

Ponapean Nasal Substitution: New Evidence for Rhinoglottophilia

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Proceedings of the Eighteenth Annual Meeting of the Berkeley Linguistics Society: General Session and Parasession on The Place of Morphology in a Grammar (1992), pp. 2-21

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Ponapean Nasal Substitution: New Evidence for Rhinoglottophilia*

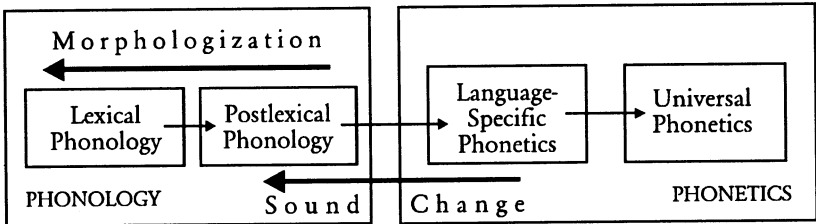
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1. Introduction

This paper addresses a particular diachronic problem which is of general interest for at least two reasons. First, on our analysis it adds to the evidence for the intriguing and relatively rare process identified in our subtitle. Second, it bears on a long-standing debate over the characteristics of sound change — in particular, the well-known claim that sound change is conditioned only phonetically. Like the rest of the neogrammarian framework this has received its share of criticism, but in our view some of the criticism stems from an imprecise understanding of the notion 'sound change'. The notion may have been unproblematic within neogrammarian theory, but, in today's more elaborate frameworks, testing hypotheses about 'sound change' requires saying what that is. For concreteness' sake we use the model in (1), although nothing here depends either on the general assumption that morphophonological rules are of two distinct types or on the particular assumptions of the theory of Lexical Phonology.

(1) A Model of Morphophonological Synchrony & Diachrony



Within this model we understand the notion 'sound change' informally as follows:

- (2) Sound change is the innovation of a phonological rule via the reanalysis of output previously determined by phonetic implementation rules.

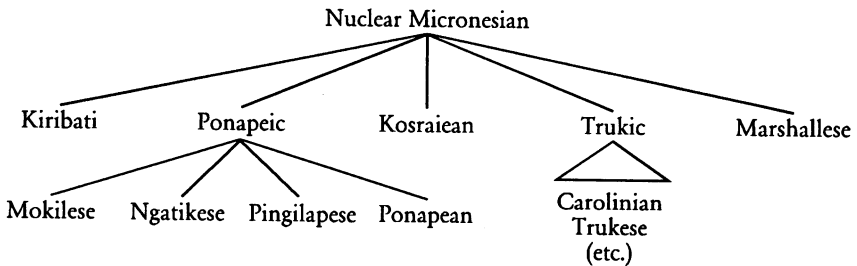
In a sense, then, sound change is the phonologization of phonetic implementation — for example, the reanalysis of vowel–vowel coarticulation as phonological umlaut. Within this framework the innovation of a phonological rule is distinguished (as 'sound change') from subsequent changes it undergoes; later changes involving the acquisition of morphological or morphosyntactic conditioning may, as indicated in (1), be subsumed under the rubric 'morphologization'. In our view precisely this approach to 'sound change' and 'morphologization' best captures the neogrammarian distinction between 'sound change' and 'analogy'.

A trivial consequence of the working definition in (2) is that sound change is conditioned only phonetically. A more interesting question, one which we believe usefully recasts the debate, is whether phonological processes have diachronic sources other than sound change and its morphologization. One relatively constrained view of morphophonological change is that they do not: sound change and morphologization together exhaust the possible system-internal sources of phonological rules.

This model of linguistic change is counterexemplified by any synchronic phonological process which cannot be plausibly explained as the reflex or reanalysis of a process which was once phonetically conditioned. Consequently, it focusses particular attention on rules which are phonologically natural but appear to be unnatural phonetically. While a detailed understanding of the development of any phonological process is certainly quite valuable, a particular desideratum is thus the diachronic analysis of those processes which seem phonetically implausible.

2. Ponapean Nasal Substitution

Nuclear Micronesian, a subbranch of the Oceanic branch of Austronesian, contains at least the following languages and dialect groups:



We omit possible internal subgrouping other than the well-established Ponapeic and Trukic groups. Among the Ponapeic languages, Mokilese and Ponapean are well-documented and a grammatical sketch of Pingilapese now exists.¹

Each Ponapeic language has bilabials *p* and *m*, velarized bilabials *p^w* and *m^w*, velars *k* and *ŋ*, and a set of coronals reflecting Proto-Ponapeic **t*, **c*, **ç*, **n*, **l*, and **r*. A summary of the reflexes of these coronals is given in (3); note that while each Ponapeic language has a single fricative *s*, Proto-Ponapeic had none.

(3) Proto-Nuclear

Micronesian	Proto-Ponapeic	Mokilese	Pingilapese	Ponapean
* <i>s</i>	* <i>t</i>	<i>t</i>	<i>t</i> [t̚]	<i>t</i> [t̚]
* <i>n</i>	* <i>n</i>	<i>n</i>	<i>n</i> [n ~ ŋ]	<i>n</i> [ŋ]
* <i>l</i>	* <i>l</i>	<i>l</i>	<i>l</i> [l̚]	<i>l</i> [l̚]
* <i>r</i>	* <i>r</i>	<i>r</i>	<i>r</i>	<i>r</i>
* <i>c</i>	* <i>c</i>	<i>c</i>	<i>s</i>	<i>s</i> [s ^y ~ c]
* <i>t'</i>	* <i>ç</i>	<i>s</i>	<i>s</i>	<i>ç</i>

All sonorants can occur long or short in Ponapean, but geminate obstruents do not occur morpheme-internally within the native vocabulary.² When identical obstruents come together as a result of reduplicative morphology, they surface as homorganic nasal–stop sequences, as in (4). Reduplication is the productive marker of durative aspect in Ponapean and was formerly used to derive intransitive verb stems from transitives.

(4) Ponapean Lexical Nasal Substitution — durative reduplication

a	/pap-pap/	<i>pampap</i>	'swimming'	(<i>pap</i> 'swim')
b	/p ^w up ^w -p ^w up ^w /	<i>p^wum^wp^wup^w</i>	'falling'	(<i>p^wup^w</i> 'fall')
c	/tit-tit/	<i>tintit</i>	'building a wall'	(<i>tit</i> 'build a wall')
d	/sas-sas/	<i>san^ysas</i>	'staggering'	(<i>sas</i> 'stagger')
e	/çaç-çaç/	<i>çaңçaң</i>	'writhing'	(<i>çaç</i> 'writhe')
f	/kak-kak/	<i>kaŋkak</i>	'(being) able'	(<i>kak</i> 'able')

Following Rehg 1981 and 1984, we refer to the process illustrated in (4) as 'nasal substitution'. Rehg proposes two Nasal Substitution rules in Ponapean. The first rule is based on forms like those in (4):

- (5) Ponapean Nasal Substitution Rule I: 'When two identical voiceless consonants come together as a consequence of reduplication, the first will become a nasal that agrees in position of articulation with the second' (Rehg 1981: 58).

