VOICELESS NASALS IN AUDITORY PHONOLOGY

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(1) focus:
nasals and vocal fold spreading in Burmese, Sukuma, and Comaltepec Chinantec

(2) claims:
different timings of articulatory gestures with respect to one another culminate in better or worse percepts
the better the percept, the less marked the pattern
the worse the percept, the more marked the pattern
optimal timing patterns correlate with degree of auditory nerve response
the greater the auditory nerve response, the less marked the pattern
the lesser the auditory nerve response, the more marked the pattern

(3) place cues in plain nasals:
(Fant 1960, Fujimura 1962, Recasens 1983, Dantsuji 1984,86,87, Kurowski and Blumstein 1984, Bhaskararao and Ladefoged 1991):

CV formant transitions >> **VC** formant transitions >> steady state formants

velic lowering induces nasal poles and zeros ("nasal formants")

labial:	coronal:	velar:
ama	**ana**	**aŋa**

(4) Nasals and Laryngeal Abductions:
(Ladefoged 1971, Ohala 1975, Dantsuji 1984, 1986, 1987, Ladefoged and Maddieson 1995)

CV formant transitions obscured
VC formant transitions obscured
steady state formants obscured

(5) simultaneity of nasal place and laryngeal abduction:

labial:	coronal:	velar:
am̥a	**an̥a**	**aŋ̥a**

(6) canonical realizations--early realization of *voiceless* nasality (e.g., Burmese):

labial:	coronal:	velar:
aN̥ma	**aN̥na**	**aN̥ŋa**

(7) Auditory phonetics (Bladon 1986):

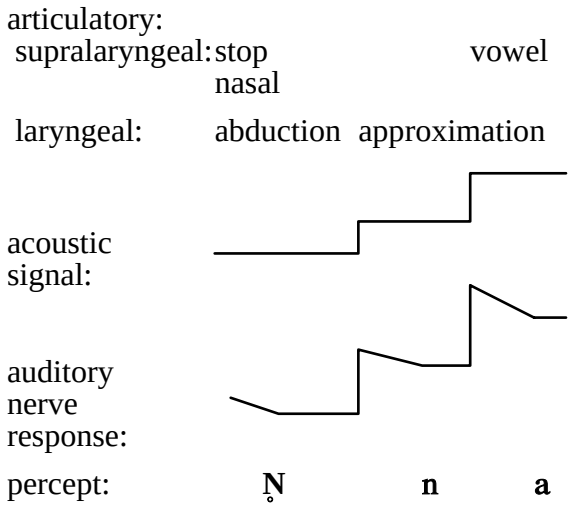
(a) **On/off response asymmetry**: spectral changes whose response in the auditory nerve is predominantly an onset of firing are much more perceptually salient than those producing an offset (Tyler, Summerfield, Wood, and Fernandes 1982).

(b) **Short-term adaptation**: after a rapid onset of auditory nerve discharge at a particular frequency, there is a decay to a moderate level of discharge, even though the same speech sound is continuing to be produced (Delgutte 1982).

(c) **Neural recovery**: silent intervals in speech sounds give rise to a rapid, high-amplitude discharge when interrupted (Delgutte 1982).

generalization: acoustic signals that involve *abrupt increases in acoustic energy* trigger maximal auditory nerve response

(8) gross schematic of articulatory, acoustic, and auditory characteristics of early *voicelessness* in nasals:



(9) **Burmese** (Okell 1969, Dantsuji 1984, 1986, 1987, Ladefoged and Maddieson 1995):

voiced nasals:		voiceless nasals:	
mą̂	lift up	**N̥m̥ą̂**	from
na	pain	**N̥na**	nose
ɲa	right	**N̥ɲa**	considerate
ŋâ	fish	**N̥ŋâ**	borrow

(10) morphological aspiration (**h**/non-**h** pairs--Okell 1969):

a. obstruent-initial:

pi	be pressed	**pʰi**	press, compress
pe	break off, be chipped	**pʰe**	break off (a piece)
po	appear	**pʰo**	reveal
ceʔ	be cooked	**cʰeʔ**	cook
sowʔ	be torn, shabby	**sʰowʔ**	tear
suʔ	be damp	**sʰuʔ**	moisten, make damp
kwe	be split, separated	**kʰwe**	split, separate

b. nasal-initial:

mjin	be high, tall	**N̥m͡jin**	raise, make higher
niʔ	be submerged, sink	**N̥n͡iʔ**	submerge, sink
ne	be loose	**N̥n͡e**	loosen (in socket, etc.)
naʔ	be completely cooked	**N̥n͡aʔ**	complete cooking

