

The Emergence of Obstruents after High Vowels

1. Introduction

Vennemann (1988) and others have argued that sound changes which insert segments most commonly do so in a manner that “improves” syllable structure: they provide syllables with onsets, allow consonants that would otherwise be codas to syllabify as onsets, relieve hiatus between vowels, and so on. On the other hand, the deletion of consonants seems to be particularly common in final position, a tendency that is reflected not only in the diachronic mechanisms outlined by Vennemann, but also reified in synchronic mechanisms like the Optimality Theoretic NoCoda constraint (Prince and Smolensky 1993). It may seem surprising, then, that there is small but robust class of sound changes in which obstruents (usually stops, but sometimes fricatives) emerge after word-final vowels.

Discussions of individual instances of this phenomenon have periodically appeared in the literature. The best-known case is from Maru (a Tibeto-Burman language closely related to Burmese) and was discovered by Karlgren (1931), Benedict (1948), and Burling (1966; 1967). Ubels (1975) independently noticed epenthetic stops in Grassfields Bantu languages and Stallcup (1978) discussed this development in another Grassfields Bantu language, Moghamo, drawing an explicit parallel to Maru. Blust (1994) presented the most comprehensive treatment of these sound changes to date (in the context of making an argument about the unity of vowel and consonant features). To the Maru case, he added two additional instances from the Austronesian family: Lom (Belom) and

Singhi. He also presented two historical scenarios through which these changes could occur: diphthongization and “direct hardening” of the terminus of the vowel.

This study seeks to provide both a broader and deeper empirical base from which this phenomenon can be understood, to extend and refine Blust’s analysis of the phenomenon, and to demonstrate that the various cases of post-vocalic obstruent emergence (POE) that have been observed represent a unified phenomenon with a shared phonetic motivation, rendering Blust’s distinction between diphthongization and direct hardening unnecessary. The analysis is presented in terms of Evolutionary Phonology (Blevins and Garrett 1998; Blevins 2004; Blevins 2006), an approach to phonology that privileges diachronic explanations of sound patterns over synchronic explanations and seeks extralinguistic—physical, perceptual, and cognitive—motivations for historical changes. Specifically, I argue that these emergent final obstruents, in each known case, originate in the context of high vowels and that high vowels engender this type of change because of their aerodynamic properties. Since high vowels and their homorganic glides entail a constriction of the vocal tract—resulting in a relatively high oral air pressure and a relatively small difference in the supraglottal and subglottal pressures—there is variable devoicing of the terminus or terminal off-glides of high vowels. The resulting whisper or “glottal catch” is mistakenly reanalyzed by learners as an obstruent coda. The differences in the phonetic properties of the resulting obstruents (stop versus fricative, dorsal versus coronal) can be largely explained in terms of learning biases imposed by the preexisting phonotactic patterns of the affected languages.

After introducing the best documented examples of the phenomenon (Section 2), I will show on a cases by case basis that POE is associated with high vowels (Section 3.1)

and present an aerodynamic model for POE that explains this relationship (Section 3.2). Then (Section 4) I will outline an exemplar-based mechanism for the interchange of qualitative-paradigmatic and privative-syntagmatic lexical contrasts using the example of Lahu tonogenesis (where an obstruent is “swallowed” into a vowel, introducing a tonal contrast) and show that this same mechanism can account for POE (where an obstruent emerges from a vowel, replacing a vowel quality contrast). Finally (in Section 5), I will argue that the same assumptions about episodic learning required for this model allow us to predict which obstruents are most likely to emerge after high vowels in a particular language and propose that the apparently ameliorative effects of POE can be explained through the same principles.

2. Introduction to the principle cases

The first case of post-vocalic obstruent emergence to gain significant attention was from Maru, a Tibeto-Burman language belonging to the Burmish group within Lolo-Burmese that is spoken in Northern Burma and Southern China. In Maru, the rhymes corresponding to Inscriptional Burmese *-iy* and *-uw* have become *-it* and *-uk* respectively¹. That Maru had developed secondary stops after some vowels was probably first reported by Karlgren (1931), who mentions it only as a side note. Likewise, Benedict (1948), who may have discovered this development independently, mentions it only as a parallel example to explain the apparent existence of Old Chinese obstruent codas in reflexes of Proto-Sino-Tibetan open syllables. It was only with Burling’s (1966; 1967) rediscovery of the non-etymological stops in Maru that a rigorous attempt was made to show that they were a secondary development rather than a conservative feature of the language. Burling showed that a simpler reconstruction of the tonal system of Proto-Lolo-Burmese, with no

tonal contrast in stopped-syllables, was possible if and only if some Maru final stops (those without parallels in the other Lolo-Burmese languages) were a relatively recent development. Burling's argument was initially met with a mixture of hostility (Miller 1970), cautious skepticism (Matisoff 1968), and approval (Lyovin 1968). However, the accumulated body of evidence has led most working Tibeto-Burmanists, even some who were initially skeptical, to accept his thesis (Bradley 1979; Matisoff 2003). The change is remarkably regular and a perusal of Dai et al. (1992) yields over 80 forms exemplifying it.