A second rule of Nasal Substitution, illustrated in (6), applies to identical labial and velar obstruent clusters in other derived environments. In (6a-b), for instance, the rule applies when directional suffixes are added to verb stems; in (6c) it is shown with the applicative suffix *-ki*; (6d-e) are cases of Nasal Substitution across a compound boundary, and (6f-g) show the same process over a word boundary.

(6) Ponapean Postlexical Nasal Substitution — labials and velars only

a	/lop-peseŋ/	<i>lompeseŋ</i>	'cut apart'
b	/sarep-pene/	<i>sarempene</i>	'scrape together'
c	/isik-ki/	<i>isiŋki</i>	'burn with'
d	/ep+p ^w oçol/	<i>em^wp^woçol</i>	'a game'
e	/sap ^w +pai/	<i>sampai</i>	'world, earth'
f	/e kalap pa:n soupisek/	<i>e kalam pa:n soupisek</i>	'He'll always be busy'
g	/soulik kin soupisek/	<i>souliŋ kin soupisek</i>	'Soulik is (habitually) busy'

In parallel environments, as shown by the forms in (7), coronal obstruents do not undergo Nasal Substitution. In (7a-b), epenthesis eliminates sequences of identical coronal obstruents; in (7c-e), geminate coronal obstruents surface, either as a result of compounding or in sandhi.

(7) Ponapean Postlexical Nasal Substitution — does not apply to coronals

a	/m ^w e-m ^w eiç-çe/	<i>m^wem^weiçeçe</i>	'just visiting'
b	/ait-to/	<i>aitoto</i>	'flow to here'
c	/mas+suwet/	<i>massuwet</i>	'ugly'

d /e ekis suwet/	e ekis suwet	'It's kind of bad'
e /ke meit taŋaŋa/	ke meit taŋaŋa	'Aren't you lazy!'

The process illustrated in (6) may be stated informally as follows:

- (8) Ponapean Nasal Substitution Rule II: When identical bilabial or velar obstruents come together in the flow of speech, the first consonant will become a nasal that agrees in position of articulation with the second.³

Within autosegmental models, rules like (5) and (8) are stated as feature-insertion rules, and reference to geminates is handled by reference to multiply-associated nodes. (9) provides formal statements of these rules, assuming partial geminate structures for adjacent identical obstruents⁴:

- (9) Nasal Substitution I (NS-I, Lexical/Level 1) Nasal Substitution II (NS-II, Postlexical)
- | | | | |
|----------|--|---------|---------------------|
| [+nas] - | | [-son] | |
| | | | Supralaryngeal tier |
| | | | Place tier |
| | | | { LAB } |
| | | | { DOR } |

Both NS-I and NS-II insert the feature [+nasal] in the first half of a geminate obstruent sequence, resulting in a nasal-obstruent sequence with shared place features. Two properties distinguish these rules: NS-I applies to all obstruents, while NS-II does not affect coronals; and NS-I is limited to the earliest level of the lexical phonology, whereas NS-II applies in all derived environments, including those in phrasal contexts.⁵

While the rules in (9) have several noteworthy properties, the one of interest here is the rarity of nasal substitution rules both synchronically and diachronically. We know no other clearly attested cases of voiceless geminate obstruents surfacing synchronically or diachronically as nasal-obstruent sequences.⁶

3. The Evolution of Ponapeic Nasal Substitution

Proto-Oceanic is usually assumed to have had only CV syllables and, with the possible exception of nasal-stop clusters, Proto-Nuclear-Micronesian also had no consonant clusters. The input clusters to Ponapean Nasal Substitution were therefore created by syncope, in most cases after Proto-Nuclear-Micronesian. Almost all the Nuclear Micronesian languages experienced parallel syncope, whose elucidation is probably the most important task confronting Nuclear Micronesian historical phonology. The relevant syncope was conditioned both by stress and morphology, with the particular result that, at least in some phonological contexts, CV and CVCV reduplication has yielded secondary consonant clusters in some languages; in some cases the resulting clusters underwent total regressive assimilation.⁷ Thus in Trukese, for instance, word-initial gemination is a reflex of CV reduplication. Roughly the same set of developments can be assumed for the

prehistory of Ponapeic — first, syncope, conditioned in part by stress and morphology, and second, total regressive consonant assimilation. Since syncope typically applied in reduplicating syllables, Ponapean Nasal Substitution is most common across reduplication boundaries and its diachronic reflexes are found morpheme-internally across fossilized reduplication boundaries. Examples of Ponapean morpheme-internal nasal–stop clusters which result from Nasal Substitution appear in (10), where at least (10a-d) were originally formed by intransitivizing CV reduplication.

(10)	Ponapean	Diachronic Source	Comparanda
a	<i>mpeŋ</i> 'to be awakened'	* <i>ppeŋ</i> < * <i>pa-paŋi</i>	<i>paŋin</i> < * <i>paŋi-ni</i> 'to awaken'
b	<i>mpek</i> 'to look for lice'	* <i>ppek</i> < * <i>pa-paki</i>	transitive <i>pakit</i>
c	<i>ŋkɔl</i> 'to make sennit'	* <i>kkɔl</i> < * <i>kɔ-kɔl</i>	transitive <i>kɔle</i>
d	<i>ntil</i> 'to torch fish'	* <i>ttil</i> < * <i>t-til</i>	Saipan Carolinian <i>ttil</i> , Ponapean <i>til</i> 'torch'
e	<i>m^wp^wul</i> 'flame'	* <i>p^wp^wul</i> < * <i>p^wu-p^wula</i>	Trukese <i>p^wp^wun</i>
f	<i>n^wsar</i> 'snare'	* <i>ccar</i> < * <i>ca-car</i>	Trukese <i>ssar</i>
g	<i>ŋça</i> 'blood'	* <i>çça</i> < * <i>ça-ça</i>	Trukese <i>çça</i> , Kiribati <i>rara</i>

Nasal Substitution is found nowhere else in Ponapeic as a living phonological process, but it has analogues in both Mokilese and Pingilapese. Mokilese evidence discussed by Harrison (1984: 386-95) shows unambiguously that Nasal Substitution did operate in the prehistory of that language. It has been lost there via levelling of the alternations it created, but its effects can still be seen morpheme-internally:

