The Phonetic Properties of Voiced Stops Descended from Nasals in Ditidaht*

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1 The Nasal to Voiced Oral Stop Sound Change

- Five genetically diverse languages in the Pacific Northwest underwent an extremely rare sound change: All the nasal consonants in these languages became voiced oral stops (e.g. /m,n/ > /b,d/; Haas 1969:112, Thompson and Thompson 1972).

$$\left[\ +nasal\ \right] > \left[\begin{array}{l} -nasal \\ +voiced \end{array}\right]$$

- When these languages lost nasality, which had non-contrastive sonorant voicing, contrastive voicing arose:

Historical → *Contemporary*

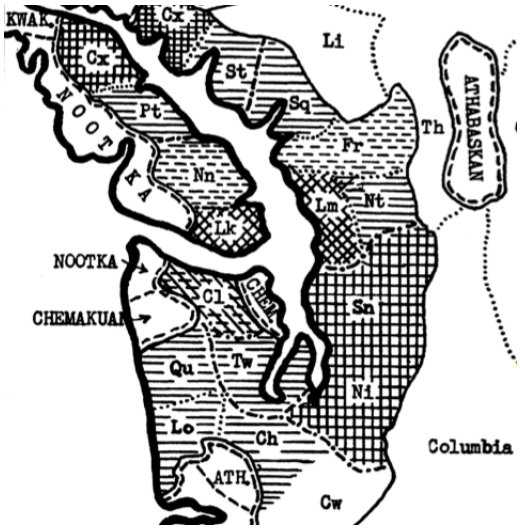
[−voi]	p	t	k	q
[+nas]	m	n		

→

[−voi]	p	t	k	q
[−nas, +voi]	b	d		

- The languages that underwent this change are (Kinkade 1985:478; map from Swadesh 1952:234):

Language	Map Label	*Stock*
Quileute	Qu	Chimakuan
Lushootseed	Sn, Ni	Salish
Twana	Tw	
Makah	"NOOTKA" on Oly. Pen.	Wakashan
Ditidaht	"KA" on Vancouver Isl.	



- The sound change spread as a result of areal contact, possibly originating in Lushootseed (Thompson and Thompson 1972:450-1).

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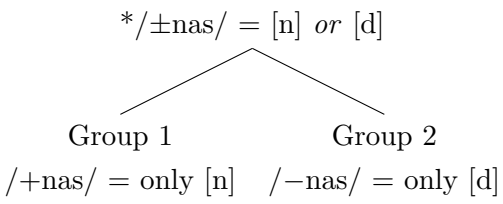
- But how could this happen, given that the Wakashan languages were split from the rest of the nasal-less languages by Chemakum and the Olympic Mountains (ibid.: 444-5)?
- Kinkade (1985) shows that there was a geographically contiguous group of languages that had at least one sound that was intermediate between a nasal and a voiced oral stop.
- This group was "virtually every littoral language of the Northwest from the 46th to the 50th parallel," and the sound was a nasal that was "sometimes pronounced without full closure of the velum" (Kinkade 1985:478). Kinkade (1985) quotes Boas (1911:565) as describing a labial sound in Lower Chinook as having "semiclosure of the nose and weak lip-closure," the sound "is therefore intermediate between *b*, *m*, and *w*, with prevalent *m* character. Between vowels, the sound approaches a *b*."
- Kinkade's view is that in these languages, the sound in question settled into being realized categorically as only one of its free variants.
- The sound change, then, was actually a single process of eliminating variation that had two results: loss of voiced oral stop variants (Group 1), or loss of nasal variants (Group 2).



