Post-nasal devoicing as contrast enhancement*

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1 Introduction

- An area of active debate in phonological theory: to what extent are phonological processes phonetically natural?
  - "Phonetically natural" generally means either promoting articulatory ease or, on the other hand, creating some sort of perceptual advantage.
  - A large number of phonological processes claimed to be phonetically natural.
- Two relevant phenomena: *post-nasal voicing* and *post-nasal devoicing*.
  - In languages that exhibit post-nasal voicing (PNV), nasal + voiceless stop sequences (NTs) are mapped to nasal + voiced stop sequences (NDs).

    (1) Stops voice after nasals in Puyo Pongo Quechua (Orrr 1962)

a.	[kam-**b**a]	'yours'	*cf.* [sinik-**p**a]	'porcupine's'
b.	[hatum-**b**i]	'the big one'	*cf.* [sača-**p**i]	'in the jungle'
c.	[wakin-**d**a]	'the others'	*cf.* [wasi-**t**a]	'the house'

  - In languages that exhibit post-nasal devoicing (PND), NDs are mapped to NTs.

    (2) Stops devoice after nasals in Nasioi (Brown 2017)

a.	tion-**p**-ant-∅-in talk-**him**-I-sg-did	'I talked to him'
cf.	kara-**b**-ant-∅-in follow-**him**-I-sg-did	'I followed him'
b.	manton-**t**-a-∅-maan feel-**you**-I-sg-do	'I feel you'
cf.	oo-**d**-a-∅-maan see-**you**-I-sg-do	'I see you'

- The processes differ in whether or not they are taken to be phonetically natural.
  - PNV is perhaps universally believed to be phonetically natural, due to a combination of articulatory factors (see Pater 1999, Hayes & Stivers 2000).
    - ⩾ A nasal + fully voiceless stop sequence requires very precise articulatory coordination: voicing ceases at the same time the velum closes.
    - ⩾ In practice: often the velum closes after voicing has ceased. This results in nasality leaking into the voiceless stop.
    - ⩾ Fully voicing the post-nasal stop results in greater articulatory ease.
  - PND is believed to be phonetically unnatural (e.g. Beguš 2018). Given the articulatory difficulty associated with NTs, why would a language create them?
- **This talk**: PND can be seen as a form of contrast enhancement.
  - The idea, following Stanton (2017) (and Hyman 2001:173): all else being equal, the N-ND contrast is less distinct than the N-NT contrast.
  - Speakers employ PND as a way to render the N-NC contrast more distinct.
  - PND is natural not in the sense that it results in articulatory ease, but instead in the sense that it enhances perceptual distinctiveness.
- Proposal is interesting not just because it illuminates a motivation for PND, but also because it bears on the relationship between articulation and perception.
  - PNV and PND are opposites, both in substance and in motivation: one enhances articulatory ease, another enhances contrast distinctiveness.
  - PNV is far more common. Raises the question: why are processes that enhance perceptual distinctiveness relatively uncommon?

Roadmap

- **Section 2**. Positional asymmetries in PND.
- **Section 3**. Perception experiment testing the perceptibility of N-ND and N-NT contrast in two contexts: prevocalically and word-finally.
- **Section 4**. Analysis of the typology in Dispersion Theory (Flemming 2002).
- **Section 5**. Discussion of PND as a series of sound changes (Beguš 2018).

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2 Typology and hypotheses

- Here, I provide a brief overview of aspects of the typology of PND.
- First (§2.1), we'll focus on a typological asymmetry: some languages allow PND word-finally only, but no languages allow PND prevocalically only.
- Second (§2.2), I'll propose a hypothesis as to why this asymmetry exists.

2.1 Typology

- I know of 14 clear cases of PND; these were identified by consulting Hyman (2001), Stanton (2017), and Beguš (2018); all discuss PND.[1]
- Many languages with PND (n=9) allow NCs in prevocalic and word-final positions. These can be divided into two classes.
  - Some languages exhibit PND word-finally and prevocalically, as in (3).

    (3) Example: PND in Konyagi (Beguš 2018:704, citing Merrill 2016)
    a. PND in word-final position
    àe-jamp 'millet stalk'
    cf. Bedik [u-jāmb], Basari [ɔ-jə̄mb]
    ì-jàenk 'be long'
    cf. Bedik [u-jàng], Basari [a-j̃ùŋ]
    b. PND in prevocalic position
    ì-nkòt 'pole'
    cf. Bedik [gɛ-ngɔ́t], Basari [ɛ-ngɔ̀t]
    àe-ncə̰l 'caterpillar'
    cf. Bedik [gɔ-nɟʌ̀l], Basari [ɑ-nɟʌ́n]

  - Other languages exhibit PND word-finally only, as in (4).

