]Of course, French is a counterexample. The assumption that [bã] has no oral coarticulation isn't crucial: changing the phonetic assumptions minorly changes the space of predicted patterns.

- **But:** there are predictable asymmetries in the typology that mirror asymmetries in the direction and extent of nasal coarticulation.
- **Main point:** shielding in contexts where V-Ṽ is more distinct asymmetrically implies shielding in contexts where it is less so.

This section...

- Reviews asymmetries in the phonetics of nasal coarticulation.
- Shows that asymmetries in the typology of shielding are correctly predicted by the phonetic asymmetries.

4.1 The phonetics of nasal coarticulation

There are asymmetries in the direction and extent of nasal coarticulation.

- Adapted from Jeong (2012)'s survey[5] (see Jeong 2012:450 for references):

(15)

Type	Language	NV	$\mathrm{VN]}_\sigma$	$\mathrm{V]}_\sigma\mathrm{N}$
1	English	82%	100%	-
	Hindi	70%	100%	-
	Bengali	(ext)	100%	-
2	Akan	85%	-	100%
	Italian	(ext)	43%	-
	French	73%	33%	17%
	Greek	71%	55%	29%
	Spanish	-	43%	-
	Thai	-	40%	-
	Swedish	(ext)	(lim)	-
	C. Arabic	72%	38%	-
	M. Arabic	(ext)	45%	-
	Ikalanga	76%	-	33%
	Japanese	(ext)	(lim)	-

- **Generalizing from (15):**
  1. Perseveratory coarticulation (NV) is more extensive than heterosyllabic anticipatory coarticulation ($\mathrm{V]}_\sigma\mathrm{N}$).[6]

[5]Abbreviations used by Jeong (2012): (ext) = extensively but non-categorically nasalized; (lim) = limited nasalization (less than 50%), (-) = unattested sequence or no data available.

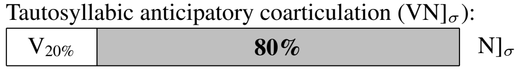
[6]With the exception of Akan. In Huffman's (1988) study, durations of anticipatory and perseveratory nasal coarticulation are roughly equivalent. But because the stimuli were of the form V_1NV_2, and V_2 is longer than V_1 (there appears to be final lengthening), V_1 was comparatively more nasalized than V_2. Further work would be required to determine if the documented asymmetry holds among vowel pairs that are more durationally equivalent.

2. Tautosyllabic anticipatory coarticulation ($VN]_\sigma$) is more extensive than heterosyllabic anticipatory coarticulation ($V]_\sigma$)N.
   - A. English (Krakow 1993): more nasalization before coda Ns.
   - Pashto, Malagasy, Delaware, Georgian, Gypsy-Telugu (Herbert 1977:348): more nasalization pre-NC than elsewhere.
   - Schourup (1973:191), on the basis of a large typological study:

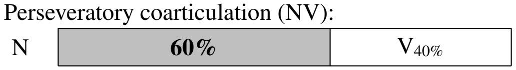
     "... In no language examined are vowels nasalized before prevocalic nasals when they are not also nasalized before all preconsonantal and word-final nasals."
3. Perseveratory coarticulation (NV) can be either more or less extensive than tautosyllabic anticipatory coarticulation ($VN]_\sigma$).
   - In "Type 1" languages, $VN]_\sigma > NV$.
   - In "Type 2" languages, $NV > VN]_\sigma$, or data is unavailable.

- Given this, we expect two types of system (%s for illustration only):
  - *Type 1:* (coarticulation in) $VN]_\sigma > NV > V]_\sigma N$.