2 Typology of Lacking Nasal Consonant Phonemes

- *Type I*: No phonemes with a nasal allophone or free variant. Nasals exist via contact or metalinguistic use. Examples: Ditidaht, Makah, Twana, Lushootseed, Quileute, Central Rotokas ("Papuan").
  - Central Rotokas is the only other language (to my knowledge) to have undergone the loss of nasal phonemes. Other languages lacking nasals may exist, but the shift from having nasals to lacking them has not been demonstrated for these languages.
  - There don't seem to be any languages that completely lack nasal consonants on the surface.
    - The five Pacific Northwestern languages have them in loanwords. For example, Ditidaht has /lijoːm/ "Devil" from Chinook Jargon (< French *le diable*).
    - Nasals are used in Central Rotokas to adapt English words and imitate foreigners trying to speak Rotokas. Firchow and Firchow (1969:274) report [mai mai] for "bye bye."
- *Type II*: No categorically nasal consonant phonemes, but certain phonemes have nasal free variants. Examples: Pawnee and Wichita (both Caddoan), Aita Rotokas ("Papuan"). E.g. Pawnee /r/ realized as [r, l, n, d] depending on speaker and phonetic context (Thompson and Thompson 1972:442 citing Boas 1911:16-17 and Wetfish 1937:1).
- *Type III*: No nasal consonant phonemes, but certain phonemes have conditioned nasal allophones (which are not free variants). Examples: Many Tukanoan languages, where nasal harmony turns voiced oral stops into nasals, e.g. Máíjɨki /$^{[+\text{nas}]}$bába/ → [mámá] 'new.'

3 The Phonetic Properties of Voiced Oral Stops Descended from Nasals

- Despite the shift from nasal consonants to voiced oral stops being extremely rare, no study to date has examined the acoustic properties of the voiced oral stops that descend from historical nasals.
- **The goal of this study**, then, is to examine the voiced oral stops to describe their phonetic properties and ascertain whether those properties can be explained by the voiced stops' historical status as nasals.
- The duration of native voiced oral stops and contemporary nasals (which are present as a result of contact and sound symbolism) is shown to be very similar. One might suppose that the duration of the voiced stops is a "phonetic relic" or holdover effect, but such a claim is very difficult to prove.
- Because nasals are generally voiced throughout their duration, one might expect the amount of pre-closure voicing in the voiced oral stops to be greater. However, the amount of pre-closure voicing (90 ms) is consistent with data from non-English languages, but is not greater than might be expected based on typological evidence.

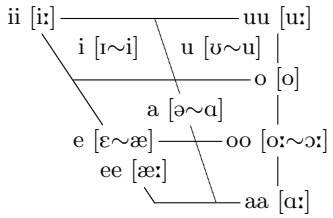
3.1 Consultants

This study examines new data collected from 3 speakers of Ditidaht in May and June 2012.

3.2 Methods

- Using wordlists, each speaker was prompted to say all 36 words (not all morphologically independent) in the working dictionary that contained a nasal consonant (m, ˀm, n, ˀn). These words are all either the result of contact or sound symbolism.
- Speakers were also prompted to say words with the voiced oral stops /b, ˀb, d, ˀd/ in as many segmental contexts as possible. /ˀm, ˀn, ˀb, ˀd/ are voiced pre-glottalized consonants that cause laryngealization (creaky voicing) on the preceding vowel. A vowel must precede these consonants (Werle 2007).
- The segmental contexts for voiced oral stops were chosen to provide the maximum variety of positions in the word, in the syllable, with respect to stress, and with respect to vowel quality. Not all possible contexts were attested in the words in the working dictionary. Examples of the contexts that were sought included those below (´ = stress, # = word boundary):
- Word-initially: #_V, #_ÝV (these possibilites are limited by the stress system[1])
- Word-finally: V_#, Ý_#, VV_#, ÝV_#

[1]Stress is predictable and non-contrastive. It falls on the second syllable of the word unless the first syllable contains a long vowel, in which case that syllable takes stress. The phonemic inventory of Ditidaht is as follows below (forms in parentheses are marginal):



	Bilab.	Alv.	Postalv.	Pal.	Vel.	Uv.	Phar.	Glot.
Plosive	p b	t d			k	q		ʔ
Glot. Plos.	pˀ ˀb	tˀ ˀd			kˀ	(qˀ)		
Nasal	(m ˀm)	(n ˀn)						
Fricative		s	ʃ		x	χ	ʕ	h
Affricate		t͡s t͡sˀ	t͡ʃ t͡ʃˀ					
Lat. Fric.		ɬ						
Lat. Affric.		t͡ɬ t͡ɬˀ						
Approx.	w			j				
Lat. Approx.		l						

- Before a coda consonant: V_C, V́_C, VV_C, V́V_C
- Intervocalically: V_V, V́_V, V_V́, V_VV, V_V́V, VV_V, V́V_V, V́V_VV.
- Elicited words were uttered in isolation, i.e. without a carrier phrase, but were uttered at a normal rate for each speaker.