There is another, similar case of POE found in the Tangkhulic sub-group of Tibeto-Burman. Huishu, spoken in northern Manipur province, India, has *-ik/* and *-uk/* where Proto-Tangkhulic (author's reconstruction) has **-i* and **-u/*-i*. Thus, Proto-Tangkhulic **-ri* 'medicine' and **-ru* 'bone' become *-rik* and *-ruk* in Huishu. Although cognate obstruent codas do not appear in any of the closely related languages, some Huishu lexical items with emergent *-k* have Maru cognates with emergent stop codas. In light of the scholarly consensus on Maru emergent stops, this is best seen as the result of parallel developments in different branches of Tibeto-Burman. Both Benedict (Benedict 1972) and (Matisoff 2003) reconstruct the primary rhymes reflected by Maru *-it/* and *-uk/* and Huishu *-ik/* and *-uk/* as **-əy* and **-əw* respectively. If these stops are treated as etymological, as Wolfenden (1939) and Miller (1970) proposed for Maru, they would have to be reconstructed for Proto-Tibeto-Burman. Doing so has several disadvantages: Burling's relatively simple and elegant reconstruction of the Proto-Lolo-Burmese tonal system, and its intellectual descendents, would have to be rejected in favor of something much less principled and an additional obstruent coda would have to be posited for Proto-

Tibeto-Burman, one that was very common in the proto-language but so prone to deletion it disappeared in all daughter languages but two. More troubling, since *-əy and *-əw function as the primary “high” vowels in open syllables the Benedict/Matisoff reconstruction (the open syllable counterparts to *i: and *u:, asserting that they were actually VC sequences would imply that only a few Proto-Tibeto-Burman roots could be reconstructed having open syllables with high vowels. This strange skewing of distributions would itself call for explanation. Once the prejudice against what Miller called “Burling’s theory of spontaneous generation of final stops” is relaxed, and it is allowed that stops can emerge after final vowels, a far more economical solution to all of these problems is available.

A development especially reminiscent of the Huishu case is known from certain Grassfields Bantu languages of Cameroon. Stallcup (1978) noted that there were non-etymological -/k/ codas in certain Momo languages such as Moghamo, and noted the parallel between this innovation and the emergence of final stops in Maru. Moghamo -/ək/, -/ək/, and -/ok/ correspond to word final -/i/, and -/i/, and -/u/ in the closely related language Meta. Thus, for Meta *ɛ-tu* ‘head’ and *fɪ-bí* ‘knife’, Moghamo has *-tók`* and *fí-bék`*. Stallcup’s analysis of the phenomenon concentrates on Batibo Moghamo, but he notes that non-etymological velar stops are also present in other Momo languages including Oshie and Ngie (as well as the Bamileke language Fomopea; see also Ubels (1975)). Although they are synchronically word-final, Stallcup argues that the stops developed from intervocalic glides. Nonetheless, he entertains an alternative hypothesis that they developed after word-final high vowels, following Burling’s (1966) proposal for Maru. When a broader range of data, including the independent cases of emergent

obstruents in Bamileke languages are examined, the superiority of this second hypothesis becomes evident (see Section 3.1.3 below).

Finally, there are related cases in at least two Austronesian languages: Lom (Belom), a “Middle Malay” dialect of Bangka island, east of Sumatra, and Singhi, a “Land Dayak” language of Borneo (Blust 1994). The Lom case is very similar to the cases enumerated so far: word-finally, PAN *-i becomes Lom -ic and PAN *-u becomes -ek. Thus, PAN **isi* ‘flesh’ and **asu* ‘dog’ become *isic* and *asek* respectively. The Singhi development differs from the other cases in that the emergent segment is a fricative rather than a stop. PAN *-i and *-u become Singhi -is and -ux. Thus, **iti* ‘this’ and **batu* ‘stone’ become *itis* and *batux*.

The Singhi and Ngomba cases bear more than a passing resemblance to the “occlusivization” seen in certain Scandinavian dialects. For example, in certain Danish dialects of Jutland, low high vowels are produced with a devoiced or fricative off-glide (Andersen 1972:26-27). Thus, *bi* ‘bee’ is pronounced as [bi̥] in some varieties and as [biç] in others. In still other varieties, the fricative off-glide has “hardened” into a stop, yielding [bik̚] or [bic], paralleling the rest of the cases discussed above. However, the Danish case differs from those discussed at length here in that emergent obstruents are not confined to open syllables (e.g. *lun* [lux̚n] ‘warm’). The development of these “parasitic” obstruents is apparently conditioned historically by *stød* (Ejlskjær 2005:1725; Ejlskjær 2006), a laryngeal prosody often characterized by creaky phonation. The fact that they are conditioned by a suprasegmental prosody rather than a position in prosodic structure may account for some of their divergent properties.

POE has been documented in at least three major language families, with cases distributed from the Indonesian Archipelago to central Africa. Each of these cases represents a robust, regular sound change with similar inputs and a similar output. Evolutionary Phonology, following a long tradition of similar thought (Blevins 2004), holds that recurrent sound changes are likely to be “natural”—driven by physical and psychophysical constraints. I will argue below that POE is a “natural” change, in the sense that it has a clear, unified extralinguistic motivation, but “unnatural” in that it can only occur if particular combination of phonetic and structural conditions are met.

3. High vowels as a context for POE

The following section will argue that high vowels are a recurrent conditioning environment for POE and that this relationship follows from aerodynamic properties of high vowels that are also active in so-called high vowel devoicing (HVD). First, an examination of each of the major cases will show that the vowel-obstruent sequences seen in HVD almost always reflect high vowels. Then, I will show that high vowels serve as the context for a related phonetic phenomenon that causes the final portions of high vowels to be realized as devoiced or fricative off-glides.