(11)	Mokilese	Diachronic Source	Comparanda
a	<i>iŋkɔŋ</i> 'sharp'	* <i>kkaj</i> < * <i>ka-kaj</i>	Trukese <i>kken</i> , Kiribati <i>kakaŋ</i> , Ponapean (unreduplicated) <i>keŋ</i>
b	<i>um^wp^wul</i> 'flaming'	* <i>p^wp^wul</i> < * <i>p^wu-p^wula</i>	(10e) above
c	<i>insa</i> 'blood'	* <i>çça</i> < * <i>ça-ça</i>	(10g) above

As these forms indicate, another difference between Mokilese and Ponapean is that word-initial Nasal Substitution reflexes — including geminate nasal sequences — are preceded by a prothetic vowel *i* or *u* in Mokilese but not in Ponapean. However, in the same context a prothetic vowel is 'optional' in Ponapean, as in (*i*)*n^wsar* 'snare' (Rehg 1981: 55). These prothetic vowels were Proto-Ponapeic and are now being lost in Ponapean, as shown by Rehg (1984: 329-30), rather than being an innovation of Mokilese spreading areally to Ponapean. In support of this claim Rehg notes that the prothetic vowel is 'optional' not only in Nasal Substitution contexts but also where a genuine etymological high vowel happens to fall word-initially before a nasal–stop cluster, as in (*u*)*m^wp^wel* 'earth oven filled with food', historically a compound derived from *um^w* 'earth oven' and *p^wel* 'earth'.

To show that Nasal Substitution indeed operated in the prehistory of Mokilese, it is also necessary to show that no Mokilese geminate obstruents must continue geminates which antedate the proposed Nasal Substitution rule of Proto-Ponapeic.

This argument is made by Harrison (1984: 387-92): he notes that the only surface geminate obstruents in Mokilese are word-medial — inherited initial geminate obstruents being reflected by nasal-obstruent clusters — and he shows that these all have secondary origins within Mokilese. One diachronic scenario suggested by his and Rehğ's work on Mokilese and Ponapean respectively is therefore as follows:

(12) Diachronic Evolution of Nasal Substitution (version I)

- | | | | |
|---|----------------|-----|---|
| a | Proto-Ponapeic | i | syncope and consonant assimilation |
| | (or earlier): | ii | high vowel prothesis before initial geminates |
| | | iii | Nasal Substitution |
| b | Mokilese: | | Nasal Substitution eliminated via levelling |
| c | Ponapean: | | 'optional' prothetic vowel loss |

The third and most recently documented member of the Ponapeic group is Pingilapese. This language has no traces of a Nasal Substitution process, but instead, in contexts where Ponapean has a nasal-obstruent cluster, it shows a single consonant with compensatory lengthening of the preceding vowel, as in (13-14)⁸:

(13) Identical obstruent clusters in Pingilapese

- | | | | | |
|---|-------------|----------------|---|--------------------------|
| a | /tet-tetei/ | <i>tetetei</i> | 'sewing' | (<i>tetei</i> 'to sew') |
| b | /pap-pap/ | <i>papap</i> | 'swimming' | (<i>pap</i> 'to swim') |
| c | /tol-tol/ | <i>totol</i> | 'to pick with the hands' (intr.) ⁹ | |

(14) Historical identical obstruent clusters in Pingilapese

- | | |
|---|---|
| a | <i>itil</i> 'to torch fish' (intransitive) < * <i>til</i> < * <i>t-tik</i> ; cf. (10d) above |
| b | <i>isij</i> 'to write' (intransitive) < * <i>çij</i> < * <i>ç-çij</i> ; cf. Mokilese <i>insij</i> ,
Ponapean <i>ñçij</i> , Kosraien <i>si-sij</i> 'to etch a tatoo' (intransitive) |
| c | <i>saisal</i> 'to be shown, to be made clear' < * <i>caccał</i> ; cf. Mokilese <i>cancał</i> 'to be clear (of speech), open, obvious', Ponapean <i>san^ysal</i> 'clear' |
| d | <i>isa</i> 'blood' (Harrison 1984: 394) ¹⁰ < * <i>çça</i> < * <i>ç-a-ç</i> ; cf. (10g) and (11c) above |

(13a-b) are examples of durative reduplication, and (13b) in particular is the exact cognate of the Ponapean form in (4a), with Nasal Substitution. (13c) is an instance of intransitivizing reduplication; compare the Pingilapese form with lengthening and its cognates, Ponapean *tontol* 'to pick' (transitive *toluŋ*) and Mokilese *tottol* 'to pick' (transitive *tolŋ*), with and without Nasal Substitution respectively. The forms in (14) are synchronically opaque, although (14a-c) were originally reduplicated intransitives.

A final relevant context where Pingilapese single consonants appear arises in verbal derivation. To judge from the data available in Good & Welley 1989, directional suffixes like *-ta* 'up' and *-ti* 'down' cause stem-final consonant deletion:

(15) Suffixal consonant deletion in Pingilapese

- | | |
|---|--|
| a | /m ^w o:t-ti/ → m ^w o:ti 'to sit down';
cf. Ponapean m ^w o:t 'to sit', Trukese mo:t 'to sit', mo:ttiw 'to sit down' |
| b | /pajin-ta/ → pajita 'to wake up' (transitive); |

cf. Mokilese *paġin*, Ponapean *paġin*, Trukese *fəŋini*

- c /wen-ti/ → *wɛ:ti* 'to lie down'; cf. Ponapean *wen* 'to lie', *wenti* 'to lie down'

The stem-final vowel lengthening seen in (15) is not significant, since Pingilapese directional suffixes always lengthen preceding vowels, but the forms cited are nonetheless of great interest historically. They show a process otherwise apparently cognate to Ponapean Nasal Substitution operating in a context where Nasal Substitution fails to apply — between coronals across suffixal boundaries. This is important evidence that the Ponapean lexical Nasal Substitution rule (NS-I), synchronically restricted to reduplication, once had a wider domain; in fact probably the two Ponapean synchronic Nasal Substitution rules reflect a single process which originally applied postlexically to all consonant clusters. Rehg (1981: 63-64) has reached a similar conclusion on the basis of Ponapean *m^wonti* 'to sit down' < **m^wo:ti*. This isolated form is the exact cognate of the Pingilapese form in (15a) and, like (16a) and the fossilized compounds in (16b-c), it can only be explained if NS-I formerly operated across suffixal and compound boundaries.

