

A Cross-Language Study of Vowel Nasalization¹

Lawrence C. Schourup

0. Introduction

The study of nasalization crucially involves nasal consonants, both because it appears, as Ferguson (1963: 59) has claimed, that, borrowing and analogy aside, contrastively nasalized vowels almost always² arise through loss of a nasal consonant, and because of the structure of the nasal consonant itself of which one striking feature is the independence of oral closure and nasality. This double structure has lead Drachman (1969: 202), Foley (196?: 21) and others to view nasals as nasally released stops; but the uniqueness of the nasal consonant rests primarily in the fact that the nasality component can represent the entire segment without accompanying oral closure in the phonetic representation. It is assumed below that several nasalization phenomena can be correctly viewed as the extension, contraction, or migration of the velic opening and/or oral closure components of nasals. Five aspects of nasalization are examined separately with a view to determining their cross-language characteristics, and the tentative universals that emerge from this comparative work are for the most part accounted for by referring to physiological pressures and constraints.

1. The environment for regressive nasalization

Below are listed several languages claimed to exhibit regressive nasalization of vowels before nasal consonants:

1. Amoy* (Chu 1970: 144) N#
2. Hausa (Hodge 1947: 10) N#
3. Tillamook (Thompson (1966: 314) N\$ (\$=syllable)
4. Germanic* (Moore and Knott Nx (x=velar fricative)
 1955)
5. Polish* (Lightner 1963: 225) N#,
 N [+cont] (+cont=
 fricative, nasal, or liquid)
6. Old English* (Moore and Knott N [+cont]
 1955) +obst

7. Lithuanian* (Kenstowicz 1969)	<u> </u> N# <u> </u> N [+cont] (+cont=j, v, l, r, m, n, s, z, s, z)
8. Ijò (Williamson 1965: 16-7)	<u> </u> N# <u> </u> NC
9. Fanti (Welmers 1946: 16)	<u> </u> N# <u> </u> NC
10. French* (Morin 1972: 102; cf. Schane 1968: 48 and Lightner 1970: 193)	<u> </u> N#
11. Old Church Slavonic* (Lightner 1970: 182)	<u> </u> N# <u> </u> NC (C≠j)
12. Hindi-Urdu (Narang and Becker 1971: 653-4)	<u> </u> N# <u> </u> NC
13. Korean (Jung (1962: 13-20)	<u> </u> N# (i, u) <u> </u> N (e, o)
14. Navaho (Sapir and Hoijer 1967: 11)	<u> </u> n, ñ (.=syllabic)
15. Ayutla Mixtec (Pankratz and Pike (1967: 289)	<u> </u> N
16. Portuguese (Saciuk 1970: 198)	<u> </u> N
17. Old Norse* (Gordon 1957: 267)	<u> </u> N
18. Keresan (Spencer 1946: 235)	<u> </u> N

This list provides a basis for the following generalizations:

(1) In no language considered do non-continuants after nasals permit nasalization when continuants do not also do so. Moreover, there are four languages in which continuants, but not non-continuants, permit nasalization.

(2) Environments which include # are highly favored among these languages. In some--Amoy, Korean (i, u), Hausa--nasalization occurs only word-finally. The two languages claimed to nasalize vowels in other environments, but not word-finally, are known only from written records (Old English and Germanic) and are therefore highly questionable sources for information about a subtle feature like nasality.

In Keresan (Spencer 1946: 235) vowels are nasalized before nasals regardless of the following environment, but nasalization is most apparent before word-final nasals.

(3) In no language examined are vowels nasalized before prevocalic nasals when they are not also nasalized before all

preconsonantal and word-final nasals.

Turning now to the characteristics of the vowel that undergoes nasalization, more generalizations are possible:

(4) Low vowels are more likely to be regressively nasalized than high ones. Lightner (1970: 214-5) quotes Delattre (unpub. paper) as saying that in French a was nasalized first historically, followed by mid and then high vowels. A similar tendency is observed in Korean where nasalization of mid vowels occurs before all nasals, but nasalization of high vowels occurs only before word-final nasals. In Thai (Noss 1964: 15) only low vowels are nasalized progressively. In Kashubian (Shevelov 1965) ě is raised in some environments to ī and lowered in others to ǣ; when ě is raised to ī, nasalization is lost, but it is retained when ě is lowered. In no language considered are high vowels regressively nasalized while low ones are not. Harrington (1946) and Moll (1962) have suggested that low vowels nasalize more readily because the palatoglossus muscles which connect the velum with the tongue musculature tend to draw the velum down when the tongue is lowered for a low vowel.

(5) There is also a tendency for back vowels to nasalize more readily than front ones. In Island Carib (Taylor 1951: 231) a, o and u are nasalized word-finally after a nasal, but i and e remain oral. In Ijò (Williamson 1965: 17) back vowels are more nasalized than front ones, with i (cf. (4) immediately above) least nasalized of all. In Sora and other Munda languages (Stampe, personal communication) only back vowels are progressively nasalized; front and central vowels are unaffected.

(6) Stress and nasalization are strongly correlated. In Irish (O'rahilly 1932: 194) only stressed vowels undergo shifts attributable to nasality. In Portuguese (Saciuk 1970: 209) a denasalization rule affecting the first member of vowel sequences affects that vowel only if it is unstressed. In Panama Spanish (Robe 1960: 36) progressive nasalization is claimed to affect only stressed vowels. In the Darmstadt dialect of German (Keller 1961: 166) nasalized vowels have arisen only where stressed oral vowels preceded final nasals. In the Upper Austrian dialect of German (Keller 1961: 207) all vowels are nasalized before nasals, but nasalization is often lacking when the vowels in question are in unstressed position in the sentence. In Goajiro (Holmer 1950: 50) "every syllable containing a medial nasalized vowel...has main stress." In Cashibo (Shell 1950: 199) only when a contrastively nasalized vowel is stressed does nasalization spread from that vowel to a following one. In Breton (Dressler 1972: 21) unstressed final vowels are denasalized in fast speech. In early Icelandic (Gordon 1957: 267) nasalization was lost first in unaccented syllables. In Island Carib (Taylor 1951: 232-3) "nasalization is usually stronger with stressed than with unstressed syllables." And, in the Hopkins dialect of the same language, "in every case where a shift of nasalization occurs, it is accompanied by a parallel shifting of stress." The following forms show the concurrent shift of stress and

nasalization:

ida lía sa	'how is it (that...)?'
má-buga nía	'didn't I tell thee?'
íó	'hymen'
tíó	'her hymen'
uí-bai	'whistle it!'
uáiriti lía	'great-is-it his-anger'

versus:

ida líã-gi	'how is he?'
aríha níã-dibu	'mind lest I see thee.'
gaiôgíru	'she's still a virgin'
maiôharu	'she's no longer a virgin'
tíuira	'she whistle(s, d)'
gãíaha uogóri lêa	'this man got angry'

Consider also:

/gáiu+ẽ/ --- gãie 'eggs'

(See also Taylor (195 : 233) for details of a similar alternation.)
Finally, in the same dialect, a "word-final unstressed vowel usually becomes oral when the word takes a suffix."

In no language examined is there attested nasalization of unstressed vowels to the exclusion of stressed vowels.

The problem which now arises is what to make of these results. If the data are representative, we might be justified in proposing a universal rule of roughly the following form:

$$\left[\begin{array}{c} V \\ !stress \\ !back \\ !low \end{array} \right] \rightarrow [+nasal] / \text{---}N \left[\begin{array}{c} \# \\ +cont \\ -cont \\ +syll \end{array} \right]$$

where exclamation points indicate preferred environments and the vertical arrow indicates a strict implicational hierarchy among the post-nasal conditioning factors; thus, if vowels are nasalized before a nasal followed by any element of the hierarchy, then they are also nasalized before all elements listed in the hierarchy above that element.³

The position adopted here, however, is that the formula above is an expression of several constraints on regressive nasalization and is not necessarily a universal rule. This reservation seems essential in light of the absence of arguments for the stronger position.⁴

It seems likely that further investigation will provide more detail to the present formulation--for example some specification of which continuants are most likely to permit nasalization before a preceding nasal, and perhaps of which nasals facilitate nasalization, and of finer detail in the ease with which different vowels undergo nasalization.