3.1. Case studies

3.1.1. Huishu

Of the cases of POE listed above (excluding the Danish case, where the details of the language’s history are well documented), Huishu is the one which high vowels are most obviously the source of the emergent obstruents. This is true for the following reasons:

1. The vowels can be probably be reconstructed as phonetically high even at the Proto-Tibeto-Burman level.
2. They can more clearly be reconstructed as high vowels at the Proto-Tangkhalic level.
3. The vowel nuclei remain high in the VC sequences resulting from POE.

In Table 1, Huishu etyma with emergent final stops are compared with reconstructions of Proto-Tibeto-Burman (Matisoff 2003) and Proto-Tangkhalic (author's reconstruction) and with two other Tangkhalic languages: Ukhrul, a conservative language which is closely related to Huishu, and East Tusom, a language whose relationship to Huishu is more remote.

Table 1 Correspondences with Huishu emergent stops in Proto-Tibeto-Burman, Proto-Tangkhalic, East Tusom, and Ukhrul

PTB	PTk	East Tusom	Ukhrul	Huishu	
*s-hywəy	*-ʃi	ʔa-si	ʔà-ʃi	ʔa-sik	'blood'
*si	*rik-si	n-tsi	rik-si	ʔa-roʔ-sik	'comb'
*səy	*-tʰi	tsi	kə-tʰi	kə-tik	'die'
*kri	*-ŋə-ci	kə-tsi	kʰə-ŋə-ci	kə-tsik	'fear'
*b-ləy	*-pʰə-li	mə-lj-a	mə-ti	mə-kik	'four'
—	*-ŋə-ci	ʔa-n-tsi	ʔà-ŋə-ci	ʔa-nə-tsik	'horn'
*r-tsəy	*-ri	—	ʔà-ri	ʔa-rik	'medicine'
—	*-ni	ʔa-ni	ʔà-ni	ʔa-nik	'mother-in-law'
*tsyi	*mə-ci	mə-tsi	mə-ci	ʔ-mə-tsik	'salt'
*s-nis	*ci-ni	sə-ni-he	ʃi-ni	thi-nik	'seven'
*g-nis	*kʰə-ni	—	kʰə-ni	kʰə-nik	'two'
*g-rus	*-ru	ʔə-ri-kuə	ʔà-rú-kúj	ʔa-ruk	'bone'
*nəw	*-nu	—	ʔà-nù	ʔa-nə-nuk	'breast'
—	*-ŋə-wu	—	kʰə-ŋə-vù	kə-nə-vuk	'carry'
—	*-ru	kə-tsi-nĩ	ʔà-rù	ʔa-ruk-re	'grandchild'
—	*-kʰu	—	ʔà-khu	ʔa-kʰuk-e	'insect'
—	*-mə-su	khə-n-si	kʰə-mə-sú	kə-mə-suk	'tie'
*k ^w əy	*hi	—	fu	ʔa-huk	'dog'
*har-rəy	*ar-ri	ʔuə-tsi	hèr-ru	ʔa-ho-pʰə-ruk	'egg'
*m-nwəy	*-mə-ni	kha-n-ni	kʰə-mə-nù	kə-mə-nuk	'laugh'

*rəy *-ri n-tsi tɛ̃-ru ʔa-ruk ‘water’

Both Ukhul and East Tusom always have high vowels corresponding to Huishu vowel-emergent obstruent sequences. A three-way contrast in high vowels has to be constructed based on data from another language, Kachai (not seen here). In East Tusom, all of these vowels have merged as /i/, a “super-high” vowel which is often realized with considerable friction. In Ukhul and Tusom, *-i and *-u have merged. This may be a shared innovation which occurred prior to POE in Huishu.

The rhymes that are reconstructed as *-i, *-i, and *-u primarily reflect the Proto-Tibeto-Burman rhymes reconstructed by Matisoff as *-əy, *-əy (after labialized onsets and *r-), and *-əw. These two rhymes are reflected as -i and -u in most branches of Tibeto-Burman. Matisoff (2003:160) notes that they should not be interpreted as literal phonetic reconstructions. He also considers an alternative reconstruction in which *-əy and *-əw are reconstructed the long high vowels *-i: and *-u: rather than as diphthongs. He rejects this hypothesis not on the basis that it would account for the Tibeto-Burman data inadequately, but rather on the grounds that (i) reconstructing these rhymes with diphthongs may provide a better match with Old Chinese and (ii) this would give Proto-Tibeto-Burman vowel-length contrasts in open-syllables, which would be unusual for a Tibeto-Burman language. These reconstructions, then, are structural rather than phonetic in their motivation, and the merger of *-əy and *-əw with *-is and *-us in Tibeto-Burman languages that lose *-s suggests that *-əy and *-əw were phonetically close to high vowels. The segments that gave rise to Huishu -/uk/ and -/ik/ were high vowels from the Proto-Tibeto-Burman stage up until POE took place.

3.1.2. Maru

Because Maru emergent obstruents have the same source in Proto-Tibeto-Burman as those in Huishu, some of the same arguments for the thesis that the emergent stops develop from high vowels hold. Consider Table 2 below. Here, two dialects of Maru are represented. Maru₁ forms are taken from Burling (1966); Maru₂ forms, representing a dialect spoken in China, are from (Dai 1992; Sun 1991). The table also gives cognates from Maru's closest relative (Atsi) and Written Burmese, and Proto-Tibeto-Burman. Note that Maru₁ and Maru₂ are substantially identical except that *-/it/* has become *-/ik/* in Maru₂ (regardless of whether the */t/* resulted from POE).