(16) Ponapean evidence that NS-I formerly applied in nonreduplication contexts

- a *pinti* 'to be stranded in shallow water' < **pit-ti* < **pit-ti*, cf. *piil* 'water' and Mokilese *piil* 'fresh water', *pit-ti* 'to be melted'
- b *kamaŋçik* 'to move slowly, to cautiously persuade' < **kamaççik* < **ka-maŋ-çik*, cf. *ka-* (causative prefix), *malmal* 'to be slow', *tititik* 'small' (Mokilese *siksik*, causative *kasiksik*)
- c *piŋçaç* 'to convulse' < **piç-çaç* < **pir-çaç*, cf. *pir* 'to turn, spin', *çaç* 'to writhe'

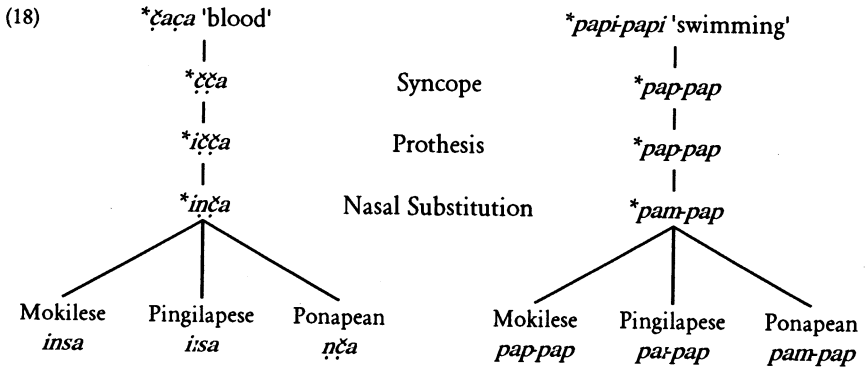
The originally unitary process of Nasal Substitution was split into two processes when, in the case of coronals, it was restricted to reduplication contexts; synchronically *m^wonti* and the forms in (16) are simply memorized.

Harrison (1984: 394) and Rehg (1984: 333) suggest that Pingilapese represents essentially a further development of the Ponapean state of affairs. On this view the historical background to Nasal Substitution may be revised as follows:

(17) Diachronic Evolution of Nasal Substitution (version II)

- | | | | |
|---|----------------|-----|--|
| a | Proto-Ponapeic | i | syncope and consonant assimilation |
| | (or earlier): | ii | high vowel prothesis before initial geminates |
| | | iii | Nasal Substitution |
| b | Mokilese: | | Nasal Substitution dies |
| c | Pingilapese: | | nasals are lost with compensatory lengthening in vowel–nasal–obstruent sequences |
| d | Ponapean: | | 'optional' prothetic vowel loss; partial morphologization of Nasal Substitution |

Two sample derivations are given in (18):



Parts of this account are certainly plausible a priori; for example, nasal loss with compensatory lengthening is attested in many languages. The model presents one serious problem, however: whatever its original conditioning, how could the process of Nasal Substitution possibly reflect the phonologization of any aspects of the phonetic implementation of geminate voiceless obstruents?

4. Previous Analyses of Nasal Substitution

Rehg 1984 was the first to suggest a possible phonological explanation for the origin of Nasal Substitution. He argues as follows (332):

One obvious motivation for nasal substitution is the functional role it plays in limiting the number of optimal consonant cluster types in PNP ... [N]asal substitution rules interact with a complex series of other rules as part of a conspiracy to reduce 144 potential consonant cluster types to 12 optimal ones. Thus nasal substitution is motivated in part by the role it plays within the phonological system of PNP.

For any phonological rule, of course, the same could be said: the rule is motivated by the fact that its output is grammatical, while its input is not. We are no closer to understanding why geminate obstruents COULD have been reanalyzed as nasal-obstruent clusters, that is, in what sense this sound change might be phonetically explicable.¹¹ Rehg also offers a perceptually-based explanation: 'Voiceless geminate obstruents are difficult to perceive, especially when they are in initial or final position. By lowering the velum and adding voicing to the first obstruent — the changes involved in nasal substitution — this perceptual problem is alleviated' (332). Finally, Rehg suggests (333-34) that Nasal Substitution is an instance of syllable-final weakening:

The motivation for the weakening of consonants in syllable-final position, and thus a motivation for nasal substitution, is almost certainly related to the fact that the single universal syllable is the open syllable — CV ... Substituting a nasal for a syllable-final obstruent would appear to be one way of opening up the syllable, as evidenced in the many languages in the world that permit only open syllables, or syllables ending in a nasal. Thus nasal substitution may represent an attempt to restore the optimal pattern

of syllables in [Ponapean], sequences of open syllables, that was violated by earlier vowel deletion rules.

Whether or not these observations are correct, as explanations they all have the same disadvantage: the development of nasal-obstruent sequences from geminate consonants is not phonetically grounded. In addition, other factors argue against the weakening analysis.¹² Most importantly, while the sound change underlying Nasal Substitution only applied to geminates, rules of coda weakening typically do not apply to geminate consonants. Three rules of coda weakening are presented in (19) with examples illustrating their failure to apply to geminates:

(19) Geminate inalterability in coda weakening (Hayes 1986)

- | | | | | | |
|--|-------------------|----------------|-------------------|----------------|--|
| a Persian <i>v</i> → <i>w</i> in the syllable coda | | | | | |
| i. non-geminate coda | | | ii. geminate coda | | |
| /nov-ru:z/ | <i>nowru:z</i> | 'new-day' | <i>ævvæl</i> | 'first' | |
| /bo-ræv/ | <i>borow</i> | 'go!' | <i>qolovv</i> | 'exaggeration' | |
| b Klingenberg's Law in Hausa: syllable-final obstruents become sonorants | | | | | |
| i. non-geminate coda | | | ii. geminate coda | | |
| /sabroo/ | <i>sawroo</i> | 'mosquito' | <i>babba</i> | 'big' | |
| c Toba Batak debuccalization: stop → ? / _ C | | | | | |
| i. non-geminate coda | | | ii. geminate coda | | |
| /halak batak/ | <i>hala?batak</i> | 'Batak person' | <i>nakka</i> | 'jackfruit' | |

Harrison 1984 proposes a phonetic account of the apparent spontaneous nasalization occurring in Nasal Substitution. He suggests that Nasal Substitution can be viewed as 'a response to the heightened pressure inherent in geminate obstruents. This pressure can be reduced by lowering the velum to allow some air to escape through the nasal cavity, thereby destroying the obstruent articulation' (393). There are several problems with this account. First, there is no need to reduce intra-oral air pressure in voiceless obstruents: reaching peak intra-oral air pressure levels does indeed result in cessation of voicing, due to the reduction in the transglottal pressure drop, but since the segments in question are voiceless, not voiced, there is no incompatibility involved.¹³ Second, this account is inconsistent with observed effects of intra-oral air pressure in voiceless obstruents, which in fact serves to secure velic closure and, as a result, inhibits nasalization. Ohala (1975: 300) makes the following related comment:

Nasalization would be least compatible with oral obstruents, especially stops, since the noise of fricatives and affricates and the burst at the release of stops requires a build up of air pressure in the oral cavity. This would require that no air leak out of the oral cavity into the nasal cavity.