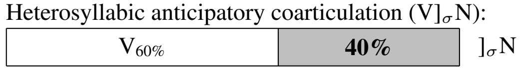
(16) a. Tautosyllabic anticipatory coarticulation ($VN]_\sigma$):



b. Perseveratory coarticulation (NV):

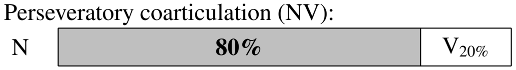


c. Heterosyllabic anticipatory coarticulation ($V]_\sigma N$):

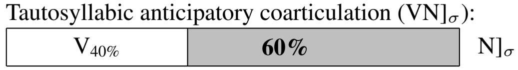


  - *Type 2:* (coarticulation in) $NV > VN]_\sigma > V]_\sigma N$.

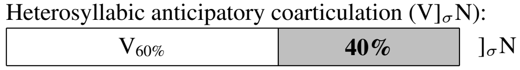
(17) a. Perseveratory coarticulation (NV):



b. Tautosyllabic anticipatory coarticulation ($VN]_\sigma$):



c. Heterosyllabic anticipatory coarticulation ($V]_\sigma N$):



- Assuming that the greater the degree of nasal coarticulation on V, the less distinct it is from Ṽ, then we expect the following:[7]
  - *Type 1:* $\Delta V]_\sigma N\text{-}\tilde{V}]_\sigma N > \Delta NV\text{-}N\tilde{V} > \Delta VN]_\sigma\text{-}\tilde{V}N]_\sigma$
  - *Type 2:* $\Delta V]_\sigma N\text{-}\tilde{V}]_\sigma N > \Delta VN]_\sigma\text{-}\tilde{V}N]_\sigma > \Delta NV\text{-}N\tilde{V}$

[7] Below, Δ = 'the auditory distance between'.

Typological predictions

- If shielding is a strategy to render V-Ṽ contrasts more distinct, then the phonetic asymmetry in (15) should lead to a typological one.
  - **Predicted:** shielding in a context where V-Ṽ is *more* distinct implies shielding in all contexts where V-Ṽ is *less* distinct.

    (18) a. *Type 1*: shielding in $V]_\sigma N \Rightarrow NV \Rightarrow VN]_\sigma$

    b. *Type 2*: shielding in $V]_\sigma N \Rightarrow VN]_\sigma \Rightarrow NV$
  - **Not predicted:** languages where shielding applies in limited contexts, to preserve only the more distinct V-Ṽ contrasts.
- *Why* do we predict these implicational laws?
  - MINDIST constraints set thresholds of distinctiveness. If some contrast *x-y* satisfies MINDIST in some context C_1, it satisfies MINDIST in all contexts C_n where Δ *x-y* / $C_n \geq \Delta$ *x-y* / C_1.
  - For example, NASDUR$_{50\%}$ (19) will penalize V-Ṽ in only NV and $VN]_\sigma$, but not $V]_\sigma N$, given the phonetics assumed in (16-17).

    (19) MINDISTV-Ṽ = NASDUR$_{50\%}$: for V-Ṽ to be distinct, V must be at least 50% oral and Ṽ fully nasal.
  - No MINDIST constraint can penalize only more distinct contrasts.

4.2 Testing the predictions

Predicted and non-predicted patterns in (20). (✓ = presence of shielding)

(20)

	Context NV	$VN]_\sigma$	$V]_\sigma N$	*Predicted?*	*Type*	*Description*
a.		✓		Yes	1	*Shielding in $VN]_\sigma$ context only*
b.	✓			Yes	2	*Shielding in NV context only*
c.	✓	✓		Yes	1/2	*Shielding in $VN]_\sigma$ and NV*
d.	✓	✓	✓	Yes	1/2	*Shielding in all contexts*
e.	✓		✓	No	-	*Shielding in NV and $V]_\sigma N$ contexts*
f.		✓	✓	No	-	*Shielding in $VN]_\sigma$ and $V]_\sigma$ contexts*
g.			✓	No	-	*Shielding in $V]_\sigma N$ context only*

The systems in (20a-d) are predicted, and attested.[8]