(11) non-canonical realiation--late realization of *breathy* nasality (e.g., Sukuma):

m͡m̤ **n͡n̤** **ŋ͡ŋ̤**

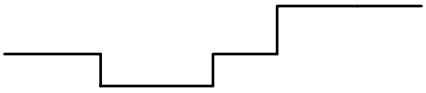
(12) **Sukuma** (Maddieson 1991):

ndɯn̤͡n̤͡ɔ͡ɔ	ladle
m͡m̤ą̤͡ą̤͡ala	gazelle
m͡m̤ą̤͡ą̤͡ala n͡n̤ą̤͡ą̤͡ale	small gazelle
m͡m̤ą̤͡ajɔ	word

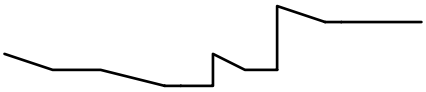
(13) gross schematic of articulatory, acoustic, and auditory characteristics of late *breathiness* nasals:

articulatory:
supralaryngeal: stop vowel
nasal

laryngeal: abduction
approximation approximation:



acoustic signal:



auditory nerve response:

percept: **n** **n̤** **a̤** **a**

(14) Optimality Theory (Prince and Smolensky 1993, McCarthy and Prince 1993):
--The grammar may be viewed as a struggle between ease of perception and ease of production (Martinet 1952, Lindblom 1990)
--Optimality Theory allows us to formally express this struggle as a series of ranked constraints

(15) **(a)** **recover**: render contrasts auditorily recoverable

(no stars) = cue fully (optimally) recoverable
* 1 star = cue sub-optimally recoverable
** 2 stars = cue unrecoverable

(b) **economize**: maximize articulatory ease

(no stars) = no gesture
* 1 star = relevant gesture implemented

(**c**) **overlap**: cues present in parallel

(no stars) = cue present in full parallel with maximally expanded cue
* star = cue not fully overlapped with maximally expanded cue

(16) At the lexical level **recover** is always most highly valued

recover		**recover**
economize	or	**overlap**
overlap		**economize**

(17) Nasals and laryngeal abductions in Burmese:

input place nasal abduction	**recover** place: **offset transitions** **onset transitions** **anti-resonance** nasal: **low F1: mid-range plateau;** abduction: **broadband noise**	**economize** place: **oral closure** nasal: **velic lowering** abduction: **laryngeal opening**	**overlap** place: **anti-resonance** nasal: **low F1: mid-range plateau** abduction: **broadband noise**
☞	**n̥n** place: **offset transitions** ****onset transitions** **anti-resonance** nasal: **low F1: mid-range plateau** abduction: **broadband noise**	**n̥n** place: ***oral closure** nasal: ***velic lowering** abduction: ***laryngeal opening**	**n̥n** place: ***anti-resonance** nasal: ***low F1: mid-range plateau** abduction: ***broadband noise**
	nn̥ place: ***offset transitions** **onset transitions** **anti-resonance** nasal: **low F1: mid-range plateau** abduction: ***broadband noise**	**nn̥** place: ***oral closure** nasal: ***velic lowering** abduction: ***laryngeal opening** voicing: ***approximation**	**nn̥** place: **anti-resonance** nasal: **low F1: mid-range plateau** abduction: ***broadband noise**

(18) nasals and laryngeal abductions in Sukuma:

input place nasal abduction	**recover** place: **offset transitions** **onset transitions** **anti-resonance** nasal: **low F1: mid-range plateau** abduction: **broadband noise**	**overlap** place: **anti-resonance** nasal: **low F1: mid-range plateau** abduction: **broadband noise**	**economize** place: **oral closure** nasal: **velic lowering** abduction: **laryngeal opening**
☞	**nn̥** place: ***offset transitions** **onset transitions** **anti-resonance** nasal: **low F1: mid-range plateau** abduction: ***broadband noise**	**nn̥** place: **anti-resonance** nasal: ***low F1: mid-range plateau** abduction: ***broadband noise**	**nn̥** place: ***oral closure** nasal: ***velic lowering** abduction: ***laryngeal opening** voicing: ***approximation**
	Nn̥ place: **offset transitions** ****onset transitions** **anti-resonance** nasal: **low F1: mid-range plateau** abduction: **broadband noise**	**Nn̥** place: ***anti-resonance** nasal: **low F1: mid-range plateau** abduction: ***broadband noise**	**Nn̥** place: ***oral closure** nasal: ***velic lowering** abduction: ***laryngeal opening**