    (4) Example: PND in Naman (Crowley 2006b:26-7)
    a. PND in word-final position
    /naːb/ → [naːmp] 'fire'
    /aɣug/ → [aɣuŋk] 'you (sg.)'
    b. No PND in prevocalic position
    /bələs/ → [mbələs] 'tree species'
    /iget/ → [iŋget] 'we (pl. incl.)'

- The rest of the languages (n=5) exhibit PND in prevocalic position, but do not allow word-final NCs. Nasioi (2), for example, does not allow final clusters.

[1] Note that I include only the cases where data is provided or easily accessible. There are further cases discussed in Beguš (2018) for which I have not yet checked the original sources.

Table 1: Summary of PND typology

Language Source(s)	Prevocalic PND?	Word-final PND?
Avava Crowley (2006a)	✗	✓
Kobon Davies (1980, 1981)	✗	✓
Konyagi Merrill (2016), Beguš (2018)	✓	✓
Murik Blust (2005, 2013)	✓	✓
Naman Crowley (2006b)	✗	✓
Nasioi Brown (2017)	✓	
Neverver Barbour (2012)	✗	✓
Páez Rojas Curieux (1998)	✗	✓
Shekgalagari Lukusa & Monaka (2008), Solé et al. (2010)	✓	
Southern Italian Rohlfs (1949)	✓	
Tape Crowley (2006c)	✗	✓
Tswana Hyman (2001), Gouskova et al. (2011)	✓	
Yaghnobi Xromov (1972)	✓	✓

- Patterns exhibited by each language are summarized in Table 1.
  - A ✓ means PND occurs; a ✗ means PND does not occur.
  - Cells are grayed out when there is no way to tell whether or not PND occurs (NCs are not allowed in that position). Does not bear on generalizations.
- What's most interesting about this table is the pattern that is missing.
  - All attested patterns are either ✗/✓ or ✓/gray. There is no ✓/✗.
  - In words: no language has prevocalic PND without having word-final PND.
- **Question**: why should prevocalic PND imply word-final PND?

2.2 Hypotheses

- To explain this asymmetry, let us return to the hypothesis that **postnasal devoicing is enhancement of the contrast between N and ND**.
- To understand how this can be viewed as enhancement, we need to understand what the cues are to the N-ND contrast, and how devoicing could enhance them.
  - Contrasts between Ns and NCs are cued in part by acoustic differences within the segments and segment sequences themselves.
    - ⩾ NCs have an oral closure and release. Ns don't (Burton et al. 1992).
    - ⩾ In some cases, NCs are longer than Ns (e.g., Riehl 2008).
  - They also are cued by differences in the surrounding vowels.
    - ⩾ All else equal, NC precedes oral vowel and N precedes nasal vowel.
    - ⩾ Potential difference in F0 of following vowel: vowels following Ts often have higher F0 than vowels following Ds (e.g., Repp 1979 for English).
  - There are reasons to believe that N-NT contrast is more distinct than N-ND.
    - ⩾ NTs have an overall longer duration than do NDs, including a longer oral release (e.g., Maddieson & Ladefoged 1993, Coetzee & Pretorius 2010).
    - ⩾ Vowels sometimes shorten before NTs, but not before NDs or Ns (e.g., Maddieson & Ladefoged 1993).
    - ⩾ Potential larger difference in F0 in N-NT than N-ND: sonorants often pattern like voiced stops (e.g., Repp 1979 for English).
    - ⩾ Previous results (Kaplan 2008) demonstrate that N-NT is more perceptible than N-ND in final position.
- Typology of PND allows us to make testable predictions regarding the perception of the N-ND and N-NT contrasts. First, the fact that PND exists suggests (5).

  (5) **Prediction 1**:
  N-NT should be more discriminable than N-ND in all positions.

- Second, the generalization that prevocalic PND asymmetrically implies word-final PND suggests (6).

  (6) **Prediction 2**:
  N-ND should be more discriminable in prevocalic position than in word-final position.

- Reasoning behind (5) is self-explanatory; but (6) needs more explanation.
  - The linking hypothesis between perception and typology that I assume is Licensing by Cue (Steriade 1997, (7)).

  (7) **Licensing by Cue (Steriade 1997)**:
  If two contexts (C_1, C_2) differ in that some contrast x-y is better-cued in C_1 than in C_2, the presence of x-y in C_2 implies its presence in C_1.