The reluctance of syllabics to permit nasalization before a preceding nasal can be explained by referring to syllabification. Since languages normally exhibit CV syllables, all that need be said is that a nasal allied to a following syllable (normally the case when a nasal is followed by a vowel) is least likely to nasalize a preceding vowel. Stampe (personal communication) points out the reluctance of nasalization to spread across syllable boundaries in the English words:

zĩ.no 'Zeno' (only slight nasalization of i)
1 3

fĩ̃.ɲo 'Finno(-Ugric)' (heavier nasalization of ɲ)

Drachman and Drachman (1971, to appear) note that in Greek voiceless continuants permit vowel nasalization before a preceding nasal more readily than voiceless stops; the following statement, which they offer in explanation, accounts nicely for part of the post-nasal hierarchy detailed above:

The reason for this seems to be that, since the velum is necessarily raised to satisfy the air-flow (or pressure) condition for the continuant (or stop), it is lowered for the nasal segment prematurely. But if the velum-lowering is sufficiently early, the stop component may well be inhibited altogether; the time allotted to the nasal will be added to the preceding vowel, since that time is required in any case for the velum to rise again for the following consonant.

Drachman's observation coincides with the view expressed earlier, that nasality is the information-bearing component of the nasal.

This explanation is very appealing; indeed, it is difficult to imagine a better one since the requirement which must be met by any theory on this point is that it account for the fact that the vowel is affected by a segment two places to its right. It therefore seems necessary to posit an explanation involving anticipation.

Interestingly, a solution involving pressure and air-flow does not account for the fact that a word boundary is the most likely environment for nasalization. A different principle seems to operate in final position. One possibility emerges if we consider that the range of planning of words is greater than a single segment. In the VNC cases, the velum will act conservatively because it must shut later in the word (a time-consuming operation; see Bjork 1961); that is, it will remain as nearly approximated as it can while still enabling the contrastive function of nasality (of the consonant), but in the case of word-final nasals, the velum need not be prepared for a new ascent and can therefore open early and more completely and remain open longer (cf. Keresan above). This speculation is consistent with an experiment by Moll (1962) in which it was shown that the velum is lowered more when oral vowels are spoken in isolation than when they are flanked by consonants. Unfortunately, the validity of this study is questionable because the corpus consisted of nonsense syllables. More clearly relevant is a study by Bjork (1961) which shows that the velum can be lowered quickly, but must be raised very slowly.

2. Progressive nasalization

Progressive nasalization has been all but ignored in studies of nasalization, but examples of this phenomenon are not scarce. The degree of nasalization can vary from slight (English, Portuguese⁵) to heavy (Yoruba, Warao, Sundanese, Navaho, Sora). Below are listed several languages claimed to exhibit progressive nasalization:

1. Ayutla Mixtec (Pankratz and Pike 1967: 289) N__
2. Cora (McMahon 1967: 133) N__
3. Picuris (Trager 1971: 32) N__
4. Sundanese (Robins 1957: 91) N__
5. Yoruba (Ward 1952: 13) N__
6. Central Ewe (Stahlke 1970: 51) N__
7. Land Dayak (Scott 1964: 432) N__
8. Icelandic (Gordon 1957: 267) N__
9. Finnish (Lehiste 1964: 177) N__
10. Fanti (Welmers 1946: 16) N__ (freedom of degree)

11. Ijò (Williamson 1965: 17) N__ ("somewhat" nasalized)
12. Navaho (Sapir and Hoijer 1967: 11) n__ (heavy)
13. Sora (Stampe, personal communication) m__ (not n__)
14. Portuguese (Saciuk 1970: 203) N__ (minor rule)
15. Warao (Osborn 1966: 111-2) N__
#m__#
16. Eskimo (Thalibitzer 1964: 153) m, n__# (Optional, effects e only)
17. Hindi-Urdu (Narang and Becker 1971: 657) $\left\{ \begin{array}{c} \# \\ + \end{array} \right\} m_ \left\{ \begin{array}{c} \# \\ + \end{array} \right\}$
18. Thai (Noss 1964: 15) N, h, #__

Languages with progressive nasalization do not necessarily inhibit regressive nasalization. Both types are attested for Mundari, Ijò, Navaho, Fanti, Portuguese, Icelandic and Thai. Without experimental verification, it is unsafe to speculate about the existence of languages with neither progressive nor regressive nasalization. The same difficulty exists in trying to show that there are languages with only one kind of nasalization, but Lehiste (1964: 177) has shown that there is at least one language, Finnish, in which the only appreciable nasalization is progressive and recently Fant⁶ has claimed that nasalization of the following vowel is a necessary condition for the perception of a prevocalic nasal as such.

In at least four of the languages with progressive nasalization (Ayutla Mixtec, Yoruba, Navaho, Ijò) the distinction between oral and nasal vowels is neutralized after nasal consonants, but this is not a necessary concomitant of progressive nasalization; in Picuris underlying and surface nasalized vowels contrast on the surface, but there are apparently vowel quality changes which enforce the distinction (Trager 1971: 32).

In Sora (Stampe, personal communication) the hierarchy of vowel heights posited above for regressive nasalization (section 1) is reversed. Back vowels after m are nasalized, but u receives heavy nasalization, o less heavy, and ɔ least of all. Notice that if the velum remains at the same degree of closure, production of a high vowel shunts proportionally more air through the nasal cavities producing heavier nasalization than for a low vowel. It appears, therefore, that two different tendencies for the nasalization of vowels must be recognized: if the velum tends to be held stationary, higher vowels will be

more nasalized than lower ones (so far this has only been observed for progressive nasalization); on the other hand, if the velum bows to anatomical pressures, low vowels will be more nasalized. Since we might expect to find some languages in which both tendencies operate simultaneously, it is not surprising that in Yoruba nasalization (again progressive) is heavy for both high and low vowels, but light for the mid vowels e, ɛ, o, ɔ. This situation can be accounted for by supposing that in Yoruba there is a restriction on the degree to which the velum may be raised in the production of nasal vowels.

3. A constraint on nasalization

In most of the languages considered in this study, nasalization spreads only to vowels adjacent to the nasal (data is not often available concerning diphthongs). But in several languages nasalization spreads into distant syllables:

(1) In Warao (Osborn 1966: 111-2) nasalization initiated by a nasal consonant spreads progressively until it encounters either juncture or a consonant other than the glides w, y, and h.

mõãũ	'give it to him'
nãõ	'come'
inãwãhã	'summer'
mõyõ	'comorant'
mẽhõkõhi	'shadow'
nãõte	'he will come'
mõãũpu	'give them to him'
mõãũ/ihi	'give it to him, you!'

(2) A strikingly similar phenomenon is observed in Sundanese (Robins 1957: 91). Nasality initiated by the production of a nasal consonant is stopped only by supraglottally articulated consonants, but spreads freely through h and glottal stop.⁷

mãro	'to halve'
ɲiãr	'to seek'
ɲiãñ	'to wet'
nĩʔis	'to take a holiday'

mīāsih	'to love'
kumāhā	'how?'
pāhōkvn	'to inform'
bṛqhār	'to be rich'

(3) The constraint holds also for regressive nasalization. In the Kolokuma dialect of Ijò (Williamson 1965: 16) nasalization spreads regressively from nasals and is stopped only by juncture or consonants other than w, r, and ɣ.