Table 2 Correspondences of Proto-Tibeto-Burman (PTB), Written-Burmese (WB), and Zaiwa (Atsi) with Maru emergent stops.

PTB	WB	Atsi (Zaiwa)	Maru ₁	Maru ₂	
*səy	se	šî	šit	sik	'die'
*krəy	khre	khyí	khyit	khyik	'leg/foot'
*rəy	re	—	yit	yək	'water'
*gyəy	kyê	jì	jit	—	'parrot'
*kləy	khyê	khyi	khyit	khyik	'dung'
*krəw	khruí	khyúí	khyùk	khyùk	'horn'
*ŋəw	ŋui	ŋâu	ŋùk	ŋùk	'cry'
*məw	mûi	màu	mùk	mùk	'sky'
*rəw	rûi	vùi	yùk	yùk	'bone'
*kəw	-khûi	-khàu	-khúk	-khúk	'smoke'
*r-kəw	khûi	kháu	khúk	khúk	'steal'
*pəw	ʔəphûi	phàu	phúk	əphúk	'grandfather'

As in Huishu, all of the emergent stops in Maru are preceded by high vowels. However, some concern might be raised by the cognates in WB and Zaiwa, where Maru₁ *-/it/* corresponds to WB *-/e/* and Maru₁ *-/uk/* corresponds to Zaiwa *-/au/*. Fortunately, there are reasons to believe that these are secondary developments. WB *-/e/* corresponds to *-/iy/* in its forerunner, Inscriptional Burmese; likewise, WB *-/ui/* corresponds to Inscriptional Burmese *-/uw/*. Since certain other Burmish languages close to Maru, like

Hpun, reflect PTB *-əy and *-əw as -/i/ and -/u/, there is little reason to doubt that, as hypothesized by Burling, the early Maru reflexes were high vowels, probably with significant diphthongization (and perhaps not unlike those implied by the orthography of Inscriptional Burmese).

3.1.3. Grassfields Bantu: Moghamo and Fomopea Bamileke

As was mentioned in Section 2, POE occurred at least twice, independently, in Grassfields Bantu. The best documented cases is in the Momo group, but there is a least one additional case (and a number of marginal cases) in the Bamileke group. Table 3 presents reconstructions of Proto-Grassfields Bantu (PGB) and their reflexes in Moghamo, Meta, and Ngie for etyma where a non-etymological stop is present in Moghamo:

Table 3 Proto-Grassfields Bantu reflexes in three Momo languages: Ngie (Gregg 2002), Meta (Lem and Brye 2008) and Moghamo (Stallcup 1978)ⁱⁱ

PGB	Ngie	Meta	Moghamo	gloss
*tú`	atəu	ǎtú	-tók`	‘head’
*cùl`	utʃəu	ítʃû	-côk`	‘mouth’
*bùà`	ibəu	bú	bók`	‘dog’
*gùà`	igəu	–	-gok`	‘fall’
–	–	ǎwū	awok`	‘leg’
–	abəu	ə̀bù-ê	bók`	‘nine’
*líà`	idzək	dʒi(g)	-jək`	‘eat’
*mù-Vl`	umək	íʒimí	í-mək`	‘moon’
*mí(l)`	amec	émî	ímék`	‘neck’
*L(u)í`	idzutfi	ídʒwí	jwék`	‘nose’
*tí`	–	–	ték`	‘stone’
*bé`	ubec	fíbí	fí-bék`	‘knife’

Unlike Maru emergent stops, for which an origin after stem-final high vowels is now generally accepted, there is a serious competing hypothesis regarding the origin of non-etymological -/k/ in Momo languages. Stallcup proposed to explain the existence of these segments through a proposal that can be outlined in three parts:

1. All of the non-etymological instances of /k/ in Momo languages reflect a single historical change predating proto-Momo. The differences in the distribution of /k/ among Momo languages is the result of deletion (rather than the independent innovation of /k/ in different languages). The same seems also to apply to the Bamileke languages. These losses took the form of areally propagated sound changes radiating from the southern extent of the range of the Widikum-Tadkon subgroup of Momo (to which Moghamo belongs) and consist of the most widespread change in which /k/ was deleted before front vowels, a more restricted change in which /k/ was deleted before back vowels, and the most restricted change in which /k/ is deleted before mid vowels.
2. Non-etymological /k/ developed when epenthetic intervocalic glides were reinterpreted by speakers as underlying stops. With the loss of the final vowels, intervocalic spirantization rules no longer applied to them, and the segments consequently surfaced as /k/.
3. The vowel sequences into which the glides were epenthesized were of two types: clusters which can be reconstructed at a Proto-Bantu (and therefore Proto-Grassfields Bantu and Proto-Momo) level ('dog', 'fall', 'eat', etc.), and vowel clusters that resulted from the breaking of monophthongs ('knife', 'stone', 'head', etc.). This secondary breaking is not unprecedented, since similar developments do occur in Momo languages like Ngie and Oshie; however, it is posited in these cases just to explain the existence of the emergent segment.