  - Applying this to N-ND: there is reason to believe that it is better-cued in prevocalic position than in final position (see, also, Beddor & Onsuwan 2003).
    - ⩾ In word-final position, important cues to the contrast (e.g., difference in nasalization of the following vowel) are absent.
    - ⩾ In some languages, stops are unreleased word-finally; an additional cue to the contrast (presence vs. absence of oral release) is potentially absent.
    - ⩾ By (7), we can predict that **the presence of N-ND in prevocalic position should asymmetrically imply its presence in word-final position**.
  - Licensing by Cue is typically used to predict patterns of neutralization, but we can use it to predict patterns of enhancement, too.
    - ⩾ Enhancement and neutralization are two sides of the same coin: positional asymmetries in the typologies are parallel (Stanton 2017, Flemming 2017).
    - ⩾ Not surprising: both are reactions to an insufficiently distinct contrast.
  - The typological predictions we can make, given (7) and what we know about the acoustics and perception of the N-ND contrast, are summarized in (8-9).

    (8) Predictions regarding neutralization of N-ND

Type of language	Prevocalic neutralization	Final neutralization
Possible	✓	✓
Possible	✗	✓
Impossible	✓	✗

    (9) Predictions regarding enhancement of N-ND

Type of language	Prevocalic enhancement	Final enhancement
Possible	✓	✓
Possible	✗	✓
Impossible	✓	✗

  - The predictions in (8) were verified by Stanton (2017), for a typology of 50 languages. The predictions in (9) line up with the findings in §2.1.
- All that remains to be shown is that the perceptual facts are as the typological generalizations suggest.
  - To do this, I designed an AX task that examines listeners' ability to discriminate N vs. ND and N vs. NT in prevocalic and word-final position.
  - **Preview**: the perceptual facts align perfectly with the predictions in (5-6).

3 Perception experiment

- Here: acoustic properties of the stimuli, and findings regarding discriminability.

3.1 Materials

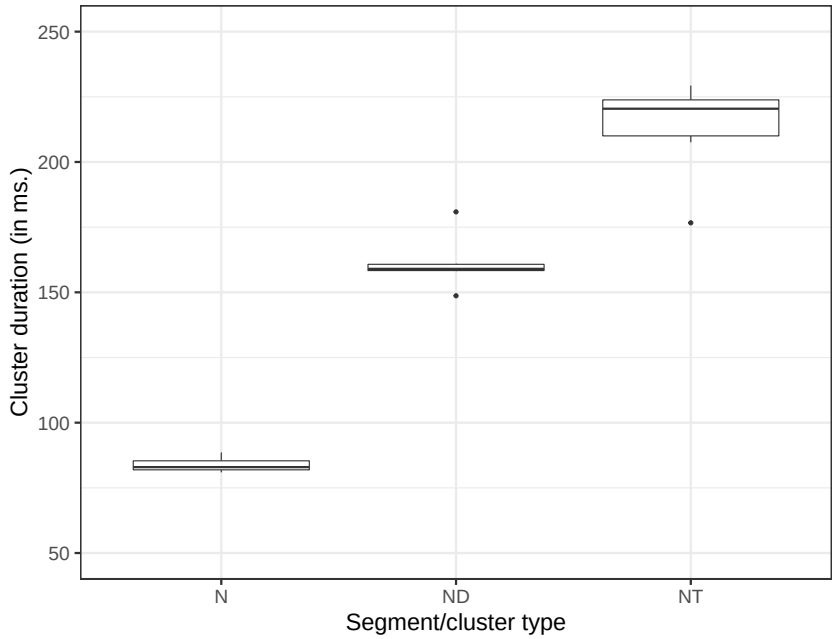
- The stimuli were constructed from trisyllabic nonce words, read aloud by a native speaker of (Peruvian) Spanish.[2] Prevocalic forms were constructed as follows:
  - In σ_1, onset C varied between /p/, /t/, and /k/ (to keep the task interesting).
  - In σ_2, onset C was always /d/ (to limit the number of variables).
  - In σ_3, onset C was labial or coronal N, ND, or NT.
  - In all syllables, the nucleus was /a/, and there was no coda.
- Word-final forms created by deleting the final vowel from the prevocalic forms.
  - The idea behind this method: deleting the final vowel gives listeners the best possible chance of hearing NC's oral portion.
  - True word-final NCs might have quieter releases, or no releases at all.
- The 'same' stimuli were constructed by pairing two recordings of the same form. (In one case, *padanda*, I used the same recording twice, due to speaker error.)
- The 'different' stimuli were created by pairing two recordings of different forms. Contrasts were N-ND, N-NT, and ND-NT (we'll focus on the first two).
- Examples of stimuli follow in Table 2.