In addition, the instability of voiceless geminate obstruents suggested by Harrison is not reflected in their phonological behavior, e.g. with respect to the otherwise regular rules of weakening illustrated in (19). The same generalization is evidenced elsewhere. For example, Lass notes in a survey of Uralic weakening processes that

'the double stops never undergo either sonorization or opening, though they may shorten ... Consonants are not so prone to lenition if protected by another consonant as they are standing alone' (1984: 182). For these reasons, we consider Harrison's phonetic explanation inadequate, and we offer a new analysis.

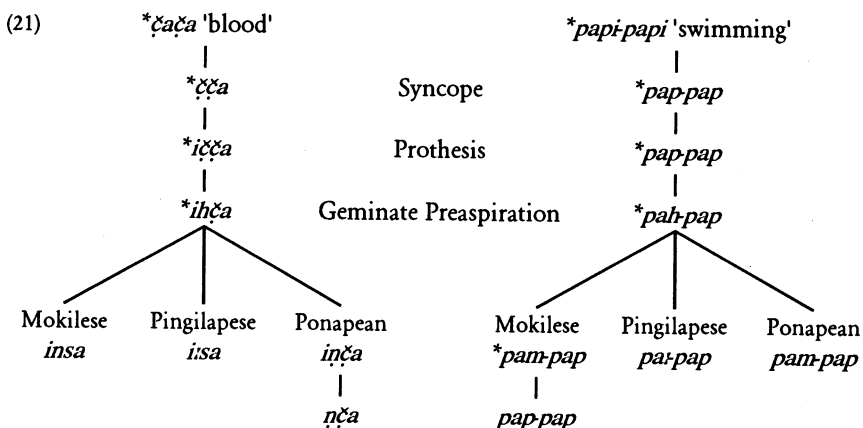
5. A New Analysis of Nasal Substitution

We propose that Nasal Substitution is historically the result of the two sound changes in (20), where T_i is an obstruent and N_i is a homorganic nasal:

(20) a Geminate Preaspiration: $T_iT_i > hT_i$

b Aspirate Nasalization: $hT_i > N_iT_i$

The change in (20a) was Proto-Ponapeic, and was followed in the Ponapeic daughter languages by (20b), restricted to Mokilese and Ponapean, and by *h* loss with compensatory vowel lengthening in Pingilapese. The sample developments in (18) may be revised as follows:



The default competing hypothesis is that Nasal Substitution occurred as a single process. In our view, however, Nasal Substitution alone would be a phonetically unnatural sound change: to our knowledge, geminate voiceless stops have no articulatory or acoustic property which would explain either their evolution into or their reanalysis as nasal–stop clusters. On the other hand, as we will show, the developments proposed in (20) are phonetically natural and attested elsewhere.¹⁴

5.1. Geminate Aspiration

The first sound change proposed in our analysis of Nasal Substitution is Geminate Preaspiration in (20a). This seems to be a particular case of a more general phenomenon whereby spontaneous aspiration arises from plain voiceless geminate obstruents. In (22), we list languages known to us where aspiration has or may have developed from voiceless unaspirated geminate obstruents:

(22) Cases of Geminate Aspiration

- a Saipan Carolinian (Jackson 1984)
- b Polynesian Outliers (Oceanic): Kapingamarangi (Elbert 1948; Lieber & Dihepa 1974); Nukuoro (Carroll 1965; Carroll & Soulik 1973); Pileni (Elbert 1965); West Futuna (Dougherty 1983)
- c New Caledonian (Oceanic) languages: Fwâi, Jawe, Nemi, Pije (Haudricourt 1968, Ozanne-Rivierre 1982)
- d Scandinavian: Icelandic (Pétursson 1972, 1976; Garnes 1976; Thráinsson 1978); Faroese (Werner 1963); Norwegian dialects (Wolter 1965)
- e Scots Gaelic dialects (Borgstrøm 1937, 1940, 1941; Oftedal 1956; Ternes 1973; Shuken 1979)
- f Sami, northern dialect (Engstrand 1987)

The case of Saipan Carolinian in (22a) is of interest because it belongs to the Trukic branch of Nuclear Micronesian and is therefore closely related to Ponapeic. This language has both short and geminate voiceless stops. As elsewhere in Trukic — and in our view Proto-Ponapeic — geminates in Saipan Carolinian result from vowel syncope followed by assimilation. Jackson (1984: 244) describes the contrast between short and geminate stops as follows: 'For the most part, the geminate variety of each consonant is simply longer and tenser than the single segment ... All consonants are unaspirated, although when geminate the stops often seem aspirated.' The Polynesian Outliers and New Caledonian languages in (22b-c) have undergone similar developments, as illustrated in (23) for two of the former:

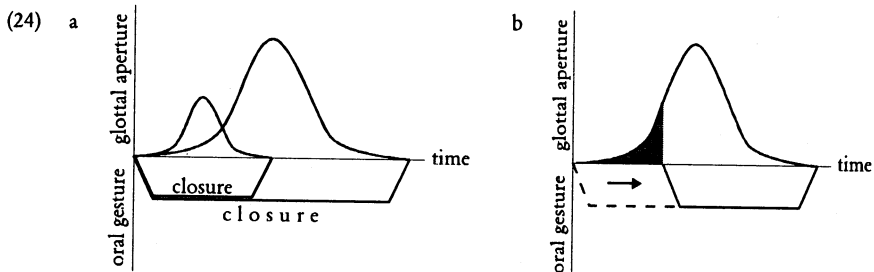
(23) Proto-	Nukuoro	Kapingamarangi	
Polynesian	(Carroll & Soulik 1973)	(Lieber & Dikepa 1974)	gloss
* <i>tuki</i>	<i>tuki</i>	<i>tuki</i>	'kick'
* <i>tu'tuki</i>	<i>t^huki</i>	<i>t^huki</i>	'kick' (emphatic)
* <i>taʒi</i>	<i>taʒi</i>	<i>taʒi</i>	'weep' (sg.)
* <i>ta'taʒi</i>	<i>t^haʒi</i>	<i>t^haʒi</i>	'weep' (pl.)