The first assumption collides with the fact that final velar stops have to be reconstructed for Proto-Grassfields Bantu. These inherited stops do not undergo the same

pattern of debuccalization or deletion, in the various daughter languages, as the secondary stops. Furthermore, the areal coherence of Stallcup's model is reduced when it is observed that these deletions would have had to sweep almost all of the Momo and Bamileke range, leaving only scattered islands where non-etymological *-/k/* persists in some environment or another. Also problematic for a monogenetic model is the absence of evidence for medial obstruents or glides corresponding to emergent *-/k/* when Proto-Grassfields Bantu vowel sequences are preserved in modern languages. For example, Stallcup would predict **búyà* 'dog' (< Proto-Bantu *búà*) for the shared ancestor of Bamileke and Momo. However, Fe'fe' Bamileke has [mvǔɑ] with no medial glide or fricative (implying an improbably pattern of intervocalic consonant deletion) while Fomopea Bamileke 'dog' is *m̀búk*, with an emergent *-/k/*. Finally, it is notable that several Bamileke languages show low-level phonetic processes where certain short high vowels are implemented with a fricative off-glide. Take, for example, Baloum [pi^x] 'be extinguished' and [a-pi^x] 'rot' (Ubels 1975), or Ngomba [r̀mbiç] 'give birth' and [pix] 'red sawdust' (Satre 1997:16). The best predictor for the occurrence of these fricative off-glides seems not to be the synchronic nature of the preceding vowel rather than the presence of secondary obstruents in cognate forms. Compare, for example, the items from PGB, Baloum, and Fomopea in Table 4:

Table 4 Comparison of forms from Proto-Grassfields Bantu (PGB) and three Bamileke languages (Fomopea, Baloum, and Fongo). PGB *E represents a vowel that is indeterminate between *e and *i.

gloss	PGB	Fomopea	Baloum	Fongo
'head'	*tú̀	ə-tuk	t ^h ʊ	tfu
'tree'	*tí́	ə-tík	t ^h ə	t ^h í
'be extinguished'	*bÉt	pɛ	pi ^x	psai
'rot'	*bè	p ^h ie	a-pi ^x	m-bi

The Baloum process, which seems to be a predictable matter of phonetic implementation does not apply to back vowels. The process in Fomopea did apply to front vowels, but did not apply in ‘be extinguished’ and ‘rot’ since the vowels in these forms were not raised to [i] in Fomopea. In other words, there is relationship between the synchronic height of Bamileke vowels and their tendency to be followed by secondary onsets.

But what about Moghamo, where secondary obstruents always occur after mid vowels? One apparent advantage of Stallcup’s proposal is that it does not make overly restrictive predictions about the vocalic environments in which *-/k/* can develop. On closer analysis, though, this turns out to be a disadvantage since the historical environment for POE in Moghamo was, in fact, highly restricted and his analysis fails to capture this generalization. Note, first, that Moghamo */ok/* corresponds regularly to Meta */u/* and Ngie */əu/*. This set reflects PGB **u*, whether with a following vowel or liquid (as in ‘mouth’, ‘dog’, ‘fall’, and ‘leg’) or without (as in ‘head’ and ‘stone’). Likewise, Moghamo */ək/* corresponds to Meta */i/* and Ngie */ək/*, all from a PGB super-high vowel followed by a vowel, and Moghamo */ek/* corresponds to Meta */i/* and Ngie */eC/* or */i/* (from PGB **e* or **i*). In Meta, which is very closely related to Moghamo but shows no evidence of a regular POE process, PGB **e* and **i* have merged as **i*.

Furthermore, there is internal evidence that the vowels preceding Moghamo secondary obstruents were historically high. Instances of [e] [ə] and [o] occurring before *-/k/* differ from other instances of the same vowels in that, when they occur in an open syllable (due to the presence of a following vowel-initial suffix) they are realized as [i], [i], and [u] (Stallcup 1978:97):

	perf	imperf
'cry'	(dèk)	dì.ɣè
'eat'	jók	jì.ɣî
'fall'	gòk	gù.ɣo

Stallcup presents a convincing argument that, synchronically, the underlying vowels in these forms must be mid, namely that the imperfect suffix only has the form - /o/ following a root vowel /o/. While this may be true synchronically, the diachronic and comparative facts suggest that the high vowel was original and that the mid vowel alternates are the result of conditioning from velar codas. This leads us to the following scenario:

PGB	merger and coalescence	diphthongization	Moghamo / Ngie
*u	> u	> [uw]	> ok / əu
*ja	> i	> [iɥ]	> ək / ək
*i, *e	> i	> [ij]	> ek / ec

After PGB *i and *e merged, short high vowels were subject to secondary diphthongization (like the tense high vowels of English). As an artifact of the reanalysis of the vowel into two segments, the cues marking the former vowel as high were “parsed” to the following coda. In morphological contexts where there was no final coda to which the low F1 could be reassigned, the vowels remained high.