Table 2: Stimuli examples

	Same	Different
Prevocalic	kada**n**a$_1$-kada**n**a$_2$	kada**n**a-kada**nd**a
	kada**n**a$_2$-kada**n**a$_1$	kada**nd**a-kada**n**a
	pada**nd**a$_1$-pada**nd**a$_2$	pada**n**a-pada**nt**a
	pada**nd**a$_2$-pada**nd**a$_2$	pada**nt**a-pada**n**a
	tada**nt**a$_1$-tada**nt**a$_2$	tada**nt**a-tada**nd**a
	tada**nt**a$_2$-tada**nt**a$_1$	tada**nd**a-tada**nt**a
Word-final	kada**n**$_1$-kada**n**$_2$	kada**n**-kada**nd**
	kada**n**$_2$-kada**n**$_1$	kada**nd**-kada**n**
	pada**nd**$_1$-pada**nd**$_2$	pada**n**-pada**nt**
	pada**nd**$_2$-pada**nd**$_2$	pada**nt**-pada**n**
	tada**nt**$_1$-tada**nt**$_2$	tada**nt**-tada**nd**
	tada**nt**$_2$-tada**nt**$_1$	tada**nd**-tada**nt**

[2]The nonce words discussed here were part of a larger set of forms recorded by this speaker (the forms were intended to be used for multiple experiments). Forms were read aloud as a list, with filler words at the beginning and end of the list, twice each.

Figure 1: Overall duration according to segment/cluster type



3.2 Acoustic properties of productions

- To know if (5-6) are applicable, necessary to verify that there are acoustic dimensions along which N-NT is marked by larger differences than N-ND.
- To investigate this, I took five different acoustic measurements from forms ending in *-ana* (n=6), *-anda* (n=5), and *-anta* (n=6).
  - Measurements taken: duration of V_1, duration of consonant(s), duration of oral release, intensity of oral release, and F0 of the first 10 ms. of V_2 .
  - For three measures, larger difference between N-NT than N-ND. For the remaining two, no difference. (Never the case that N-ND more different!)
- **Overall duration of segment/cluster (Figure 1)**
  - Comparison of the durations of N, ND, and NT reveal that ND is longer than N and shorter than NT (both $p < .001$, linear regression).
  - Pairwise comparisons (Tukey's HSD) confirm that all three durations are significantly different from each other (all at $p < .001$).

- **Duration of oral release according to segment/cluster type (Figure 2)**
  - Comparison of the durations of N, ND, and NT's oral releases reveal that ND's is longer than N's and shorter than NT's (both $p < .001$, linear regression).
  - Pairwise comparisons (Tukey's HSD) confirm that all three durations are significantly different from each other (all at $p < .001$).
- **F0 of the vowel following the segment/cluster (Figure 3)**
  - Comparison of the F0 of the vowels following N, ND, and NT reveal that N's F0 is lower than NT's ($p < .01$, linear regression).
  - A difference between N and ND is visible, but not significant.
  - Pairwise comparisons (Tukey's HSD) confirm that the only significant difference is between N and NT ($p < .05$).
- **Oral vs. nasal quality of the following vowel (not pictured)**
  - I did not measure this, due to the low number of tokens (acoustic measures of nasality work best when there are large numbers of tokens; Styler 2022:29).
  - However, prior work documents perseveratory nasalization following N in (peninsular) Spanish (Fernández Planas 2020, Beristain 2021).
- **Overall**: larger acoustic differences between N-NT than N-ND along several dimensions (overall duration, release duration, and F0 of the following vowel).
- Acoustics of the forms are in line with the discussion in §2, and the predictions.
  - Given the differences in overall and release duration, plausible that discrimination of N-NT will be better than that of N-ND, regardless of context.
  - F0 trends and perseveratory nasalization suggest that discrimination of N-ND will be worse in final than in prevocalic position.

3.3 Procedure

- 50 American English speakers were recruited through Amazon's Mechanical Turk. Participants were compensated for their time.
  - Three participants were excluded because they performed worse than chance.
  - Performing above chance wasn't hard: overall accuracy was 71%.
- Each trial had an inter-stimulus interval of 250 ms. between the forms. Participants were allowed to listen to each item once and only once.
- Participants selected whether the two words they had just heard were the same word or different words. They had unlimited time to make their selection.