(4) In Tereno (Bendor-Samuel 1966: 350) nasalization is a suprasegmental morpheme denoting first and second person pronouns. It starts at the beginning of either a verb or noun and spreads as follows: "all the vowels and glides are nasalized up to the first stop or fricative," but nasalization spreads freely through h and glottal stop.

(5) In Ayutla Mixtec (Pankratz and Pike 1967: 289) nasalization spreads progressively through an intervocalic glottal stop:

$$\left\{ \begin{array}{c} V \\ VV \\ V?V \end{array} \right\} \rightarrow [+nasal] /N__$$

but is blocked by other consonants.

(6) In Island Carib nasalization shifts with stress, but "nasalization cannot follow stress when the latter moves across consonant boundaries" (Taylor 1951: 233).

sū	'all, every'
sūhali	'he has finished'

but

ásura	'to finish'
-------	-------------

Similarly:

busuě	'in need/want of'
busěti	'he wants'

but

abúsera	'to want'
---------	-----------

(7) Holmer (1952: 220) remarks that in Seneca "nasalization affects all adjacent vowels and may even extend over a semi-vowel, as in kawenyahsa 'her heart' = [kāwē...].

(8) In Greenlandic Eskimo (Thalbitzer 1964: 153) nasalization spreads from a nasal to a preceding r, "often even spreading

to the vowel before r."

(9) Stampe (personal communication) reports that in midwestern dialects nasalization spreads through r, l, w, j, i, u, h, and vowels. It is interesting in connection with what was said in section 1 about the relation between stress and nasalization, that in these dialects nasalization spreads to a syllable with main stress, but not beyond it; thus

r̃āim	'rhyme'
r̃jūm	'fume'
h̃ēlɔ̃n	'Helen'
h̃āɪf̃iŋ	'hollering'
kɪf̃r̃ɔ̃ts	'Clarence'

but

riw̃āɪf̃iŋ	'rewiring'.
------------	-------------

(10) In Land Dayak (Scott 1964: 435) "prosodic glottal stop, as a junction feature, does not check progressive nasalization...Intervocalic h, j, and w do not in all cases check nasality."

ñh̃in	'place'
sim̃h̃iŋ	'ten'
ñāh̃ān	'bear'
pim̃ā ^j iŋ	'a game'
ñi ^j ūm	'kiss'
ŋājūn ñājūn	'swing'
ñū ^w āŋ	'pour'

(In each of these examples there is a supporting nasal in the final syllable which would not, alone, be sufficient to provoke nasalization of an adjacent vowel.)

(11) In Breton (Dressler 1972:16) nasalization may spread regressively through the glide w as in

me:w	'drunk'
m̃e:wī	'make drunk'

but not through other consonants.

These facts, along with the absence of languages in which

nasalization spreads through obstruents, suggest the following constraint on nasalization:

A.0 Nasalization initiated by a nasal segment⁸
may never spread through an obstruent.

Gibson (1956: 258) claims that in Pame "nasalization is a suprasegmental phoneme...continuing [from a certain vowel] to the end of the word." If the spread of nasalization in Pame is indeed unrestricted, it represents a counterexample to A.0; but examination of the data given by Gibson in support of his claim fails to turn up a single case of nasalization spreading through an obstruent:

lanhãt	'they will arise'
ŋgolhẽ?ẽ	'tamale'
nanã	'his tongue'
khã?ãt	'they put him in office'
mãikt	'let's go'
snahõl?	'his shirt'
ta?ẽhil ^y k	'you sleep (du.)'

Here the only segments that offer no resistance to spreading nasalization are, predictably, glottal stop and h.⁹

Stampe (personal communication) points out that in the midwestern dialects discussed above nasalization sometimes spreads through a fricative, as in

hãznt	'hasn't'
-------	----------

which necessitates reformulation of the constraint to allow nasalization to occasionally spread through lax obstruents. But rather than attempt to adjust the constraint as new and slightly different counterexamples turn up (as they probably will) it seems preferable to formulate the constraint as follows:

A: Nasalization will not spread from an initiating segment through a segment whose airflow or oral pressure requirements are so high that the velum is forced to close.

This formulation in physiological terms gives a principled explanation of the observed data; it is empirically testable; and it permits variation in the set of segments which may be penetrated by nasalization in particular languages.

4. Vowel quality changes

Often, but by no means always, the quality of a vowel changes when it becomes nasalized (beyond the change in quality attributable to nasalization itself). Following the data listed below is a composite diagram on which directional tendencies can be seen. Arrows indicate the origin and destination of each change.

Vowel Shifts:

NL=nasalization accompanying nasal loss; oral vowels unchanged
 PN=possibly phonemic nasalization; oral vowels unchanged
 AN=allophonic nasalization near a nasal
 NNA=nasalization not specifically attested, but quality change in the vicinity of nasals only
 H=historically; limited to nasal vowels.

- | | |
|---|---------------------------------|
| 1. Old Norse (Gordon 1957: 275) | ī---ē NL |
| | ū---ō NL |
| 2. French (Schane 1968: 48) | ē---ǣ NL |
| | ī---ē NL |
| | ē---ē NL |
| | ÿ---ǣ NL |
| | ø---ǣ NL |
| 3. Hindi (Fairbanks and Misra 1966: xvii) | ē---ē AN |
| 4. Irish (O'rahilly 1932: 194) | ē---ī AN (stressed vowels only) |
| 5. Southern Irish (O'rahilly 1932: 195) | ǣ---ō AN (stressed vowels only) |
| | ō---ū |
| 6. Scottish Irish (O'rahilly 1932: 195) | ō---ō AN |
| | ǣ---ē AN |
| 7. Portuguese (Saciuk 1970: 198) | ǣ---ǣ̂ AN |
| | ē---ē AN |
| | ō---ō AN |

8. Breton (Dressler 1972: 15)	ɛ̃---ɛ̃ [~]	AN
9. Burmese (Haas 1949: 28-9)	ĩ---ĩ	PN
	ẽ̃---ẽ̃	PN
	ũ---ũ	PN
10. Mezquital Otomi (Wallis 1968: 215)	ẽ̃---õ	PN
11. Slave (Howard 1963: 42-7)	õ---õ	PN
12. Pame (Gibson 1956: 258)	ũk---õ	PN
13. Yoruba (Ward 1952: 7, 12)	ɔ---õ [^]	PN
	ĩ---ĩ [~]	PN
	ũ---ũ [~]	PN
	ẽ̃---ẽ̃ [~]	PN
14. Slavic (Halle 1963: 295)	e---æ	NNA
	o---u	NNA
15. Hidasta (Halle 1963: 296)	e---i	NNA
	o---ɔ	NNA
16. Peki (Ewe) (Stahlke 1970: 51)	õ---õ [~]	H
	ẽ̃---ẽ̃ [~]	H
17. Siouan (Wolff 1950: 68-71)	ã---õ	H (Osage)
	ũ---õ	H (Osage)
	ũ---ã	H (Omaha-Ponca)
18. Kashubian (Shevelov 1965: 325)	ẽ̃---ã	H (/___#) hard dentals
	ẽ̃---i	H (elsewhere)
19. Gujarati (Pandit 1961: 56)	ã---ũ	H
20. Germanic (Moore and Knott 1955)	ã---õ	H (___N)

21. White Tai (Fippinger and Fippinger 1970: 93)	e---i H NNA (/__N)
	o---u H NNA (/__N)
22. Russian (Lightner 1963: 295)	o---u H NNA (/__NC)
	e---o H NNA (/__NC)
23. Assiniboine (Levin 1964: 14)	i---a NNA (when i occurs morphologically /__N)
24. Southern English (Foley 65)	ɛ---ɪ NNA (/__n)

From the following diagram it is apparent that when vowels become nasalized, they tend to shift back in the mouth rather than forward. The only language in which a nasalized vowel shifts forward is Omaha-Ponca (perhaps not a counterexample, depending on the phonetic quality of a). The explanation for this tendency is not self-evident, but one possibility is that backing of vowels equalizes the volume of the oral and nasal pharynges, as in French (Delattre 1968), causing severe reduction of F_1 and thereby heavy perceived nasality (see section 5 below); thus, we might view vowel backing as a factor contributing to nasalization.