The developments from Proto-Polynesian to these languages parallel in some detail those which we propose for Proto-Ponapeic. Finally, the languages in (22d-f) are of interest because they have preaspirated (not just postaspirated) stops and because the preaspirates in at least some of them probably continue geminates.¹⁵

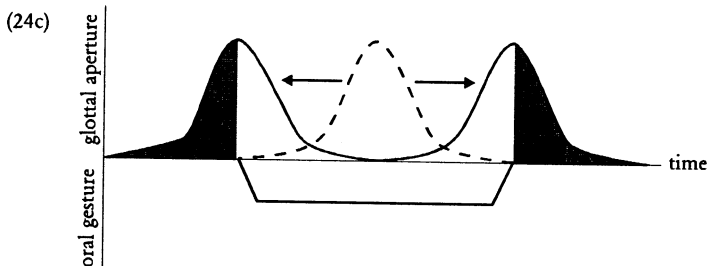
We now turn to the question of what phonetic factors might explain the appearance of aspiration on voiceless geminate obstruents.¹⁶ First, following several researchers (e.g. Lisker & Abramson 1964, 1971, Rothenberg 1968, Löfqvist 1980), we assume that the most important factor in the control of aspiration is the timing of the laryngeal gesture in relation to supraglottal articulations: if glottal abduction begins at implosion and peak glottal opening is aligned with the early portion of the stop closure, a voiceless unaspirated stop results, whereas if peak glottal opening occurs late during closure, or following release, postaspirated segments result. A

secondary factor in the control of aspiration appears to be the degree of glottal opening: in at least some languages, glottal aperture is larger for aspirated or heavily aspirated stops than for unaspirated or lightly aspirated stops (Kagaya 1971, Hirose, Lisker & Abramson 1972, Hirose, Lee & Ushijima 1973, Dixit 1975). For preaspiration to arise from a voiceless unaspirated stop, then, the laryngeal gesture must occur earlier relative to oral stop closure, and the peak glottal opening should be increased.

Both an increase in the magnitude of glottal aperture and the mistiming of oral and laryngeal gestures can naturally arise in the production of plain voiceless geminate stops. As demonstrated by Sawashima & Miyazaki 1973 for Japanese, the production of geminate as opposed to short voiceless unaspirated stops already involves glottal gestures of greater magnitude.¹⁷ This is depicted schematically in (24a):



In plain voiceless stops, these glottal gestures of greater magnitude are aligned with oral implosion. However, as shown in (24b-c), there are two ways in which aspiration (indicated by shading) can arise spontaneously from such articulations. First, as in (24b), simple shortening of the oral gesture, a common fast speech phenomenon, can result in audible noise before closure which may eventually be reinterpreted as preaspiration. Second, as in (24c), slight temporal misalignment of oral and glottal gestures — i.e. anticipatory or perseveratory coarticulation — can also result in spontaneous aspiration¹⁸:



Anticipation of glottal gestures for aspirated obstruents has been reported for English and Swedish by ní Chasaide & Goble 1988, who observe vocal fold abduction before stop closure in VT^hV contexts. Although the most perceptually

salient cases of preaspiration involve long segments, these studies suggest that preaspiration in short stops might also result from simple anticipation of the laryngeal gesture.

Subsequent to phonetic developments like those shown in (24b-c), which result in lightly aspirated segments, enhancement of both preaspiration and postaspiration can also be understood phonetically. Oral closure gestures in preaspirated segments will be further delayed or inhibited, due to the greater volume and velocity of airflow in the supralaryngeal cavity: that is, oral closure gestures encounter higher resistance in slightly preaspirated segments, resistance which could further shorten the closure phase of the stop.¹⁹ In slightly postaspirated segments, on the other hand, increased aspiration can be viewed as acoustically enhancing the already noisy character of the stop burst.²⁰

In sum, laryngeal gestures of greater magnitude appear necessary in long as opposed to short voiceless stops in order to produce voicelessness for the greater part of the stop closure. Shortening of stop closure or slight mistiming of such laryngeal gestures may result in lightly preaspirated or postaspirated segments; subsequent enhancements of this aspiration can also be explained in aerodynamic and acoustic terms. Spontaneous aspiration is therefore a phonetically natural development from plain geminate voiceless obstruents.

5.2. Aspirate Nasalization

The second sound change which on our analysis underlies Nasal Substitution is Aspirate Nasalization in (20b). This change manifests what Matisoff, in a classic paper, has called 'rhinoglottophilia — an affinity between the feature of nasality and the articulatory involvement of the glottis' (1975: 265). Insofar as Nasal Substitution has no other plausible historical explanation, it is important evidence for this unusual phenomenon.

At least two aspects of the Ponapeic development distinguish it from other cases of spontaneous nasalization noted in the literature: it involves nasalization induced by *h* and no other consonant, and the quality of adjacent vowels is irrelevant. We will refer to nasalization processes with these two properties as 'simple' rhinoglottophilia for the reason that they have a single phonetic basis, summarized succinctly by Ohala (1975: 303)²¹:

... [h] may produce an effect on vowels that 'mocks' that of nasalization. Because of the open glottis during phonation accompanying an [h] (or breathy voice), the spectrum of the vowel will be changed in the following ways: there will be upward shifting of the formants, especially F_1 ..., increased bandwidth of the formants, presence of anti-resonances in the spectrum and an overall lowering of the amplitude of the vowel ... This is identical to the effect of nasalization on vowels. Articulatory re-interpretation may occur, i.e., actual nasalization may be produced on the vowel.

Before identifying what we believe to be other cases of simple rhinoglottophilia, it may be useful to summarize the varieties of spontaneous nasalization known to us

and to comment briefly on the nature of the evidence discussed in earlier rhinoglottophiliological literature. In some cases the evidence may illustrate processes other than simple rhinoglottophilia, processes whose diachronic basis cannot be explained by reference to the acoustic effects of *h* noted by Ohala.

Several types of spontaneous nasalization are identified in (25):

(25) Types of Spontaneous Nasalization

- a Simple rhinoglottophilia — nasalization induced by *h* (and breathy voice)
- b Rhinochthamalphilia — nasalization induced by pharyngeal consonants or low vowels (Ohala 1971, Henderson 1984, Whalen & Beddor 1989)
- c Rhinosyrigmatophilia — nasalization induced by sibilants (Lintz & Sherman 1961, Ohala & Amador 1981)

Matisoff's 1975 treatment discusses facts from Thai, Lao, Lahu, Lisu, East Gurage, and English. None of these cases involves the development of nasalization from *h* alone. In East Gurage, nasalization develops adjacent to pharyngeal and glottal consonants and may, in the case of pharyngeals, be caused by the lowering of the uvula involved in these sounds, which creates a velic opening (Hetzron 1969). In the other languages, nasalization is found after *h* and *ʔ*, or after *h* and in vowels with no consonantal onset at all, and appears to be restricted to low vowels. Spontaneous nasalization of low vowels is common cross-linguistically, and receives a possible explanation in the fact that low vowels are produced with the velum lowered relative to its position for other vowels. Low vowel and pharyngeal nasalization, called 'rhinochthamalphilia' in (25b), has an articulatory basis rather than the acoustic explanation associated with simple rhinoglottophilia.