Figure 2: Duration of oral release according to segment/cluster type

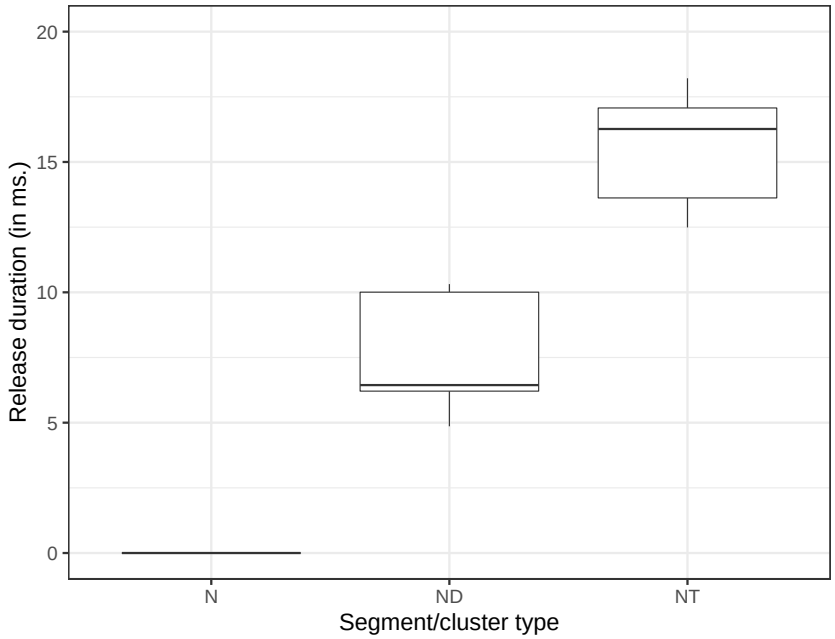


Figure 3: F0 of vowel according to preceding segment/cluster type

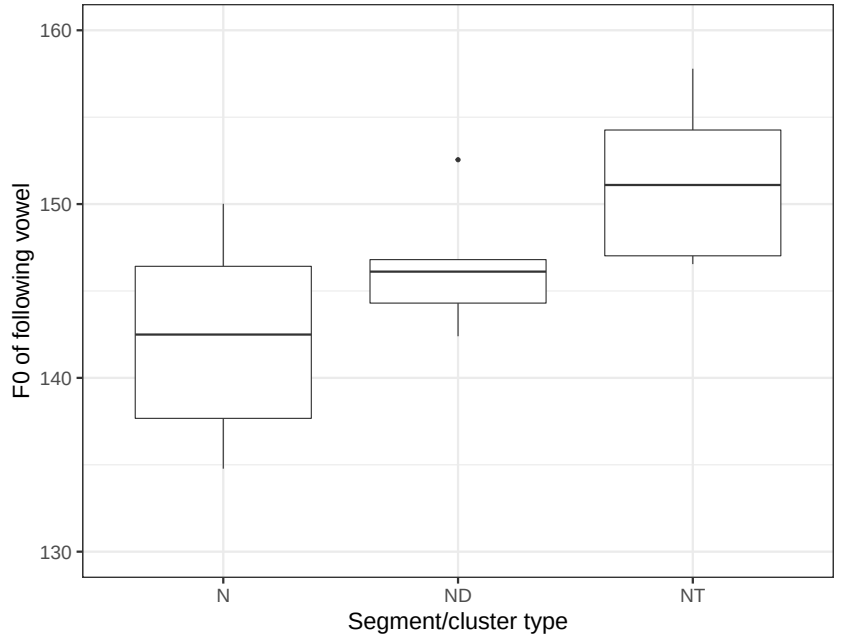
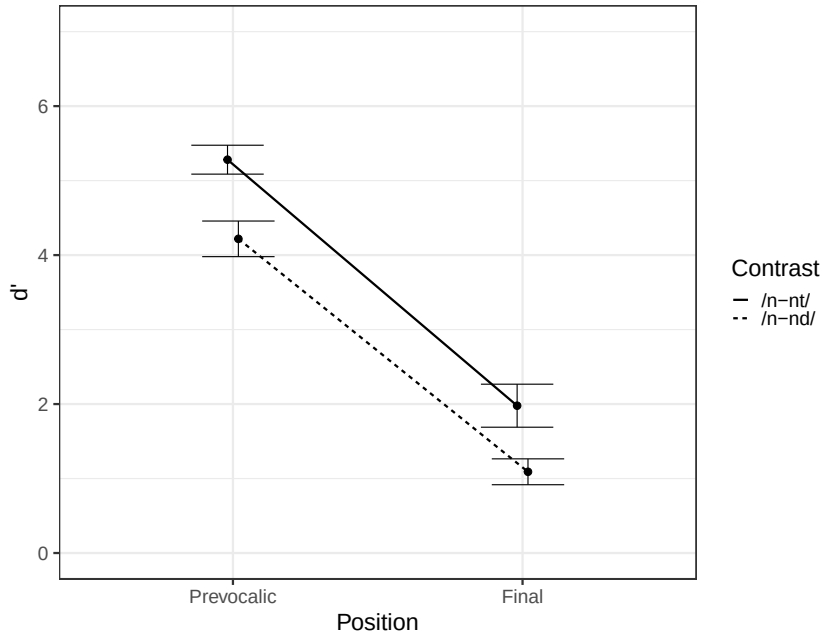


Figure 4: Perceptibility of N-ND and N-NT contrasts, by position



3.4 Results

- The results (in Figure 4) are consistent with the hypotheses. Results are presented in d'; the higher the d', the more discriminable the contrast.
  - In both contexts, N-NT is more perceptible than N-ND.
  - N-ND is more perceptible in prevocalic position than in word-final position.
- A mixed-effects linear regression finds significant effects for both the identity of the contrast (N-NT vs. N-ND) and the position (prevocalic vs. final).
  - Both fixed effects (Contrast and Position) were sum-coded.
  - Reference level for Contrast is N-NT; reference level for Position is Prevocalic.