The final development of obstruents from the off-glide of close diphthongs of this kind may have plausibly occurred independently in more than one subgroup of Momo (accounting for some comparative problems that result if monogenesis is assumed) since the conditions required for the emergence of the the new segment were already in place in their common ancestor. Evidence from Bamileke languages likewise shows that Proto-

Bamileke high vowels had some of the very properties that would favor the emergence of obstruent codas. For example, cognates to Fomopea formsⁱⁱⁱ having emergent obstruents often display aspiration or affrication in onsets in languages like Fe’fe’ Bamileke (Hyman 1972) and Nwametaw (Michael Ayotte and Charlene Ayotte 2003) (compare also Ngomba from (Kouhegnou and Satre 2003)):

gloss	PGB	Fomopea	Fe’fe’	Nwametaw	Ngomba
head	*tú̀	átúk	tʰũ	atú	/tú/
mouth	*cúl̀	ñcūk	nšú	ntʃù	/ntsu/
dog	*bùà	m̀búk	mvǎa	m̀býé	/mǎmvú/
tree/wood	*tí́	átík	tʰũ	àtʰý	/tí/

This type of development is exactly what one would predict if the following vowels were close enough, historically, to significantly impede airflow, resulting in delayed voice onset time and increased turbulence. There parallel development of emergent obstruents in Grassfield’s Bantu languages is no more coincidental than the parallel development of split ergativity in various parts of the Iranian language family (Harris and Campbell 1995:243-245)—in each case, the members of a language family inherited a linguistic structure whose natural correlates and inherent ambiguities predisposed successive generations of language learners to reanalyze it in a similar way.

3.1.4. Lom (Belom)

So far, we have seen parallel developments of emergent obstruents in Tibeto-Burman and Grassfields Bantu. It should not be surprising, then, that POE should have occurred independently, in substantially identical environments, in another language family. Of the two or more cases of POE in Austronesian, the one that most resembles POE in Huishu, Maru, and Moghamo is found in the Middle Malay language Lom

(Belom). As show in Table 5 below, Lom emergent stops appear in reflexes of Proto-Austronesian (PAN) *-i and *-u:

Table 5 Postvocalic obstruent emergence in Lom (Blust 1994)

PAN	Lom	
*awRi	aric	‘day’
*isi	isic	‘flesh, meat’
*laki	lakeik	‘husband; male’
*beli	melic	‘to buy’
*Caqi	taic	‘excrement’
*qabu	abek	‘ash’
*au	aok	‘yes’
*asu	asek	‘dog’
*batu	batek	‘stone’
*bubu	bubek	‘tunnel trap’
*bulu	bulek	‘body hair’
*taRu	tarok	‘put, place’
*qulu	ulek	‘headwaters’

Smedal (1987), from whom Blust gleaned these Lom data, noted that his “e” was sometimes backed before /k/. Furthermore, Blust notes that Smedal sometimes transcribes the reflex of PAN *-u as /ok/ (as in ‘yes’, ‘put, place’). This suggests that Smedal’s /ek/ may have been something like [ək]. Suggesting that the change of *u to /e/ before /k/ is somewhat puzzling (in part, because /u/ is unaffected elsewhere), Blust argues for an intermediate state of diphthongization such that, e.g. *qabu > *abəw > /abek/. This explanation, in its essence, is consistent with the argument presented here regarding high vowels—they are prone to two types of diphthongization, one of declining sonority and one of failing phonation. Nearey and Assman (1986) have shown that “tense” vowels, even when they would be transcribed and analyzed phonologically as monophthongs, often include as part of their basic phonetic makeup, significant decreases in F1 across the duration of the vowel. That is to say, they may be phonetic diphthongs with a nucleus that is somewhat lower than the off-glide. The increasing constriction of

the oral cavity over the duration of the vowel would also compound the difficulty of maintaining voicing (as discussed in Section 3.2 below) contributing to the emergence of an obstruent coda. As with the Moghamo case discussed above, it is possible that the change in vowel quality of the nucleus is not the result of a “radical” diphthongization prior to the epenthesis, but a reorganization of perceptual cues into phonological structures concomitant with the emergence of final obstruents.

3.1.5. Singhi

While the result of POE in the Land Dayak language Singhi is somewhat different than in the cases described so far—it yields fricative rather than stop codas—there can be no question but that high vowels serve as the source of Singhi emergent obstruents. The evidence for this can be seen in Table 6 below, which compares PAN forms to their Singhi reflexes:

Table 6 Postvocalic obstruent emergence in Singhi (Blust 1994)

PAN	Singhi	
*qubi	bis	‘yam’
*besi	bosis ‘small axe’	‘iron’
*iti	itis	‘this’
*kali	karis	‘dig’
*bili	miris	‘buy’
*suligi	sirugis	‘spear’
*qabu	abux	‘ash, fireplace’
*batu	batux	‘stone’
*baqeRu	baux	‘new’
*kuCu	gitux	‘louse’
*CuNu	ninux	‘burn’
*CebuS	tobux	‘sugarcane’

The same high vowels, -i and -u, are present in the PAN reconstructions and their Singhi reflexes. Both parsimony and congruence with the cases discussed so far lead to the conclusion that high vowels served as the environment from which obstruents

emerged in Singhi. However, there are reasons to believe that the chain of events that led to the development of the final fricatives in Singhi differed from that in the cases examined above. In Singhi, unlike the other languages examined, there are instances of non-contrastive and non-etymological $[-h]$ after certain non-high vowels. Blevin's (2008:92-93) argues for a two-step process in which $[h]$ emerges word finally and is "strengthened" to become a fricative just in case it is coarticulated with a preceding high vowel. This is plausible, since the tighter constrictions of high vowels would result, aerodynamically, in greater turbulence, more aperiodic noise, and—subsequently—a percept more similar to that of an oral fricative than the looser constrictions of other vowels. Blevin's account, similar in spirit but differing in details from the general account offered below, has the advantage of accounting for the final laryngeals that appear after non-high vowels and the emergent fricatives in a unified and elegant fashion. Nevertheless, the fact that a general process of final laryngeal epenthesis is not attested in the other languages suggests that high vowels do more in POE than provide a turbulent context for coarticulation. In light of these considerations, Singhi should be perhaps regarded as displaying a development that is like, but possibly not identical to, the other cases discussed in this paper.