As indicated in (25c), spontaneous nasalization has also been reported in vowels adjacent to sibilants. Such cases of 'rhinosyrigmatophilia' might actually have the same explanation as simple rhinoglottophilia if sibilants are produced with the same glottal configuration as *h*, and if this laryngeal configuration perseveres into the following vowel. However, since evidence regarding the timing of glottal gestures in these cases is unavailable to us, we tentatively distinguish rhinoglottophilia and rhinosyrigmatophilia.

There are also processes which manifest some connection between nasalization and certain laryngeal consonants or features but which should not be mistaken for the phenomenon under discussion. For example, it is well known that laryngeal consonants in some languages are transparent to nasalization and so can be nasalized allophonically by adjacent nasals or nasalized vowels (Cohn 1990). Such laryngeal transparency may well have the same phonetic basis as simple rhinoglottophilia, but the actual source of nasalization in such cases is not the transparent segment itself. This is clear enough in well-known cases like Sundanese, but can be harder to identify retrospectively. In the prehistory of Avestan, for instance, Proto-Iranian **h* became a voiceless velar nasal (spelled *ṛh*) between low vowels; e.g. **wahauš* > *vaṛhəuš* 'of good' (Vedic *vásoḥ*) and **asat* > *aṛhaṭ* 's/he would be' (Vedic *ásat*), but **ahura* > *ahura* 'lord' (Vedic *ásura*). In this case it is

impossible to determine whether the change was in part caused by the acoustic properties of *h*, or whether nasalization was induced by low vowels and has only surfaced diachronically on *h*.

Rhinoglottophilia as described above could equally well result in reanalysis of nasalization as aspiration, leading to what might be called 'spontaneous aspiration'. An Owerri dialect of Igbo illustrates this process.²² In this dialect aspiration is contrastive for the following segments:

(26) plain voiceless	<i>p</i>	<i>pʷ</i>	<i>t</i>	<i>s</i>	<i>c</i>	<i>k</i>	<i>kʷ</i>	<i>h</i>				
plain voiced	<i>b</i>	<i>bʷ</i>	<i>d</i>	<i>z</i>	<i>j</i>	<i>g</i>	<i>gʷ</i>		<i>r</i>	<i>w</i>	<i>y</i>	
voiceless aspirated	<i>pʰ</i>	<i>pʷʰ</i>	<i>tʰ</i>	<i>sʰ</i>	<i>çʰ</i>	<i>kʰ</i>	<i>kʷʰ</i>	<i>hʰ</i>				
voiced aspirated	<i>bʰ</i>	<i>bʷʰ</i>	<i>dʰ</i>	<i>zʰ</i>	<i>ʃʰ</i>	<i>gʰ</i>	<i>gʷʰ</i>		<i>rʰ</i>	<i>wʰ</i>	<i>yʰ</i>	

Vowels are not contrastively nasalized, but they are allophonically nasalized after the aspirated sonorants, the aspirated fricatives, and the aspirated palatalized and labialized stops; e.g. /ènùgʷʰù/ → *enugʷʰù*. The natural class of segments triggering aspiration appears to be those with aspirated [+continuant] release; palatalized and labialized segments fall into this class as a consequence of their aspirated off-glides. Despite appearances, however, this case does not parallel Ponapeic: Hyman 1972 and Williamson 1973 have argued that the diachronic source of both aspiration and nasalization in Owerri is a lost nasal consonant: *CVNV > *CNV > C^NV̄ > C^hV̄, as Ladefoged et al. 1976 schematize the development.²³

Another case of rhinoglottophilia is found in the Northwest Caucasian languages Bzhedukh and Shapsegh. Both of these languages contrast aspirated and unaspirated spirants. Vowels following aspirated spirants are nasalized. Colarusso (1988: 42) notes:

The velum appears to be lowered slightly, not enough to cut down the air flow through the oral occlusion, but enough to cause secondary turbulence in the nose. This enhances the aspirated quality of these segments, and must also enhance the formant-like concentrations of energy by introducing nasal-like formants into the spirant noise in such a way that they reinforce the formant-like bands of energy that are already there due to aspiration alone.

For example, Bzhedukh /ʃʰaʃʰ/ 'horse's milk' surfaces as [ʃʰʰʰʃʰʰ] or [ʃʰʰʰʃʰʰ]. Further development of the aspirated spirants in Shapsegh parallels the Ponapeic developments suggested above. In the Israeli dialect of Shapsegh there is no longer a contrast between aspirated and unaspirated spirants: instead, distinctive vowel nasalization has arisen. Colarusso (1988: 43) concludes:

This nasalization ... appears to be the etymological reflex of the aspiration of an earlier aspirated spirant ... It appears that at some stage in the history of this dialect the secondary phonetic effect of partial nasalization must have been reinterpreted as the basis for a phonemic contrast, the aspiration of the spirant being reevaluated as a mere secondary acoustic effect. The aspiration was lost, leaving behind a distinctive nasalization where no nasal had previously existed.

Continuancy alone is an insufficient trigger of vowel nasalization, since vowels are not nasalized after plain voiceless spirants. Hence vowel nasalization here can be viewed as a case of simple rhinoglottophilia enhanced by rhinosyngmatophilia.

6. Conclusion

Any attempt to take the Neogrammarian view of sound change seriously from a modern point of view naturally focusses special attention on the diachrony of phonetically implausible but clearly documented phonological innovations. To the extent that these can be decomposed into phonetically sensible intermediate developments, as in the case of Ponapeic Nasal Substitution, a constrained and natural model of phonological change is supported.

Notes

* We are very grateful to Henry Churchyard, Mark Hale, Bob Harms, Shelly Harrison, Jay Jasanoff, John Kingston, Björn Lindblom, and especially Ian Maddieson for discussion and references.

¹ Ngatikese is undocumented. See Bender 1971 for a survey of the Nuclear Micronesian family and other languages spoken in Micronesia; among them, Nauruan may be Nuclear Micronesian. We cite Mokilese data from Harrison 1976, 1984 and Harrison & Albert 1977, Pingilapese data from Good & Welley 1989, and Ponapean data from Rehg 1981, 1984, 1986 and Rehg & Sohl 1979; outside Ponapeic, we cite Kiribati data from Sabatier 1971, Kosraean data from Lee 1976, and Trukese data from Goodenough & Sugita 1980. Since the standard Nuclear Micronesian orthographies are incommensurate, we use IPA symbols with standard American modifications (e.g. underdots for retroflex consonants). Note also that, although *e* and *ɛ* contrast in Ponapean, Rehg 1981 and Rehg & Sohl 1979 follow the standard orthography and do not distinguish them; we too write *e* here for both vowels.