(10) Results of statistical model

	Estimate	*t* value	Significant?
(Intercept)	3.12		
Contrast	-0.50	-4.98	Yes ($p < .001$)
Position	-1.63	-1.63	Yes ($p < .001$)

- Adding an interaction does not improve model fit (χ^2 (1) = 0.15, p = 0.70), indicating that the N-ND and N-NT contrasts are equally impacted by position.

4 Analysis

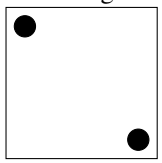
- My analysis of the PND typology has two main goals:
  - To reflect the motivation for PND – contrast enhancement – in the formalism.
  - To provide an analysis for all and only the PND patterns that exist.
- To achieve these goals, I adopt Flemming's (2002) Dispersion Theory.
- The analysis presented here largely follows Stanton (2017).

4.1 Dispersion Theory and PND

- The theoretical core of Dispersion Theory is that selection of phonological contrasts is determined by three functional goals.
  1. Maximize the distinctiveness of contrasts.
     Why? Language is a communicative medium: we want listeners to be able to tell words apart, so the sounds contained in them should be distinguishable.
  2. Minimize articulatory effort.
  3. Maximize the number of contrasts.
     Why? Because having a larger number of contrasts allows languages to distinguish words without them becoming excessively long.
- These goals inherently conflict. (In (11), the assumption is that the closer a dot is to the edge, the more effort it requires.)

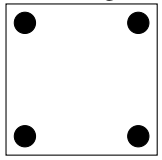
(11) Schematic dispersion of contrasts (from Flemming 2004:237)

a. Two categories, most separation, more effort.



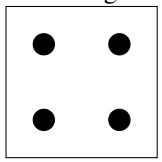
Inventory includes only one contrast.
Contrast is maximally distinct.

b. Four categories, less separation, more effort.



Inventory includes more contrasts.
Expanding the inventory moves sounds together.
Maximizing number vs. distinctiveness of contrasts.

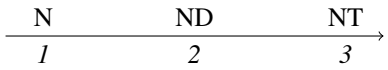
c. Four categories, least separation, less effort.



Producing the sounds requires less effort.
Sounds are closer together.
Maximizing distinctiveness vs. avoiding effort.

- These three goals are formalized as three separate families of constraints.
- **Distinctiveness constraints** require that contrasting sounds (or sound sequences) be sufficiently far apart along some acoustic dimension.
  - For PND, the distinctiveness of N vs. ND vs. NT is relevant.
  - One dimension we can use: overall length of the segment or segment sequence. This is diagrammed in (12).

    (12) Scale for overall length of N, ND, and NT

  - Requirement to have distinct contrasts formalized as a ranked set of constraints requiring a certain auditory distance between forms (MINDIST constraints).
  - MINDIST constraints requiring smaller distances $\gg$ constraints that require bigger differences. The smaller the distance, the greater the violation.

    (13) MINDIST = LENGTH:1 $\gg$ MINDIST = LENGTH:2

  - MINDIST = LENGTH:1 penalizes N-NC contrasts not differentiated by 1 by (12); MINDIST = LENGTH:2 penalizes contrasts not differentiated by 2.

    (14)

	MINDIST = LENGTH:1	MINDIST = LENGTH:2
a. N-ND		*
b. N-NT		

  - If MINDIST constraints had their pick, all N-NC contrasts would be N-NT. This isn't the case, so there must be something counterbalancing it.
- **Effort constraints** penalize segment (sequences) that are articulatorily difficult.
  - There is not a general theory of effort associated with Dispersion Theory.
  - Usual practice is to motivate these constraints as they become relevant.
  - The only relevant constraint here is *NT (Pater 1999; justification in §1).

    (15) *NT: assign one * for each nasal + voiceless stop sequence.

  - Effort constraints limit the range of possible contrasts. N-NT is more distinct than N-ND, but N-NT is harder to implement, so it is penalized.
- **Contrast preservation** is enforced by *MERGE ((16), Padgett 2003).

  (16) *MERGE: assign one * for each pair of input candidates (words) that share an output correspondent.

4.2 Word-final and prevocalic PND

- In languages that PND both prevocalically and word-finally, N-ND must not be a sufficiently distinct contrast in either position.
- Here, must be the case that MINDIST = LENGTH:2 dominates *NT. Contrast distinctiveness takes priority over effort minimization.
- What about the role of contrast preservation?
  - Maintaining the N-NC contrast is more important than avoiding NTs, so it must be the case that *MERGE $\gg$ *NT.
  - No basis to establish a ranking between *MERGE and MINDIST = LENGTH:2, so I assume they are together in the top tier.
- In prevocalic position, MINDIST = LENGTH:2 is not satisfied, so PND occurs.