(19) **Comaltepec Chinantec** (Anderson 1989, Anderson, Martinez, and Pace 1990, Pace 1990, Silverman 1995):

prevocalic voiceless nasals:

N̥m͡iː^{L}	water
N̥n͡œː^{L}	green beans
N̥ŋ͡ajɲʔ^{LM}	he kills

(20) post-vocalic voiceless nasal:
aN̥

(21) Place of articulation in post-vocalic nasals is non-contrastive:

Anderson, Martinez, and Pace, 1990:

"(a) The postnuclear nasal is [...] alveolar preceding **n** within the word, or preceding any alveolar consonant across a word boundary.

ka^{L}ẉweⁿ̥ʔ^{LM}ne^{L}	the animal was frightened
j̥juːⁿ̥^{HLH}la^{HL}	this child
j̥juːⁿ̥^{HLH}zeʔ^{MH}	sick child

(b) Preceding a labial consonant, within the word or across a word boundary, the postnuclear nasal is labial.

pimʔ^{H}	(<..**Nʔ** + **p**)	he is tiny
j̥juːm̥^{HLH}piŋʔ^{H}		small child

(c) Preceding a velar or laryngeal consonant, or pause, the postnuclear nasal is velar.

j̥juːŋ̥^{HLH}kʌŋʔ^{MH}	big children
ẉwiŋ̥ʔ^{H}	black child
j̥juːŋ̥^{HLH}haŋʔ^{MH}	perverse child

(d) Preceding **z̨** within a word, the postnuclear nasal assimilates the **z̨** and actualizes as a fronted velar with a nonsyllabic high front vocoid onglide.

ni^{L}l̥lej̥n̥^{M}	(<..**N̥** + **z̨**)	he will tremble
ʔʌj̥n̥^{LM}	(<..**N̥** + **z̨**)	he pulls (him)"

(22) nasality and laryngeal abductions in Comaltepec:

input nasal abduction	**recover** nasal: **low F1: mid-range plateau** abduction: **broadband noise**	**economize** nasal: **velic lowering** abduction: **laryngeal opening**	**overlap** nasal: **low F1: mid-range plateau** abduction: **broadband noise**
☞	**N̥** nasal: ****low F1: mid-range plateau** abduction: **broadband noise**	**N̥** nasal: ***velic lowering** abduction: ***laryngeal opening**	**N̥** nasal: ****low F1: mid-range plateau** abduction: **broadband noise**
	N̥n nasal: ****low F1: mid-range plateau** abduction: ***broadband noise**	**N̥n** nasal: ***velic lowering** abduction: ***laryngeal opening**	**N̥n** nasal: ****low F1: mid-range plateau** abduction: ***broadband noise**
	nn̥ nasal: ****low F1: mid-range plateau** abduction: ***broadband noise**	**nn̥** nasal: ***velic lowering** abduction: ***laryngeal opening** voicing: ***approximation**	**nn̥** nasal: ****low F1: mid-range plateau** abduction: ***broadband noise**

or

input nasal abduction	**recover** nasal: **low F1: mid-range plateau** abduction: **broadband noise**	**overlap** nasal: **low F1: mid-range plateau** abduction: **broadband noise**	**economize** nasal: **velic lowering** abduction: **laryngeal opening**
☞	**N̥** nasal: ****low F1: mid-range plateau** abduction: **broadband noise**	**N̥** nasal: ****low F1: mid-range plateau** abduction: **broadband noise**	**N̥** nasal: ***velic lowering** abduction: ***laryngeal opening**
	N̥n nasal: ****low F1: mid-range plateau** abduction: ***broadband noise**	**N̥n** nasal: ****low F1: mid-range plateau** abduction: ***broadband noise**	**N̥n** nasal: ***velic lowering** abduction: ***laryngeal opening**
	nn̥ nasal: ****low F1: mid-range plateau** abduction: ***broadband noise**	**nn̥** nasal: ****low F1: mid-range plateau** abduction: ***broadband noise**	**nn̥** nasal: ***velic lowering** abduction: ***laryngeal opening** voicing: ***approximation**

(23) --different timings of articulatory gestures with respect to one another culminate in better or worse percepts
--optimal timing patterns correlate with degree of auditory nerve response
--the greater the auditory nerve response, the less marked the pattern
--the lesser the auditory nerve response, the more marked the pattern
--a functional link may be established between the timing of articulatory gestures and their recoverability

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