3.3 Data

- The token counts represent the total number of instances of each relevant phoneme across all speakers.
- Nasals: 89 total tokens (from all known words with nasals in the language)
  - By phoneme: /m/ = 21, /ˀm/ = 2, /n/ = 57, /ˀn/ = 9
  - By speaker: M = 31, W_1 = 23, W_2 = 35
- Voiced Oral Stops: 194 total tokens (representative subset as detailed above)
  - By phoneme: /b/ = 59, /ˀb/ = 27, /d/ = 69, /ˀd/ = 39
  - By speaker: M = 66, W_1 = 65, W_2 = 63
- Plain Voiceless Stops: 106 total tokens
  - By phoneme: /p/ = 54, /t/ = 52
  - By speaker: M = 36, W_1 = 32, W_2 = 38
- Ejective Voiceless Stops: 55 total tokens
  - By phoneme: /p'/ = 27, /t'/ = 28
  - By speaker: M = 18, W_1 = 19, W_2 = 18

3.4 Transcription

- Used Praat (Boersma and Weenink 2001) to label WAV files.
- Labeled the word using an ASCII equivalent of the Ditidaht orthography.
- Labeled the phoneme of interest and, where applicable, pre-closure voicing ('prevoicing'), duration of stop closure ('closure'), and VOT.
  - Nasals were labeled according to where F2 and F3 were weakened and voicing still occurred with a strong F1. This was visually obvious in the spectrogram and correlated well with what could be heard.
  - Included "nasal bursts," which occurred at the ends of nasals and looked similar to stop bursts, but also didn't seem to fit auditorily with the following vowel.
  - In words with multiple nasals, the one before the stressed vowel was selected, e.g. in /ˈnaːniː/, "grizzly bear," only the first nasal was labeled and used as a token.
  - With pre-glottalized /ˀm, ˀn, ˀb, ˀd/, the laryngealization that occurred before them was not included in the duration of the token.

- Voiced oral stops were labeled from the beginning of closure to the onset of the following vowel (or the end of release noise if there was no vowel).
- Pre-closure voicing in voiced oral stops was labeled from the onset of any voicing until that voicing ended. The beginning and ending of voicing was judged based on pulses identified by Praat and verified visually in the spectrogram.
- In tokens with more than one voiced oral stop, the stop that provided the necessary environment was labeled. For example, in /ɬaˈtaːbʔub/, "hair," the final /b/ was labeled to get a token for the V_# environment.
- In voiced oral stop tokens after a vowel, pre-closure voicing was only labeled where the voicing of the vowel continued (usually more weakly) and the other formants of the vowel were absent.
- As a sanity check, voiceless stops and ejectives were labeled to be sure that there was any durational contrast between different kinds of stops.
- Where possible, the closure period was included for voiceless stops. This generally was not possible when the voiceless stops were word-initial.
- VOT was measured for voiceless stops, including ejectives, in the standard way: from the stop burst to the onset of voicing in the following vowel.

3.5 Analysis

- Ran 5 two-tailed *t*-tests in R (R Development Core Team 2011) to determine whether the classes of sounds (nasals, voiced oral stops, voiceless stops, and ejectives) differed in terms of duration.
- To address the problem of multiple comparisons, I used a Bonferroni correction to adjust the α-level from 0.05 to 0.01 (= 0.05/5).