  (17) PND in prevocalic position

$ana_1\ anda_2$	*MERGE	MINDIST = LENGTH:2	*NT
a. $ana_1\ anda_2$		*!	
☞ b. $ana_1\ anta_2$			*
c. $ana_{1,2}$	*!		

- In word-final position, MINDIST = LENGTH:2 is not satisfied, so PND occurs.

  (18) PND in word-final position

$an_1\ and_2$	*MERGE	MINDIST = LENGTH:2	*NT
a. $an_1\ and_2$		*!	
☞ b. $an_1\ ant_2$			*
c. $an_{1,2}$	*!		

4.3 Word-final only PND

- In languages that have PND word-finally only, the MINDIST constraints we currently have are not sufficient.
  - If *NT $\gg$ MINDIST = LENGTH:2, we expect N-ND in both contexts.
  - If MINDIST = LENGTH:2 $\gg$ *NT, we expect N-NT in both contexts.
  - No way to construct an analysis predicting final N-NT and prevocalic N-ND.
- What we need: a constraint that requires a difference of LENGTH:2, *only in contexts where other cues to the contrast are missing* (i.e., word-finally).

– Recall: other cues to N-NC lie in the next vowel (mostly, nasality vs. orality).

– I'll refer to this difference as VOWELQUALITY.

- We can formalize the intuition that one or the other of these differences is needed for N-NC to be sufficiently distinct as (19).

(19) **MINDIST = LENGTH:2 ∨ VOWELQUALITY**:
one * for every N-NC contrast that does not differ in either LENGTH:2 or VOWELQUALITY.

- The ranking is the same as above: *MERGE, MINDIST ≫ *NT.

- In prevocalic position, VOWELQUALITY is present; *NT blocks PND.

(20) No PND in prevocalic position

ana_1 $anda_2$	*MERGE	MINDIST = LENGTH:2 ∨ VOWELQUALITY	*NT
☞ a. ana_1 $anda_2$			
b. ana_1 $anta_2$			*!
c. $ana_{1,2}$	*!		

- In word-final position, VOWELQUALITY is absent; PND occurs.

(21) PND in word-final position

an_1 and_2	*MERGE	MINDIST = LENGTH:2 ∨ VOWELQUALITY	*NT
a. an_1 and_2		*!	
☞ b. an_1 ant_2			*
c. $an_{1,2}$	*!		

4.4 An alternative: word-final PND as final devoicing

- **Question**: why not analyze these languages characterized by §4.3 as exhibiting word-final devoicing, and not PND (Beguš 2018)? Two reasons:

1. Restrictions on final Ds and final NDs do not always parallel each other.
   – Wolof (Ka 1994), Boukhou Saafi (Mbodj 1983), and Basáa (Hyman 2001): word-final NDs licit but word-final Ds are not.
   – Jabêm (Bradshaw & Czobor 2005): final Ds are licit but not final NDs.
2. In at least one language, PND varies with neutralization of the N-ND contrast.

- In Neverver (Barbour 2012), the final N-ND contrast is enhanced or neutralized.

(22) Final N-NC alternations in Neverver (Barbour 2012:30-1)

a.	/bor/	→ [mbor]	'tasteless'
b.	/lablab/	→ [lablamp] ∼ [lablam]	'be big'
c.	/gel/	→ [ŋgel]	'slice'
d.	/muwag/	→ [muwaŋk] ∼ [muwaŋ]	'canoe, boat'

- Difficult to characterize this pattern if final-only PND is just final devoicing.
  – We'd have to claim that, in (22), violations of *[-son, +voi]# are repaired through devoicing or deletion of the final D.
  – The latter of these is an unattested repair to *[-son, +voi]# (Steriade 2009).

- Variation is, however, easily captured with constraints already introduced here.

- Only difference from analysis in §4.3: ranking of *MERGE and *NT is variable.
  – When contrast preservation is favored over avoiding NTs, *MERGE ≫ *NT.
  – When avoiding NTs is favored over contrast preservation, *NT ≫ *MERGE.

- In prevocalic position, neither PND nor neutralization occurs.

(23) No PND or neutralization in prevocalic position

ana_1 $anda_2$	MINDIST = LENGTH:2 ∨ VOWELQUALITY	*MERGE	*NT
☞ a. ana_1 $anda_2$			
b. ana_1 $anta_2$			*!
c. $ana_{1,2}$		*!	

- In final position, PND varies with neutralization.