Although it is often claimed that nasalized vowels tend to lower, the diagram shows that this tendency is not very pronounced. There is, however, apparently a tendency for vowels to lower when nasalization is accompanied by nasal loss (French, Old Norse). There is also a marked tendency for vowels to be raised when they are allophonically nasalized adjacent to nasals (Irish, Southern Irish, Scottish Irish, Portuguese, Breton). Vowels with apparent phonemic nasalization do not show clear directional tendencies.

The justification for plotting vowels for which nasalization is not specifically attested on the same diagram as those for which it is attested is that a certain amount of nasalization is inevitable on any prenasal vowel; otherwise the nasal would have to be released by means of velic plosion. (This follows since time must be expended when raising or lowering the velum.)

5. Perceived nasality versus velum lowering

One issue that must be resolved if nasalization is to be better understood is the extent to which perceived nasality is attributable to factors other than velum-lowering. Moll (1962) suggests that the inherent nasalization of \underline{a} may not be primarily due to velum lowering, but instead to damping caused by jaw lowering. This conclusion is confirmed by House and Stevens (1956) who point out that even when \underline{a} was synthesized without any nasal coupling, it was still perceived as somewhat nasalized. The acoustic correlate which these experiments identified as the cue for nasality is wider bandwidth of the first formant.

In a remarkable study Delattre (1968) has shown that vowel nasalization is produced differently in French and, for example, English or Portuguese; that is, not by velum-lowering alone, but by velum-lowering in conjunction with equalization of the volume of the oral and nasal pharynges. The striking acoustic effect of this (cineradiographically confirmed) articulatory phenomenon is that the first formants of all French nasalized vowels are weak and all at the same frequency. Simple lowering of the velum produces attenuation of F_1 , while the 'double' nasalization of French is more marked and characterized not only by attenuation of F_1 but also by virtual annihilation of its harmonics.

Finally, notice that Williamson (1965: 16) claims that in Ijò nasalization is perceptually heavier after \underline{m} than \underline{n} , but she notes that kymography shows the degree of nasal airflow to be identical for both consonants.

It seems likely that these observations will assume considerable importance when more subtle aspects of nasalization are studied.

6. Relation between nasalization and nasal loss¹⁰

A process which causes sequences VN to be realized as long nasalized vowels occurs frequently in natural languages, both synchronically and diachronically. Lightner (1970) considers three alternative analyses for this phenomenon:

- (1) nasalization of the vowel; loss of the nasal; compensatory lengthening of the vowel.
- (2) nasalization of the vowel; lengthening of the vowel; loss of the nasal
- (3) nasalization of the vowel; complete assimilation of the nasal to the nasalized vowel.

He argues that the first solution is wrong because compensatory lengthening is an "ill-conceived notion" and cites four examples to justify this claim. He argues against the second solution indirectly by showing that the third solution is preferable.

I will first argue that the first solution cannot be rejected as easily as it is claimed, since the arguments against compensatory

lengthening are insubstantial. Finally, I will suggest that none of the three solutions listed above is entirely correct because all are constrained by unrealistic notational conventions. I will argue in favor of a solution involving migration of articulatory components (cf. Drachman 1969: 202).

6.1. Compensatory lengthening

Lightner cites four examples to show that compensatory lengthening is a mistaken notion and that, therefore, a solution involving compensatory lengthening cannot be correct. In Latin [fagtus] became [fa:xtus] (Lachmann's Law), but [faktus] became [faxtus]. The traditional position is that vowels were lengthened before voiced stops, followed by regressive voicing assimilation in clusters. Foley (ms.), however, has claimed that the process consists rather of weakening of [g] to [x] with corresponding strengthening (compensatory lengthening) of the vowel. But, Lightner points out that Foley's position is untenable because no vowel lengthening accompanies the corresponding lenition of [k] to [x] in Latin. This does not, however, constitute evidence against compensatory lengthening as it has ordinarily been conceived; the traditional circumstance in which compensatory lengthening has been recognized involves the complementary reaction of one segment to the disappearance or change in duration of an adjacent one.

In Japanese /i/ and /u/ can be devoiced in certain environments. Lightner maintains that these voiceless vowels can be optionally deleted, and that if they are, the preceding consonant is lengthened. Since, he claims,¹¹ clusters arise in Japanese only through the loss of voiceless vowels, we can write

$$V \rightarrow \emptyset \quad (1)$$

$$C \rightarrow [+long] / _C \quad (2)$$

which, however, doesn't directly capture the notion of compensatory lengthening. The rules can capture the appropriate generalization only if their order is reversed and the second assumes global properties; thus:

$$C \rightarrow [+long] / _V^* \quad (2a) \quad (*=\text{to be deleted})$$

$$V \rightarrow \emptyset \quad (1)$$

But Lightner rejects these solutions because both appear to involve an unconditioned deletion rule, a type of rule whose existence in natural languages is highly questionable; he chooses instead an analysis in which the vowels totally assimilate to the preceding consonant.

If it is indeed true that any voiceless vowel can be lost in Japanese, we might be able to regard the rule that deletes

vowels as a stronger form of the amply conditioned devoicing rule (Ohso 1971: 22) but this may be unnecessary since Mieko Han (1962: 41) claims to have shown experimentally that Japanese voiceless vowels are not deleted at all: "the time dimension of the vowel phoneme is often taken by the preceding consonant, or period of quasi-silence, but it does not disappear." Her spectrograms show remaining traces of the vowel.

Lightner cites monophthongization as a third piece of evidence against compensatory lengthening. His claim is that the solution involving deletion of one vowel (e.g. ou---ū, eu---ū) followed by compensatory lengthening of the other is counter-intuitive and that cases of monophthongization are fundamentally the same, in his view, as the Japanese example--that is, they involve only assimilation and not deletion.

Finally, Lightner claims that the development from Latin skriptus to Italian skritto clearly involves complete assimilation rather than deletion of the first stop and compensatory lengthening of the second.

Notice that in the cases of monophthongization and the development of Italian Lightner's claims are not clearly relevant to the discussion since they do not involve assimilation of consonants to vowels. The Japanese example is apparently faulty, and the first Latin example is not relevant at all since it only disqualifies the extension of compensatory lengthening to situations where neither segment loss nor complementary lengthening is involved; thus these examples do not constitute evidence against compensatory lengthening.

6.2. True compensatory phenomena

Before continuing, I will give some arguments in favor of the existence of one kind of compensatory lengthening. In Karok (Bright 1957: 9, 17-8) distinctively short vowels are normally followed by phonetically long consonants. The rule can be stated as follows:

$$C \text{ --- } [-\text{along}] / \left[\begin{array}{c} V \\ \text{along} \end{array} \right] \text{ ---}$$

Here it is impossible to interpret compensatory lengthening as assimilation. One segment reacts to the duration of an adjacent one in such a way that the combined length of the two segments remains relatively constant. Probably the process which assigns phonetic length to consonants following vowels in Karok is similar to syllable structure processes in that it creates maximal contrast between adjacent segments; that is, compensatory lengthening here enhances the contrast between long and short vowels. Roughly the same phenomenon is observed in Italian (Agard and Pietro 1965: 11) where stressed vowels are short before geminate clusters and long before simple consonants. Allen (1962: 56) remarks that in Classical Sanskrit "gemination was automatic after short vowels." Elert (1964) has shown that

in Icelandic, Norwegian, and Swedish there is an inverse relationship between the quantity of a vowel and that of a following consonant.