3.6 Results and Discussion

3.6.1 Duration

- *Main Result*: The mean duration of nasals and the mean duration of voiced oral stops are not significantly different (corrected α-level = 0.01).
  t(137) = 0.53, $p = 0.591$
  Mean duration of nasals: 115 ms
  Mean duration of voiced oral stops 111 ms
  - Failure to reject the null hypothesis doesn't mean the null hypothesis is automatically true; however, the means are closer than one might expect.
  - Given our knowledge of the change from nasal to voiced oral stop, one might wonder whether the duration of the voiced oral stops is a "phonetic relic" from their former status as nasal consonants.
  - An open question: Are contemporary nasals similar enough to historical nasals to be compared? Difficult to know without recordings of historical nasals (which, as far as I know, do not exist).
  - Future work will compare the durations of nasals in related (and areally adjacent) Nuuchahnulth. This language did not undergo the denasalizing sound change.
  - *A priori*, one might expect the durations of nasals and voiced oral stops to be different, but typological data indicate that this is often not the case:

Language	*C*	*Duration*	*Source*
Russian	t	119 ms	Dmitrieva (2012:79)
	d	84	
	n	86	
American English	p	69	Byrd (1993)
	b	64	
	m	62	
	t	53	
	d	52	
	n	55	
Italian	t	117	Dmitrieva (2012:124)
	d	78	
	n	71	
Guinaang Bontok	p	83	Aoyama and Reid (2006:150)
	m	74	
	t	79	
	n	67	
Greek (Standard)	p	293	Arvaniti (2001:38-9)
	m	292	
	t	281	
	n	274	
Greek (Cypriot)	p	361	Arvaniti (2001:38-9)
	m	366	
	t	371	
	n	335	

- The mean duration of voiced oral stops and the mean duration of voiceless stops is significantly different. t(298) = -4.99, $p < 0.001$
  Mean duration of voiced oral stops: 111 ms
  Mean duration of voiceless stops: 140 ms
  - However, the difference between the mean durations of voiced oral stops and ejectives is *not* significant (t(247) = 0.63, $p = 0.525$; Mean duration of ejective stops = 106 ms).
- The difference between the durations of plain and pre-glottalized voiced oral stops is not significant (t(171) = -0.54, $p = 0.588$), nor is the difference between the durations of plain and pre-glottalized nasals significant (t(48) = 1.72, $p = 0.091$). This is unsurprising given the transcription methods used.

3.6.2 Pre-closure Voicing / VOT

- Another goal of this study was to examine the amount of pre-closure voicing for the voiced oral stops.
- Because nasals are often strongly voiced throughout, one might expect more pre-closure voicing than is cross-linguistically normal...
- ... especially since the loss of nasals created a minimal voicing contrast between /p, b/ and /t, d/.
- Mean pre-closure voicing for all voiced oral stops: 90 ms

- Given the mean duration of voiced oral stops (111 ms), pre-closure voicing accounts for 81% of their mean duration.
- In comparison with the cross-linguistic results obtained by Lisker and Abramson (1964), the Ditidaht voiced oral stops have a significant amount of pre-closure voicing, but still fit well among the non-English languages in the sample.
- Data from Lisker and Abramson (1964), sorted by number of voicing categories:

Language	*# of voicing categories*	*Mean pre-closure voicing of /b, d/*
Puerto Rican Spanish	2	124 ms
Hungarian	2	89 ms
Dutch	2	83 ms
Tamil	2	76 ms
English	*2*	*0 or negative* (Lisker and Abramson 1964:394-5)
Eastern Armenian	3	99 ms
Ditidaht	**3**	**90 ms**
Thai	3	88 ms

- The average amount of pre-closure voicing was approximately 87% of the pre-closure duration for labials and 76% for alveolars.
- Plain voiced oral stops had 3%-5% more pre-closure voicing than pre-glottalized voiced oral stops.
- The mean VOT of plain voiceless stops in Ditidaht is 28 ms, which is statistically significantly different ($t(159) = -5.25$, $p < 0.001$) from that of ejective stops (54 ms).

4 Conclusion

- Ditidaht voiced oral stops may retain the duration of the historical nasals from which they are descended, but their similarity in duration to contemporary nasals is actually *not* cross-linguistically unusual.
- The voiced oral stops have a cross-linguistically normal amount of pre-closure voicing, but this amount clearly separates Ditidaht from English, suggesting that subtle phonetic characteristics of Ditidaht have been maintained, even with fewer than 10 native speakers remaining.
- None of the characteristics of Ditidaht voiced oral stops can be attributed with certainty to their former status as nasal consonants, but this in itself is an important result since voiced oral stops descended from nasals have not been precisely examined before.