(21) **Shielding in VN]$_\sigma$ only: 6 lgs. (e.g. Nadëb, Barbosa 2005)**

a. /m/ → [bm] / V_C, V_#

(22) **Shielding in NV only: 39 lgs. (e.g. Kaiwá, Bridgeman 1961)**

a. /m/ → [mb] / _V

(23) **Shielding in VN]$_\sigma$ and NV: 6 lgs. (e.g. Amundava, Sampaio 1998)**

a. /m/ → [bm] / V_C, V_#

b. /m/ → [mb] / _V

(24) **Shielding in all contexts: 3 lgs. (e.g. Karitiâna, Storto 1999)**

a. /m/ → [bm] / V_Ṽ, V_#

b. /m/ → [mb] / #_V, Ṽ_V

c. /m/ → [bmb] / V_V

The systems in (20e-g) are *not* predicted, and are unattested.

(25) **Shielding in VN]$_\sigma$ and V]$_\sigma$N: unattested**

a. /m/ → [bm] / V_

(26) **Shielding in NV and V]$_\sigma$N: unattested**

a. /m/ → [bm] / V_

b. /m/ → [mb] / #_V

(27) **Shielding in V]$_\sigma$N only: unattested**

a. /m/ → [bm] / V_V, V_Ṽ

Why is this significant?

- A contrast-based account *accurately predicts* the following:
  - The existence of shielding in a given language implies the existence of a V-Ṽ contrast.
  - Shielding in contexts where V-Ṽ is more perceptible (i.e. V]$_\sigma$N) implies shielding in contexts where V-Ṽ is less so (i.e. VN]$_\sigma$).
- Other analyses could maybe describe these implicational universals, but I don't know of another analysis that could *predict* them.

[8] Recall that the exact allophones shielding produces can vary by language in unpredictable ways. For example, while some languages use [mb] to shield in NV contexts (/m/ → [mb] _V), others (like Karajá, Ribiero 2001) use [b] (/m/ → [b] / _V). Still others (like Epena, Harms 1984) allow [b] in oral contexts but [mb] in Ṽ_V. The examples in the text are the shielding patterns of the languages given.

5 Further predictions

Faced with an insufficiently distinct contrast, a language has two options: preserve the contrast through enhancement, or neutralize it.

- Whether a language shields or neutralizes its indistinct V-Ṽ contrasts is determined by the relative ranking of ID[±NAS]-V and *CONTOUR.
  - If ID[±NAS]-V >> *CONTOUR: *preservation through shielding.*

(28)

m^{a}a mã	NASDUR	ID[±NAS]-C	ID[±NAS]-V	*CONTOUR
a. m^{a}a mã	*!			
b. mã mã			*!	
☞ c. mba mã				*
d. ba mã		*!		

  - If *CONTOUR >> ID[±NAS]-V: *neutralization.*

(29)

m^{a}a mã	NASDUR	ID[±NAS]-C	*CONTOUR	ID[±NAS]-V
a. m^{a}a mã	*!			
☞ b. mã mã				*
c. mba mã			*!	
d. ba mã		*!		

- Under a contrast-based analysis, shielding and V-Ṽ neutralization are two sides of the same coin: *both avoid insufficiently distinct V-Ṽ contrasts*.
- Given that both shielding and V-Ṽ neutralization are motivated by the same set of MINDIST constraints, the contrast-based analysis predicts that the same implicational laws governing the distribution of shielding should also govern the distribution of the V-Ṽ contrast.
  - Recall: if shielding targets V-Ṽ in some context where it is **more** distinct, it should target V-Ṽ in all contexts where it is **less** so.
  - As a corollary: if neutralization targets V-Ṽ in some context where it is **more** distinct, it should target V-Ṽ in all contexts where it is **less** so.
  - More generally, the prediction is:

(30) *If two contexts C_1 and C_2 differ in that V-Ṽ is better-cued in C_1 than C_2, then both enhancement and neutralization phenomena targeting V-Ṽ in C_1 must also target V-Ṽ in C_2.*

In short: typologies of shielding and V-Ṽ neutralization should be identical.