Strangely, Lightner failed to include in his list of examples any of the kind which have traditionally been regarded as examples of compensatory lengthening. Thus, for example, in Bloomfield (1933: 379-80) we find only examples in which vowels are lengthened in response to consonant loss:¹²

Old English: niht, nixt ---modern Scotch: ni:t

Pre-Latin: dis-lego ---Latin: di:ligo:

Early Latin: cosmis ---Latin: co:mis

P.I.E. *nisdos ---Latin: ni:dus

Gothic: bringan versus Gothic bra:hta (loss of nasal).

Of course, since it is precisely this kind of compensatory lengthening that is at issue in the present case, a genuine argument against the compensatory lengthening solution would have to treat examples like those listed immediately above.

6.3. The assimilation solution

Lightner believes that the development from drink to Old Norse drekka must historically have involved nasalization and lowering of the vowel, followed by assimilation of the nasal to the following stop and denasalization of the vowel; thus

drink---drēnk---drēkk---drek.

He further claims that the development

drink---drēnk---drē:k---drek

cannot be seriously considered in the absence of independent evidence for vowel lengthening. It is not clear why this example is thought to constitute evidence for the assimilation treatment of the VN--- \tilde{V} : examples. At most it might be taken as evidence for complete assimilation of nasals to following stops.

Lightner cites Gordon's claim (1957: 267) that Old Norse had geminate stops in words like drekka, but there is some reason to doubt that Old Norse ever really had double consonants. In modern Icelandic (Einarsson 1949) orthographic geminate stops are phonetically 'preaspirated'; thus drekka is now [drehka] and what has apparently taken place is incomplete assimilation of the nasal to the following stop

(loss of nasality, voicing and point of articulation). This is not an implausible development, since a synchronic rule of Menomini (Bloomfield 1939: 113) has precisely the same effect ($n \rightarrow h/_C$) and a similar rule is found in Kitsai (Bucca and Lesser 1969: 18: $n \rightarrow h/_t, k, ?$). But even if the phonetic facts in Old Norse were what Lightner claims, they would not constitute evidence for assimilation of nasals to vowels in the $VNC \rightarrow V:C$ process.

The most interesting evidence Lightner presents is from Lithuanian. Here is the relevant information:

1. Long and short vowels contrast.
2. Stressed short vowels are characterized by high pitch.
3. Diphthongs may have the structure VV, VL or VN (this is determined only by the way in which such combinations are affected by suprasegmentals; see 5 below).
4. Before j, v, l, r, m, n, s, z (=class Z), VN is realized as V: (Lightner assumes that nasalization has been eliminated by a further rule).
5. Diphthongs and long vowels have either rising or falling pitch. Kenstowicz (1969) has shown that it is possible to account for rising and falling pitch by supposing (1) that long vowels are underlyingly VV and (2) that one member of each underlying diphthong is marked for accent (high pitch). Consider, for example,

$/brent^+o/ \text{ -- } br\acute{e}nto$ $/brens^+ti/ \text{ -- } br\acute{e}:sti$
 $/br\acute{e}nd^+o/ \text{ -- } br\acute{e}ndo$ $/br\acute{e}ns^+ti/ \text{ -- } br\acute{e}:sti$

Notice that we apparently cannot write

$$V \rightarrow [+nasal] / _N \left\{ \begin{array}{l} \# \\ Z \end{array} \right\} \quad (1)$$

$$N \rightarrow \emptyset / \left[\begin{array}{c} V \\ +nasal \end{array} \right] \text{ ---} \quad (2)$$

because the second rule would cause suprasegmental information to be lost when N is the element marked for stress. A preferable solution appears to be

$$V \rightarrow [+nasal] / _N \left\{ \begin{array}{l} \# \\ Z \end{array} \right\} \quad (1)$$

$$N \rightarrow V_i/V_{i-} \quad (2a)$$

The trouble is that, as Lightner himself points out in a different connection, there is 'presumably...a general split between segmental and suprasegmental phonology (1970: 187).' He therefore presumes himself that suprasegmentals need not be strictly aligned with segmental phenomena, in which case his own rule (2a)

would be ill-founded. Moreover, even if suprasegmentals do respect segmental constituents in this instance, it would be incautious to expand the assimilation solution to other languages on the basis of this evidence alone because it might be that the pressure to retain suprasegmental information in Lithuanian causes reinterpretation of nasal loss as an assimilation. On the other hand, we might simply entertain the possibility that suprasegmentals align themselves with underlying rather than surface representations which is equivalent to hypothesizing that a rule deleting a segment leaves its suprasegmental constituents intact in accordance with the idea that there is a split between segmental and suprasegmental phenomena.

I will also mention other criticisms of Lightner's treatment recently presented by Kenstowicz (1970: 103-8). He first questions Lightner's facilitating assumption that there is a vowel denasalization rule in Lithuanian, on the grounds that there is no vowel nasalization in the surface phonetic representation of Lithuanian words, and because Lightner's assumption is based only on poorly justified intuitions about universals. But, more importantly, he questions the assimilation solution itself:

...the validity of this analysis is far from obvious. Notice that the "assimilation" is complete, i.e. no property or feature of the original segment -the /n/- is retained, except for the accent. But it is reasonable to suppose that assimilation is of a continuous nature in which one segment becomes more and more similar to another to the limiting case of complete identity. Furthermore, it seems that clear cases of complete assimilation arise only when the two contiguous segments are already similar to begin with... Finally, it seems reasonable to assume that a hierarchy is involved in assimilation such that complete assimilation implies partial assimilation, but not vice versa...If these remarks are correct then the assimilation analysis for Lithuanian vowel-nasal sequences becomes rather suspect. Not only are there no properties of the dental nasal left behind, but it is rather difficult to imagine what such traces might be in a case such as this where the distance between /n/--a consonant--and a vowel is rather great, involving a transition across most of the feature properties--a fact which by itself casts suspicion on the analysis in the first place, given the few if any clear cases of direct conversion between consonants and vowels in language....Note that there is a much more straightforward analysis of the Lithuanian data in which only one rule is involved:

elision of the dental nasal /n/ with (compensatory) lengthening of the preceding vowel.

In Polish, nasalization occurs before word-final and precontinuant nasals. Nasals are lost before l. A problem arises here because nasal loss does not affect the preceding vowel. This is a difficulty for both the assimilation solution and one involving nasal loss, since both predict that the vowel will lengthen. But notice that the two solutions handle this problem in different ways. Lightner must claim that there is a process which simplifies the double vowel that results from assimilation; while in the case of the deletion solution, all that needs to be said is that vowel lengthening has been inhibited for some reason.

6.4. The componential treatment of nasal loss.

I will argue in favor of a fourth solution to the problem of nasal loss, one involving the independence of articulatory components (cf. Drachman 1969: 202-4). Notice that this solution involves compensatory lengthening, and, in a sense, deletion and assimilation as well, but that these three observed phenomena will now be viewed as concomitant effects of the migration of the oral closure component of the nasal toward the end of the word.

First consider three languages in which this notion of component migration seems essential:

(1) In Hausa (Hodge 1947: 10-1) final m and n may optionally be realized post-vocally as nasalization of the vowel plus a "lightly pronounced" remnant of the nasal.

(2) In Keresan (Spencer 1946: 235) "among some speakers the final nasal consonant may be almost inaudible with a result that a heavily nasalized vowel is heard."