3.1.6. Other possible cases in Austronesian

Blust (1994:124-125) notes that there are at least two other possible cases of obstruent epenthesis in Austronesia that would fit the definition of POE as given here. Both seem to involve high vowels.

1. In reviewing Haudricourt (1971), Blust (1978) notes that $/c/$ and $/k/$ seem to appear after PAN $*i$ and $*u$ (respectively) in certain languages of New Caledonia, a generalization apparently missed (or at least, not explicitly stated) by

Haudricourt. Grace (1972) also noted apparently non-etymological instances of -/c/ and -/k/ in certain New Caledonian languages, suggesting that they were suffixes, but providing no argument for this proposal.

2. For various subdialects of Trengau Malay, Collins (1983) gives the reflexes of PAN *i and *u as /əyk/ and /əwk/. Blust expresses skepticism about the implicit claim that the epenthetic consonants have the same place of articulation after both front and back nuclei, probably because it would run counter to his claim of a special relationship between coronals and the high front vowel [i]. Collins's transcription, if accurate, would provide an additional parallel to the development reported for Huishu, Moghamo, and Fomopea.

Both of these developments, to the extent that they can be confirmed, fit the pattern that has been observed in POE cases so far, most significantly, the association between close vowels and emergent obstruents.

3.2. High vowels and vowel devoicing

In each of the robust cases of POE examined in this paper, the non-etymological obstruents appear to have emerged after high vowels. This is significant because it allows us to present a plausible phonetic explanation for the development of these segments.

High vowels share a number of unique properties, the most obvious of which is the proximity of the tongue dorsum to the roof of the mouth. This could, for example, result in accidental (near-)collisions between these two articulators, which, if it happened frequently enough, could be interpreted by listeners as an intended obstruent coda. It is also commonly held that high vowels are the least sonorous vowels and therefore the vowels phonologically closest to consonants (Hankamer and Aissen 1974). One might

propose that high vowels, among all vowels, give rise to consonants because they need change the least in order to do so. This explanation, however, fails to account for the apparent rarity of changes like $-\text{/aw/} > -\text{/ak/}$ compared to $-\text{/u/} > -\text{/uk/}$ (since $-\text{/w/}$ is even less sonorous than $-\text{/u/}$). However, there is a more plausible explanatory mechanism that derives this relationship from the aerodynamic properties of high vowels, rather from an abstract phonological parameter like sonority.

Various languages are reported to have voiceless or devoiced vowels. While these have been claimed to be contrastive in a few cases, most are the result of phonological or phonetic processes. In cross-linguistic surveys, both Greenburg (1969) and Jaeger (1978) found that high vowels are more likely to be devoiced than non-high vowels. In many cases, high vowels are the only target of vowel devoicing; if non-high vowels may be devoiced, then high vowels also tend to be subject to devoicing. Jaeger attributed this fact to aerodynamic factors: high vowels are less conducive to voicing than other vowels. Later investigators like Beckman (1996) have argued that high-vowel devoicing (HVD) in languages like Japanese (where devoicing occurs in the context of voiceless obstruents) is likely to be due to articulatory factors instead of aerodynamic constraints: high vowels are shorter than non-high vowels, and the gestural overlap from the neighboring consonants therefore occupies a larger share of the vowel's duration. These effects are most pronounced when a vowel is in a prosodically weak position and has a reduced duration and amplitude. However, subsequent investigators (Fagyal and Moisset 1999; Smith 2003) have noted that, in languages like French, (high) vowel devoicing actually occurs in prosodically prominent contexts (phrase final, utterance final) positions where vowels are lengthened rather than reduced. I will argue that the second type of

HVD is most relevant to the phenomenon discussed in this paper. In the following section, I will summarize Smith's argument for distinguishing between these two types of vowel devoicing, introduce an additional case of the second type of vowel devoicing from the Lolo-Burmese language Hpun, and identify some of the properties of this type of HVD that make it a likely precursor for POE.

3.2.1. High vowel devoicing in prosodically weak positions

In many languages, including Japanese (Vance 1987), Korean (Jun and M. Beckman 1993; Jun and M. E Beckman 1994), Modern Greek (Dauer 1980), some dialects of Portuguese, Lezgi (Chitoran and Iskarous 2008), and Turkish (Jannedy 1995), high vowels are devoiced when they occur in unstressed syllables. In most of these languages, the same vowels that can be devoiced can be optionally deleted instead (Smith 2003). These devoicing effects are sensitive to speech rate such that there is more devoicing in fast speech than in careful speech. They are also sensitive to the consonantal context in which a vowel occurs. Vowels are most likely to be devoiced when they are flanked by voiceless obstruent consonants.

Beckman (1996) has argued that high vowel devoicing, at least in these cases, can be best explained as the result of an overlap between the glottal gestures for neighboring voiceless consonants and the supraglottal gestures for the vowel. This model accounts well for the recurrent properties in this kind of vowel devoicing: high vowels are devoiced because they have a relatively short duration, meaning that the gestural overlap can be very brief and still result in the devoicing of much of the vowel. The effect of reduction can be understood in the same way. Vowels that are in prosodically weak positions, and are therefore shortened, will be more vulnerable to devoicing than those in

strong positions. Finally, the qualitative properties of surrounding consonants determine the type of glottal gesture that overlaps with the vowel, and thus should be a strong determinant of HVD. This type of high vowel devoicing shares few properties with POE, as exemplified in the case studies above. However, this appears not to be the only type of high vowel devoicing.