(24) PND and neutralization in word-final position

an_1 and_2	MINDIST = LENGTH:2 ∨ VOWELQUALITY	*MERGE	*NT
a. an_1 and_2	*!		
☞ b. an_1 ant_2			*
☞ c. $an_{1,2}$		*	

- These facts suggest that the mechanisms that compel PND are different than those that compel word-final devoicing. The two should have distinct analyses.

4.5 PND and aspiration

- In two languages that I know of, word-final NDs are devoiced and aspirated.

- These patterns provide further arguments against final-only PND as final devoicing: why should a restriction on final Ds cause devoicing *and* aspiration?
- In Kobon, final NDs obligatorily undergo devoicing and aspiration.
  - Per Davies (1981:215), /b d g/ have prenasalized (e.g. [mb]) and prenasalized, devoiced, and aspirated (e.g., [mp^{h}]) allophones.[3]

(25) PND and aspiration Kobon (Davies 1981:221,226)

a.	/kɨdolmaŋ/	→	[kɨndolmaŋ]	‘arrow type’
b.	/aiud/	→	[aiunt^{h}]	‘story’
c.	/ar-ab-in/	→	[arambin]	‘go (PRES-1SG)’
d.	/ar-ab/	→	[aramp^{h}]	‘go (PRES-3SG)’

  - A suggestion that these are really aspirated stops, and not just released ones, comes from the transcription of final plain voiceless stops.

(26) Final voiceless stops in Kobon (Davies 1981:220-1)

a.	/mu-ep/	→	[mu-ep]	‘caring for pigs’
b.	/kie löp/	→	[k^{h}ielɐɸ]	‘to be hungry’

- In Paéz (Rojas Curieux 1998), there is variation akin to what we saw in Neverver.
  - Final NDs vary between N, ND, and NT^{h} ((27), glosses translated by me).

(27) Realization of NDs in Paéz (Rojas Curieux 1998:94-98)

a.	/himba/	→	[himba]	‘horse’
b.	/sʲamb/	→	[sʲamb] ∼ [sʲamp^{h}] ∼ [sʲam]	‘town’
c.	/kpinda/	→	[kpinda]	‘guava’
d.	/tund/	→	[tund] → [tunt^{h}] ∼ [tun]	‘fast’
e.	/nenga/	→	[nenga]	‘salt’
f.	/leng/	→	[leng] ∼ [lenk^{h}] ∼ [len]	‘lame’

  - Final voiceless stops are also aspirated, even when they don’t follow nasals.

(28) Realization of final voiceless stops in Paéz

a.	/ndjiʔp/	→	[ndjiʔp^{h}]	‘face’
b.	/tsut/	→	[tsut^{h}]	‘lace-up shoes’
c.	/sek/	→	[sek^{h}]	‘sun’

  - NB: possible that Rojas Curieux (1998) transcribes final release as aspiration.
- Proposed analysis extends easily to these cases of PND and aspiration: aspiration can be seen as a further enhancement to N-NC.

[3] They also have oral allophones, e.g. [b] and [p], but the distribution of these is not relevant here.

5 Alternative: PND as a historical development

- Beguš (2018) argues that all reported cases of PND have arisen from a sequence of three phonetically natural sound changes.
  1. Voiced stops spirantize except after nasals (D → Z / [-nas]__).
  2. Unconditioned devoicing of voiced stops (D → T).
  3. Unconditioned fortition of voiced fricatives (Z → D).
- IIllustration of these changes from Avestan to Yaghnobi (from Beguš 2018:717):

(29) Developments from Avestan to Sogdian to Yaghnobi

Stage	Sound change	Language	N__	Elsewhere
1		Avestan	band	dasa
2	d → ð / [-nas]__	Sogdian	βand	ðasa
3	d → t	Yaghnobi	vant	*ðasa
4	ð → d	Yaghnobi	vant	das

- One objection to this proposal: evidence that these changes have taken place is lacking or contested in a number of cases (e.g. Downing & Hamann 2021:21).
- Additionally, Beguš’s proposal would have trouble accounting for cases of final-only PND. Why should these sound changes operate only in that position?
- To be clear: I do not argue that all cases of PND arose as contrast enhancement. The claim is that it is a possible motivation with a viable synchronic analysis.
  - Very plausible that some arose by a mechanism like the one Beguš proposes.
  - In these cases, maybe an analysis of PND as contrast enhancement allows for the maintenance and transmission of the pattern (also Beguš 2018:715).

6 Summary

- PND can be seen as contrast enhancement. Asymmetries in the distribution of PND are consistent with an analysis that appeals to contrast distinctiveness.
- **Further directions**:
  - Proposed analysis can be easily extended to further cases of postnasal laryngeal alternations (i.e. those discussed by Hamann & Downing 2017).
- **Open questions**:
  - PND is rare. Analysis does not say anything about this; what’s the reason?
  - More generally: when considerations of articulatory ease and perceptual distinctiveness conflict, why is articulatory ease prioritized?

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