(3) In Brazilian Portuguese (Dahl 1961: 315-7) "some trace of the nasal consonant always persists" when vowels are nasalized by a following nasal.

Two comments are necessary. First notice the complementary relationship between vowel nasalization and the duration of oral closure in Hausa and Keresan. This is best handled as rightward migration of oral closure, while nasalization remains where it was. Next, reconsider vowel 'deletion' in Japanese in the light of these new examples. Notational conventions do not currently permit us to represent 'trace segments' as such; they must either be represented as full segments, or not given segment status at all. Also, the notion of compensatory lengthening is beyond the scope of rules as normally written when the lengthening is strictly complementary. Even with multivalued features it is impossible in principle, given the standard notation, to express the fact that one segment donates a specific but infinitely variable portion of its duration to an adjacent segment.

Other phenomena can be most incitefully viewed if the independence of nasality and oral closure is recognized:

(1) In Kaikang (Henry 1948: 195-6) nasal consonants either disappear or become voiceless and denasalized ($n \rightarrow t$ etc.) before any voiceless segment. Rather than postulate devoicing and denasalization, this process can be described as migration of the nasality component toward the front of the word since, at least in the case of $\eta \rightarrow k$, Henry points out that the change is accompanied by the addition of nasalization to the vowel.

(2) In Maxikali (Gudschinsky, Popovich and Popovich 1970: 83-6) syllable-initially

$$n \rightarrow \left\{ \begin{array}{c} nd \\ d \end{array} \right\} / _V \text{ (V=oral)}$$

This is best described by saying that the velic component of the nasal retreats toward word-initial position.

In the same language, in syllable coda

$$n \rightarrow nt / _C \text{ (C=non-homorganic)}$$

which can be handled the same way. Also

$$p \rightarrow b^m / _m \text{ (optional)}$$

which can be viewed again as regressive migration of nasalization.

Without recognizing the tendency for the nasality component of Maxikali nasals to migrate 'leftward', we have no way of capturing the essential identity of these three phenomena.

(3) In the Dakota dialect studied by Matthews (1955: 59)

$$\tilde{V} \rightarrow V / _ \text{ nasal allophone of } b, t, k$$

To describe this phenomenon without componential migration we require two ordered rules:

$$C \rightarrow [+nasal] / \left[\begin{array}{c} V \\ +nasal \end{array} \right] _ \quad (1)$$

$$V \rightarrow [-nasal] / _ \left[\begin{array}{c} C \\ +nasal \end{array} \right] \quad (2)$$

(Note: vowel nasalization does not occur before true nasals!) We can eliminate both the necessity for a strange dissimilation rule¹³ (2) and rule ordering by positing componential migration.

Finally, I will evaluate this proposal in the light of recently published work by Henning Andersen. He claims that in Polish a diachronic correspondence $\tilde{V}C \rightarrow VNC$ was implemented by means of three phonetic processes:

- (1) nasality contracts to the latter half of the vowel;
- (2) the nasalized portion of the vowel changes to a nasalized glide;

(3) the nasalized glide changes to a nasal consonant. The evidence for this is the existence of intermediate stages corresponding to each point of this progression. Andersen remarks that the first of these processes "consists in a gradually increasing delay in the onset of nasal resonance." Thus, he proposes component migration to handle at least one of the processes, and the question that immediately arises is whether the correspondence $VNC--\tilde{V}:C$ discussed above, which is essentially the reverse of that considered by Andersen, can be handled in the same way, but with the order of application of the processes reversed. This may be so, although the glide stage is rarely attested, and the change in the domain of nasalization probably occurs first whether the correspondence is $VNC--\tilde{V}:C$ or $\tilde{V}C--VNC$. In any case, it should be noted that Andersen does not specify exactly how consonantality of the final stage is achieved, and migration of oral closure is quite compatible with his treatment.

7. Summary¹⁴

(1) Regressive nasalization

(a) Regressive nasalization is most likely to occur before word-final nasals, is less likely before nasals followed by continuants, even less likely before nasals followed by non-continuant, and is most inhibited before nasals preceding vowels. These four post-nasal conditioning factors are arranged in a strict hierarchy such that those later in the foregoing list imply those earlier on. The post-nasal hierarchy can be explained by referring to sluggishness of the velum as an articulator (Bjork 1961), the requirement that the velum be raised in time to enable the pressure and airflow needs of post-nasal consonants to be met, and the tendency for vowels to be nasalized only by nasals in the same syllable.

(b) Vowels which undergo regressive nasalization are optimally low, back, and stressed.

(2) Progressive nasalization

(a) Languages may have both progressive and regressive nasalization.

(b) Post-nasal neutralization of distinctive nasalization is generally observed in languages with progressive nasalization.

(c) It is necessary to recognize two vowel hierarchies for progressive (and possibly also regressive) nasalization--one based on anatomical pressures (connection of the palatoglossus muscles and the musculature of the velum) and the other based on speaker-controlled immobility of the velum.

(3) Spreading nasalization

Nasalization does not spread from an initiating segment through a segment whose airflow or oral pressure

requirements are so high that the velum is forced shut. The set of segments permitting penetration by nasalization in particular languages is observed to vary slightly.

(4) Vowel shifts

If a nasalized vowel undergoes a change in quality not affecting oral vowels, that change is far more likely to result in backing than fronting of the vowel. Vowels undergoing contextual nasalization near nasals strongly tend to be raised rather than lowered. Vowels tend to be lowered if nasalization is accompanied by nasal loss.

(5) Nasal loss and nasalization

When, as is most frequently the case, nasals are lost to the left (rather than by assimilation to a following consonant producing gemination), they are lost through migration of the oral closure component of the nasal toward the following (almost invariably homorganic) consonant or word boundary, leaving the nasalization behind on the vowel as an information-bearing component. Compensatory lengthening of the vowel is an automatic feature of this solution.

Footnotes

1. I offer my sincerest thanks to Professor Gaberell Drachman, my adviser, for providing extensive criticism during the last few months and for reading each version of this paper. I am also grateful to Professors Arnold M. Zwicky and David L. Stampe for comments on early drafts, and to other faculty members and my fellow students in the Department of Linguistics for calling my attention to interesting data.

2. Ferguson mentions a single counterexample to this putative universal: in Iroquoian "one of the nasalized vowels posited for the protolanguage seems, on considerations of internal reconstruction, to have derived from earlier /a/ + /i/ or sequences like /awa/" (1963: 59). But beyond this, Bengali has at least one nasalized vowel which derived from a Vr sequence: sãp<sarp, 'snake,' cf. Sanskrit srp. In Spanish of rural Panama (Robe 1960: 36) nasalized vowels appear in alternation with Vr and Vl sequences in absolute final position:

bamohaßêr	or	bamohßê	'vamos a ver'
bamohasêr	or	bamohasê	'vamos a ser'
bwènomuxêr	or	bwenomuxê	'bueno mujer'
myêl	or	myê	'miel'

ānimā́ or ānimā́ 'animal'

In Sanskrit (Allen 1961: 39-46) nasalization of vowels is a feature of finality of the sentence or breath group. As mentioned earlier, vowels are nasalized following word-boundary and h as well as after nasals in Thai.

3. Arnold M. Zwicky (1972) claims that the following hierarchy occurs repeatedly in rules of English:

Vowels glides r l n m ŋ fricative stop

and points out that in Ijò w, r, y and vowels are penetrated by nasalization, but l is not (see section 3 above). Although the hierarchy established above for regressive nasalization is not as detailed as this one, the correspondences are nevertheless quite striking.