² They are found in loan words and exclamations, however. Examples include *nappa* 'Chinese cabbage' (vs. *ŋɛape* 'girt'), *ketta* 'Japanese clogs' (vs. *ketei* 'palm sp.'), *akka* 'an exclamation of surprise' (vs. *aka* 'these by me'), *kakko* 'to put on airs' (vs. *kaika* 'desiring peace and quiet while under the influence of kava'), *kassouku* 'to train for an athletic event' (vs. *kasokamai* 'to build a fish trap of coral on a reef'), and *esse* 'an exclamation of pain' (vs. *ese* 'to know, to understand'). Near-minimal pairs illustrating the contrast between short and long sonorants include the following: *kemmat* 'to change into dry clothing', *keme* 'to spank'; *lam^wm^win* 'majestic', *lim^wa*; 'next to'; *kosonnet* 'rule', *sonop* 'ball of sennit'; *mall* 'clearing in a forest', *malau* 'far apart'; *kaŋŋeɕ* 'to cause to pant', *kaŋit* 'to pound or press into a mass'; and *rerer* 'to be trembling', *rere* 'to skin, peel'.

³ This formulation differs slightly from that of Rehg 1981 and 1984, who collapses the rule with one of nasal assimilation: $C_iN_i \rightarrow N_iN_i$, where *i* indexes place features and C_i is labial or velar. We will have nothing further to say about such regressive nasal assimilation.

⁴ In particular, we assume that adjacent consonants with like place nodes undergo place-node merger; this is supported by the fact that in forms like (6d-e), the first labial assumes the backness value of the second, i.e., the two consonants share all place features.

⁵ We assume the following model of the Ponapean lexicon:

	<u>Morphology</u>	<u>Phonology</u>
Lexical	1. Reduplication	NS-I, NS-II
	2. Suffixation	NS-II (NS-I bled by epenthesis)
	3. Compounding	NS-II (NS-I does not apply)
Postlexical	Syntax	NS-II (NS-I does not apply)

⁶ An adequate treatment of the sporadic process of 'nasal dissimilation' in Aramaic (Spitaler 1954, Kutscher 1977, Macuch 1989) or of Middle Indic dialectal 'spontaneous nasalization' (Grierson 1922) requires considerable linguistic and philological detail. For some discussion see Blevins & Garrett 1992.

⁷ Syncope was no doubt originally conditioned by stress, but already in the early prehistory of the attested languages considerable morphologization seems to have occurred.

⁸ Apparent counterexamples are Ponapean loan-words in Pingilapese; see Blevins & Garrett 1992.

⁹ The obstruent cluster in this word is derived (by assimilation), not underlying.

¹⁰ Good & Welley (1989: 13) cite this form as '*isar*'.

¹¹ The implication of Rehğ's suggestion is that Nasal Substitution occurs because it is a structure-preserving process (in the sense of Kiparsky 1982): since homorganic nasal-obstruent sequences are found underlyingly, there is no cost in producing them. We are seeking to explain a regular sound change in Ponapeic, however, and the principle of structure preservation is irrelevant if, as proposed above, sound changes yield late postlexical rules in the first instance, since the latter are not subject to structure preservation.

¹² Rehğ's second argument is also only applicable to initial and/or final geminates: intervocalic length contrasts are easily perceived and are relatively stable cross-linguistically. As illustrated above and argued at some length by Rehğ himself (1984: 328-31), medial geminate obstruents also underwent Nasal Substitution.

¹³ This contrasts with the production of geminate voiced stops, where reduction in the transglottal pressure drop results in cessation of voicing, and where nasalization, lowering of the larynx, or passive expansion of the intra-oral cavity could be viewed as attempts to maintain voicing.

¹⁴ There is also concrete counterevidence to the view, explicit in (17), that all Proto-Ponapeic coda nasals were lost with compensatory vowel lengthening in Pingilapese; hence if this loss is related to Nasal Substitution, the latter cannot have occurred in Proto-Ponapeic. See Blevins & Garrett 1992.

¹⁵ The diachrony is debated: for example, although Scots Gaelic preaspirates do descend from geminates, Borgstrøm 1974 has argued that preaspiration in that language actually reflects Scandinavian contact, much as dialectal Scots English preaspiration is certainly due to Gaelic interference; for Icelandic, where not all synchronic preaspirates continue inherited geminates, there are several competing analyses (for an overview see Liberman 1982: 260-72).

¹⁶ Proto-Ponapeic had no fricatives, but note in general that the glottal aperture for *s* is already wide enough to result in aspiration. As shown by Hirose & Gay 1972, Hirose, Lisker & Abramson 1972, and Collier, Lisker, Hirose & Ushijima 1979, voiceless fricatives are produced with the widest glottal aperture of any consonants. In a sense, then, fricatives in most languages are aspirated in terms of the spread position of the vocal folds, though aspiration is normally simultaneous with oral constriction and therefore not perceived as a characteristic release feature.

¹⁷ This is probably due to the relatively symmetric curve associated with vocal fold abduction: to maintain voicelessness for longer durations, greater vocal fold abduction is necessary.

¹⁸ Cf. Löfqvist (1980: 486): '... it is possible to give a hypothetical but phonetically plausible account of the emergence of pre-aspiration in stop consonants and why it never seems to co-occur with post-aspiration. In order to avoid post-aspiration, an early timing of peak glottal opening can be used. In this process, the coordination of glottal opening and oral implosion will be more or less synchronous; if glottal opening precedes oral closure, an audible noise will occur that might eventually develop into a regular phonologic pattern.'

¹⁹ If stressed syllables are produced with even greater air mass and velocity, then stop closure in stressed syllables could be inhibited further. We thank I. Maddieson for calling such aerodynamic factors to our attention.

²⁰ Stop closure duration appears to be inversely proportional to noise duration in preaspirated and postaspirated stops (Hutterer 1985). Hence closure should be shortened as preaspiration is 'enhanced', resulting in an even more radical misalignment of oral and laryngeal gestures than that shown in (24c), where stop closure duration remains constant.

²¹ Cf. Ohala 1980, 1987 and Klatt & Klatt 1990.

²² We are grateful to J. Jasanoff for the data. These facts are also reported in Colarusso 1988.

²³ The same development has occurred in several New Caledonian (Oceanic) languages; cf. e.g. Nemi (postnasalized) *l^hoot* 'wealth' as opposed to Cémuhi *hīūt* and Pije *l^hōōt*. See Haudricourt 1972 and Ozanne-Rivierre 1982.

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