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Appendix

Ditidaht Words with Nasal Consonants

The table below shows the Ditidaht lexical items that have nasal consonants. These can all plausibly be attributed to contact or diminutive sound symbolism. In many cases, the exact explanation is known.

/m/

Word	*Gloss*	*Word Origin*
ʔamáʃ	breasts, to breastfeed, milk (n)	Also ʔadab 'breasts.' Related placename for "breast mountain" SE of Malachan is /ʔadabas/. Reconstructed for Proto-Southern Wakashan as *ʔanma 'breast, suckle' by Fortescue (2007:253). Makah has ʔadaab(a) 'breast, milk, sucking breast' and Nuuchahnulth has ʔinma 'breast, milk, suckling milk'
ham	excrement	loaned via Nuuchahnulth or kept intact; reconstructed for Proto-Wakashan in Fortescue (2007:38)
hamʕéːjqt͡ɬ	have to poop	
hamúʔɬ	toilet, washroom, women's bathroom	
mitúːliː	Victoria	loan from English
lijóːm	devil	Chinook Jargon from French *diable*
múːkʷaːwis	smokehouse	loan from English
múːsmus	cow	Chinook Jargon: "'musmus (~ WH~,MM 'mushmush, CR- 'mēsmēs). s.v.: Cow, ox, buffalo" (Zenk 1993)
t͡sʼúːmʕas	Port Alberni	probable loan from Tseshaht Nuuchahnulth

/n/

Word	*Gloss*	*Word Origin*
hiɬnájukʃt͡ɬ	a fart (female)	Baby talk? Diminutive sound symbolism?
nat͡ɬkíjeː	to kick something to somebody	?
nat͡ɬkʃít͡ɬ	to kick	Nuuchahnulth
náːt͡ɬkapiʔɬ	to put one's feet up (indoors)	?
náːniː	grizzly bear	Nuuchahnulth
sáːntiː	Sunday	Loan from English
sáːsaːnteːtχ	Saturday	Morphologically derived from /saːntiː/
neːn	Grandma! (direct address)	baby talk, diminutive (Jacobsen 1994:29)
t͡sʼiníp'uʔ	squirrel	Diminutive sound symbolism? Note that this is t͡simt'uu in Tseshaht, Hupacasath Nuuchahnulth according to Jacobsen (1994:29)

sáːsin	hummingbird	Nuuchahnulth
téːkin	socks	Loan from English, ultimately. Chinook Jargon is /stakin/ (Zenk 1993:383).
ʔíːʔinxʷaʔp	too small (to do something)	Diminutive sound symbolism? Compare English *eensy-weensy* to Ditidaht root /ʔin/ or /nii/ for "small, little, few"
ʕinqt͡ʃúː	dumplings, boiled bread	Diminutive sound symbolism?
niːt͡s'	short	Diminutive sound symbolism?
níːt͡s'akʷ'ʷt͡ʃ	to wear shorts or something short	Diminutive sound symbolism?
qʷiníː	seagull	Nuuchahnulth
ʔiníːq	a few, a little bit	Diminutive sound symbolism?
ʔisánoː	pee (female)	Diminutive sound symbolism for nasal. Note Fortescue (2007:150), "PW /ʔi(ʔ)asa/ 'urinate (woman)"'
ʔinúːwiʃt͡ʃt͡ɬ	to become small	Diminutive sound symbolism?
ʔinúːweːjaʔp	to make something small	Diminutive sound symbolism?

/ˀn/

Word	*Gloss*	*Word Origin*
náːˀnsaʔ	robin	Diminutive sound symbolism?
piˀnóː	kitten	Diminutive sound symbolism?
ʔiˀnít͡s'	a short time	Diminutive sound symbolism?
níːˀniːt͡s' aqabɬ	short hair	Diminutive sound symbolism?

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