4. On the basis of eight languages in the foregoing list (see asterisks), Theodore Lightner (1970) has attempted to formulate a universal rule for regressive vowel nasalization. He found the necessary formulation extremely complicated and had to abandon it in favor of a general tendency for languages to contain a rule of this form:

$$V \rightarrow [+nasal] / _ N \left\{ \begin{array}{c} \# \\ C \end{array} \right\} \text{ (where V and N not separated by } \$/math>$$

This formula was suggested three years earlier by Milner (1967: 280) as a marking convention:

$$[u \text{ nasal}] \rightarrow [+nasal] / \left[\begin{array}{c} V \\ _ \end{array} \right] N \left\{ \begin{array}{c} C \\ [-seg] \\ \cdot \\ \cdot \\ \cdot \end{array} \right\}$$

In view of the evidence presented above, it is at least clear that Lightner's 'tendency' must be considerably more detailed.

5. Consider, for example, Saciuk's remark (1970: 204) on Portuguese: "Very accurate measurements with mechanical devices indicate some nasalization in vowels preceded by N, but the degree of nasalization in this case is weaker than in the vowels that undergo the rules of nasalization, progressive nasalization, or secondary nasalization."

6. In a lecture presented at the Ohio State University on April 4, 1972.

7. In forms with a plural infix al/ar after a root-initial nasal consonant, nasalization is observed not only in the first vowel of the infix, but also in the second vowel following the infix (Robins 1957: 93):

mīāk---māriāk 'to stand aside'

Compare the following form which has no infix:

mārios

'to examine'

This situation, confirmed by kymography, seems best handled by a cyclic nasalization rule and a post-obstruent denasalization rule. On the first cycle, the unaffixed form is nasalized (miak---mīāk); then the infix is added and the rule applies again (--māriāk); finally, the vowel is denasalized after the obstruent. The weakness of this solution is that it is only observationally adequate. The generalization that needs to be captured is that the affixed form is 'double' in that it presents itself simultaneously to the nasalization rule both as itself and an unaffixed form.

8. This wording is meant to exclude prosodic nasalization as is found in Desano (Kaye 1971) and Gbeya (Samarin 1966: 29).

9. Some discussion is necessary here. Gibson has neglected to say exactly what it means for nasalization to spread "to the end of the word." I have taken her to be referring only to vowels, and this is reflected in my transcription of her examples (in her article Gibson only marks the phonemically nasalized vowel). I presume that if she had meant for the reader to believe that Pame has nasalized voiceless stops (whatever that might mean), she would have commented on it separately.

10. Drachman and Drachman (1971) point out that there are at least two, and possibly three ways to "dispose" of a nasal in VNC sequences; the length can be given to the preceding vowel as in the examples discussed in this section, or it may be given to the consonant (via gemination) resulting in V:C and VC: respectively. If a language permitted neither vowel length nor gemination of consonants, it might simply delete the nasal, but no cases have turned up yet.

11. This is not quite true. Clusters can arise morphologically as well (McCawley 1968).

12. In Sanskrit, to cite another example, "if through morphological processes rr would occur, it never does--instead the preceding vowel is made long, if it is not already "long" (Allen 1962: 179). Cf. also Sanskrit

taddhi → ta:dhi

du:dabha → du:dabha etc.

13. In Picuris there is what appears to be dissimilation of nasality, but unlike in the (false) Dakota example, it is incomplete. Distinctively nasalized vowels are most nasalized when not before nasals. After a nasal consonant, a nasal vowel is less nasalized at the beginning than at the end; before a nasal consonant a nasal vowel is more nasalized at the beginning than at the end. The environment in which nasalization is most diminished is the environment which, in other languages, is most likely to induce nasalization. (Consider, for example, Saciuk's remark (1970: 205); "The highest degree of nasality would appear in vowels that occur between two nasal

consonants in the phonetic representation." Robe (1960: 36) says that in Panama Spanish, although vowels are only sporadically nasalized in other environments, they regularly receive slight nasalization between two nasals. Navarro (1963: 39; cit. by Saciuk 1970) claims that Spanish exhibits completely nasalized vowels in this environment. In Pame (Gibson 1956: 258) slight non-contrastive nasalization occurs only between two nasals in a closed syllable.) Since there is apparently no reason for speakers of Picuris to try to denasalize distinctively nasalized vowels, some other account is preferable. Probably there is no disimilation at all, but instead the interaction of two kinds of nasalization of the kinds Delattre has shown exist in French (sec. 5). The 'disimilations' in Picuris could then be regarded as artifacts of the switch-over from (to) ordinary velum lowering (which, Delattre has shown, is used for nasal consonants) to (from) equalization of the volumes of the oral and nasal pharynges. This speculation should be seriously considered if the degree of nasality to which distinctively nasalized vowels are reduced when adjacent to nasal consonants in Picuris can be experimentally shown to be equivalent to the degree of contextual nasalization of oral vowels.

14. Because of delays, this paper is being published after a subsequently delivered LSA paper which clarifies and revises several of the claims made here. The two most important revisions are the establishment of a regular hierarchy governing penetration of nasalization, and the disentanglement of cases of nasal loss (with concomitant vowel nasalization) from cases of vowel nasalization proper.

Bibliography

- Agard, Frederich and Robert J. de Pietro. 1965. *The Sounds of English and Italian*. University of Chicago Press.
- Allen, W. S. 1961. *Phonetics in ancient India*. Oxford.
- _____. 1962. *Sandhi*. Mouton and Co., The Hague.
- Andersen, Henning. 1972. *Diphthongization*. *Language* 48.1.
- Bendor-Samuel, John T. 1966. *Some prosodic features in Terena*. In memory of J. R. Firth. Longmans, Green and Co., London.
- Björk, L. 1961. *Velopharyngeal function in connected speech*. *Acta Radiologica Suppl.* 202.
- Bloomfield, Leonard. 1933. *Language*. Holt, Rinehart and Winston.
- _____. 1939. *Menomini morphophonemics*. *Études phonologiques dédiées a la mémoire de M. le Prince N. S. Trubetsky* T.C.L.P. 8.105-15 (Repr. University Ala., 1964).
- Bright, William. 1957. *The Karok language*. University of California publications in linguistics No. 13. University of California Press.
- Bucca, Salvador and Alexander Lesser. 1969. *Kitsai phonology and morphophonemics*. *I.J.A.L.* 35.1.7-19.
- Buck, Carl. 1933. *Comparative grammar of Greek and Latin*. Chicago. (Cit. by Lightner).
- Chu, Chauncey C. 1970. *How relevant is historical information to synchronical linguistic description?* *P.I.L.* 2.1.
- Dahl, Ivar. 1961. *The pronunciation of Brazilian Portuguese e*. In honour of Daniel Jones. Longmans, Green and Co., London.
- Delattre, Pierre. 1968. *Divergences entre nasalités vocalique et consonantique en français*. *Word* 24.1.64-72.
- _____. 1966. *Studies in French and comparative phonetics*. Mouton, The Hague.
- Drachman, G. and A. Malikouti-Drachman. 1971. *Studies in the Acquisition of Greek as a native language: I. Some preliminary findings on phonology*. See pp. 99-114 in this issue.
- Drachman, G. 1969. *Twana Phonology*. Working Papers in linguistics No. 5, The Ohio State University.
- Dressler, Wolfgang. 1972 (mimeo). *Allegroregeln rechfertigen Lentoregeln*. To appear as a volume of *Innsbrucker Beiträge zur Sprachwissenschaft: Institut für Sprachwissenschaft, Universität, A 6020 Innsbruck, Austria*.
- Einarsson, Stefan. 1949. *Icelandic*. The Johns Hopkins Press, Baltimore.
- Elert, Chaes-Christian. 1964. *Phonologic studies of quantity in Swedish*. Stockholm-Göteborg-Uppsala: Almqvist & Wiksell.
- Fairbanks, G. H. and B. G. Misra. 1966. *Spoken and written Hindi*. Cornell University Press, New York.
- Ferguson, Charles A. 1963. *Assumptions about nasals: a sample study in phonological universals*. *Universals of language*, ed. Joseph H. Greenberg, M.I.T. Press.