5.1 Testing the prediction

- To test this prediction, I conducted a second survey.
  - Sample: all descriptions from PL5000 on, in MIT's library (so: languages of the Pacific, Australia, Africa, the Americas, and creoles).
  - 101 languages license contrasts between oral and nasal vowels.
  - In 32, contextual restrictions on the V-Ṽ contrast explicitly discussed.
- Results, for the most part, mirror asymmetries in the typology of shielding.

(31)

	Context of neutralization V/N_	V/_N]$_\sigma$	V/_]$_\sigma$N	*Predicted?*	*Attested?*	*Example*
a.	✓			Yes	Yes (19)	Vai (Welmers 1976)
b.		✓		Yes	Yes (3)	Gbeya (Samarin 1966)
c.	✓	✓		Yes	Yes (2)	Kiowa (Watkins 1984)
d.	✓	✓	✓	Yes	Yes (6)	Kana (Ikoro 1996)
e.		✓	✓	No	Yes (2)	Tinrin (Osumi 1995)
f.	✓		✓	No	No	
g.			✓	No	No	

- The two systems in (31) appear to be problematic.
  - V-Ṽ contrasts are more distinct in V]$_\sigma$N than in NV.
  - No language should neutralize V-Ṽ in V]$_\sigma$N but not NV.

But these counterexamples are only apparent.

- There is substantial evidence that Tinrin (Osumi 1995) has, or perhaps at some point had, a process of long-distance regressive nasal harmony.
  - V-Ṽ is neutralized preceding nasal vowels (Osumi 1995:24):

    "Nasal vowels can also form sequences, although they are less common. The opposition of nasal and oral vowels is neutralized before a nasal vowel in favor of nasal vowels."
  - Across an approximant ([w], [r∼ɹ], or [ɽ]), vowels almost always agree for nasality. When there are mismatches, they are largely ṼRV.[9]

(32)

	Match	*Mismatch* ṼRV	*Mismatch* VRṼ
#	305	26	4
Total	**305**	**30**	

[9]The counts in (32) include all relevant forms in the grammar; the counts in (33) are from pp. 1-100. Those transcribed variably (i.e. VRV on one page but ṼRV on another) have been excluded.

  - Across voiceless obstruents, there is a greater rate of mismatches. More consistent application across sonorants is consistent with implicational laws governing the typology of nasal harmony (Walker 2000).

(33)

	Match	*Mismatch* ṼTV	*Mismatch* VTṼ
#	43	18	5
Total	**43**	**23**	

- The other language with neutralization in both VN contexts is Xârâcùù (Lynch 2002). Existing data suggests it is amenable to the same analysis.
- **Claim**: V-Ṽ neutralization in these languages is not a reaction to insufficiently distinct contrasts, but a consequence of regressive nasal harmony.
  - Previous work suggests that harmony processes improve perceptibilty of otherwise indistinct contrasts (e.g. Kaun 1995, Walker 2005).
  - If the analysis of Tinrin and Xârâcùù presented here is correct, then it must be that some harmony processes are not perceptually motivated.

6 Are there alternatives?

Analyzing shielding as contrast preservation makes accurate predictions.

- Shielding is only attested in languages that license a V-Ṽ contrast.
- Shielding where V-Ṽ is more distinct implies shielding where it is less so.
- Identical asymmetries in the typologies of shielding and V-Ṽ neutralization.

But could another analysis derive these same results?

- An alternative analysis of shielding: it's spreading of [-nasal]. But:
  - No link between facts about the inventory (existence of V-Ṽ contrast) and facts about the phonotactics (possibility of shielding).
  - Maybe possible to say "[-nasal] can spread only if [nasal] is contrastive," but this isn't true for [+nasal] (e.g. Capanahua, Safir 1982).
  - No account for contextual asymmetries in the shielding typology and their resemblance to asymmetries in the neutralization typology.
- I don't know what other alternatives would look like.

Conclusions:

- **Narrow point:** environmental shielding is contrast preservation.
- **Broader point:** contrast is an essential part of phonological analysis.

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