- McCawley, James. 1968. The phonological component of a grammar of Japanese. Mouton & Co., The Hague.
- McMahon, Ambrose. 1967. Phonemes and phonemic units of Cora (Mexico). *I.J.A.L.* 33.2.
- Milner, J. C. G. 1967. French truncation rule. *Q.P.R.* No. 86, M.I.T.
- Moll, K. L. 1962. Velopharyngeal closure of vowels. *Journal of Speech and Hearing Research* 4.
- Moore, Samuel and T. A. Knott. 1955. The elements of Old English. Geo. Wash. Pub. Co., Ann Arbor, Michigan. (cit. by Lightner 1970).
- Morin, Yves Ch. 1972. The phonology of echo words in French. *Lg.* 48.1.
- Narang, G. C. and Donald A. Becker. 1971. Aspiration and nasalization in the generative phonology of Hindi-Urdu. *Lg.* 47.3.
- Navarro, Thomas. 1963. *Manual de pronuncion española*. Hafner, New York.
- Noss, Richard B. 1964. Thai. Foreign Service Institute, Washington, D.C.
- Ohso, Mieko. 1971. Japanese loan phonology. M.A. thesis, Ohio State University. Working Papers in Linguistics 14.
- O'Rahilly, Thomas F. 1932. Irish dialects past and present. Browne and Nolan Ltd.
- Osborn, Henry A., Jr. 1966. Warao: phonology and morphophonemics. *I.J.A.L.* 32.2.
- Pandit, P. B. 1961. Historical phonology of Gujarati vowels. *Lg.* 37.1.
- Pankratz, Leo and Eunice V. Pike. 1967. Phonology and morphophonemics of Ayutla Mixtec. *I.J.A.L.* 33.4
- Robe, Stanley. 1960. The Spanish of rural Panama. U.C.P.L. Vol. 20, University of California Press, Berkeley & Los Angeles.
- Robins, R. H. 1957. Vowel nasality in Sundanese, a phonological and grammatical study. *Studies in linguistic analysis*. Basil Blackwell, Oxford.
- Saciuk, Bohdan. 1970. Some basic rules of Portuguese phonology. *Studies presented to Robert B. Lees by his students*.
- Samarin, William J. 1966. The Gbeya language. U.C.P.L. No. 44.
- Sapir, Edward and Harry Hoijer. 1967. The phonology of the Navaho language. University of California Press, Berkeley.
- Schachter, Paul and Virginia Fromkin. 1968. A phonology of Akan: Asante and Fante. Working Papers in Phonetics No. 9, U.C.L.A.
- Schane, Sanford. 1968. French phonology and morphology. M.I.T.
- Scott, N. C. 1964. Nasal consonants in Land Dayak (Bukar-Sadong). In honour of Daniel Jones. Longmans, Green and Co., Ltd., London.
- Shell, Olive A. 1950. Cashibo I: phonemes. *I.J.A.L.* 16.4.

- Fippinger, Jay and Dorothy. 1970. Black Tai phonemes, with reference to White Tai. *Anthropological Linguistics* 12.3.
- Foley, James. ms. Systematic morphophonology.
- Gibson, Lorna F. 1956. Pame (Otomi) phonemics and morphophonemics. *I.J.A.L.* 22.4.
- Gordon, E. V. 1957. An introduction to Old Norse. Clarendon Press, Oxford.
- Gudschinsky, Sarah C. and Harold and Frances Popovich. 1970. Native reaction and phonetic similarity in Maxikali phonology. *Lg.* 46.1.
- Haas, Mary. 1949. Outline for types of linguistic structure. Mimeo.
- Halle, Morris. 1963. A descriptive convention for treating assimilation and dissimilation. Q.P.R. No. 64, M.I.T.
- Han, Mieko Shimazu. 1962. Japanese phonology. Kenkyusha, Tokyo.
- Harrington, R. 1946. A note on a linguavelar relationship. *Journal of Speech Disorders* 11.
- Henry, Jules. 1948. The Kaikang language. *I.J.A.L.* 14.3.
- Hodge, Carleton T. 1947. An outline of Hausa grammar. *Lg.* 23.4 suppl.
- Holmer, Nils M. 1949. Goajiro (Arawak) I: phonology. *I.J.A.L.* 15.1.
- _____. 1952. Seneca II. *I.J.A.L.* 18.4
- House, A. S. and K. N. Stevens. 1956. Analog studies of the nasalization of vowels. *Journal of Speech and Hearing Disorders* 21.2.
- Howard, Philip G. 1963. A preliminary presentation of Slave phonemes. *Studies in the Athapaskan languages.* ed. Hoijer, et al.
- Jung, Myung-Woo. 1962. A contrastive study of English and Korean segmental phonemes, with some suggestions toward pedagogical application. Unpublished M.A. thesis.
- Kaye, Jonathan D. 1971. Nasal harmony in Desano. *Linguistic Inquiry* 2.1.
- Keller, R. E. 1961. German dialects. Manchester University Press, Manchester.
- Kenstowicz, Michael. 1969. Lithuanian phonology. Unpublished Ph.D. thesis, University of Illinois.
- _____. 1970. On the notation of vowel length in Lithuanian. *P.I.L.* 3.1.
- Lehiste, Ilse. 1964. Juncture. *Proceedings of the Fifth International Congress of Phonetic Sciences.* S. Karger, New York.
- Levin, Norman Balfour. 1964. The Assiniboine language. *I.J.A.L.* 30.3
- Lightner, Theodore M. 1962. Nasal diphthongs in Russian. Q.P.R. No. 70, M.I.T.
- _____. 1963. Preliminary remarks on the morphophonemic component of Polish. Q.P.R. No. 71, M.I.T.
- _____. 1970. Why and how does vowel nasalization take place? *P.I.L.* 2.2.
- Matthews, G. H. 1955. A phonemic analysis of a Dakota dialect. *I.J.A.L.* 21.1.

- Shevelov, George Y. 1965. A prehistory of Slavic. (cit. by Lightner 1970). Columbia University Press, New York.
- Spencer, Robert F. 1946. The phonemes of Keresan. I.J.A.L. 12.4.
- Stahlke, Herbert. 1970. Topics in Ewe phonology. Diss. Publ. of University of Illinois.
- Taylor, Douglas. 1951. Morphophonemics of Island Carib (Central American dialect). I.J.A.L. 17.4.
- _____. 1955. Phonemes of the Hopkins (British Honduras) dialect of Island Carib. I.J.A.L. 21.3.
- Thalbitzer, William. 1964. A phonetical study of the Eskimo language. Copenhagen.
- Thompson, Laurence C. and Terry M. Thompson. 1966. A fresh look at Tillamook phonology. I.J.A.L. 32.4.
- Trager, Felicia Harben. 1971. The phonology of Picuris. I.J.A.L. 37.1.
- Wallis, Ethel E. 1968. The word and the phonological hierarchy of Mezquital Otomi. Lg. 44.1.
- Ward, Ida C. 1952. An introduction to the Yoruba language. W. Heffer and Sons, Ltd., Cambridge.
- Welters, William E. 1946. A descriptive grammar of Fanti. Lg. language dissertation No. 39. Lg. 22.3 suppl.
- Williamson, Kay. 1965. A grammar of the Kolokuma dialect of Ijò. West African language monographs No. 2.
- Wolff, Hans. 1950. Comparative Siouan. I.J.A.L. 16.4
- Zwicky, Arnold M. 1972. Note on a phonological hierarchy in English. Linguistic Change and Generative Theory, ed. R. Stockwell and R. Macaulay, Indiana University Press (in press).