3.2.2. (High) vowel devoicing in prosodically strong positions: French

Fagyal and Moisset (1999) and Smith (2003) have shown that high vowel devoicing in French does not have the same properties in French as other investigators have found for HVD in Japanese. Parisian French displays optional devoicing of both high and non-high vowels, with high vowel devoicing being the most frequent (Smith 2003). The best known example of HVD in French (cited by Fónagy (1989), Fagyal and Moisset (1999), and Smith (2003)) is the Parisian pronunciation of *oui* ‘yes’ as [wi̥] or even [wiç], where the onset of the syllable is voiced but the terminus is voiceless and sometimes accompanied by aperiodic noise (Fagyal and Moisset 1999). The phonetic studies by Fagyal and Moisset and by Smith show that (1) vowel devoicing in French is largely confined to a prosodically prominent position, phrase-final open syllables; (2) vowel devoicing in French is correlated with lengthening, not reduction, of syllable duration; (3) there are higher rates of vowel devoicing in careful speech (e.g. read text) than in casual speech (after-dinner conversation); and (4) “devoiced” vowels in French are usually only partially devoiced, with a full voicing at the beginning of the vowel (where any overlap with consonant gestures would occur). Characteristics such as these lead Smith (2003) to suggest that the phonetic mechanism behind French (H)VD is different than that motivating Japanese HVD.

Fagyal and Moisset recorded ten different speakers of Parisian French reading a text and engaging in a conversation over dinner and analyzed the distribution of voiced and devoiced tokens of [i], [y], [u], [e], and [œ]. They found that the devoiced tokens were found almost exclusively in IP-final (intonational phrase-final) positions. Smith's study, in which six subjects were recorded reading test sentences that were designed to elicit /i/, /u/, and /a/ in a variety of prosodic contexts, showed similar results. This is significant because Parisian French is also known to show significant lengthening of phrase-final syllables (Benguereel 1971; Lacheret-Dujour and Beaugendre 1999:41, 244). Fagyal and Moisset also noted much higher rates of IP-final devoicing in read texts (83-11%) than in casual conversation (1.3-6.1%). In other words, French (H)VD is not associated with the typical correlates of vowel reduction.

It is significant for the current study that Smith, as well as Fagyal and Moisset, found that French vowels are almost never fully devoiced. As Fónagy (1989) had noted earlier, the devoicing process essentially "split" the vowel into a voiced and a voiceless (sometimes fricated) portion. I argue that this type of phonetic "diphthongization" serves as the phonetic seed from which POE develops.

If, as Smith suggests, a mechanism that accounts well for HVD in Japanese will not make the right predictions for (H)VD in French, what drives (H)VD in French? Smith surveys a variety of options, not all of them mutually exclusive. She notes that there are two prerequisites to phonation: (i) the vocal folds must be properly adjusted and (ii) there must be a sufficient difference in air pressure between the subglottal and supraglottal cavities. Since voicing ceases part way through the production of the vowel, something in

the vocal tract must change between the onset of the vowel and the cessation of voicing such that one of these criteria is no longer met.

One explanation is that offered by Fagyal and Moisset: devoicing is due to a narrowing of the oral constriction. This leads to an accumulation of pressure in the supraglottal cavity so that Smith's first requirement (referred to by Ohala (1997) as the "Aerodynamic Voicing Constraint" or AVC) is no longer satisfied. She notes, however, that this explanation is not completely adequate since it accounts only for high-vowel devoicing (and Parisian French low vowels may be voiced instead). Based on Loevenbruck (1999)'s observation in French of "hyper-articulation" in prosodically prominent positions, Smith suggests that, under Fagyal and Moisset's model, /a/ should actually be less likely to devoice in phrase-final position than elsewhere (since it should be even more open than elsewhere). However, she neglects to note the possibility of a tighter pharyngeal constriction, accompanying a hyper-articulated low back vowel, having a similar effect as a dorsal constriction. Smith also considers the possibility that devoicing is caused by a decrease in subglottal pressure, since such declines in pulmonic activity across utterances have been observed. However, she notes that this mechanism is inadequate, by itself, to account for the observed pattern (i.e. only the last portion of the last segment of an utterance is devoiced). Finally, she suggests that the cessation of voicing could occur because the first requirement is no longer met: the vocal folds relax phrase finally in anticipation of their return to rest position.

Smith's conclusion is that vowel devoicing in French is probably the result of a combination of these conditions. The fact that high vowels devoice at a significantly greater rate is due to the fact that more factors affect high vowels than other vowels. The

AVC mechanism applies only to vowels or other segments with a tight enough constriction that a significant amount of air pressure can accumulate behind it during the articulation of the segment. This would include high vowels, and possibly vowels accompanied by a tight pharyngeal constriction (e.g. low back vowels), but not others. This effect would interact in an additive sense with both a decline in subglottal pressure and the abduction of the vocal folds. In other words, the mechanism leading to vowel devoicing in Parisian French probably includes both articulatory and aerodynamic factors, but it is primarily the aerodynamic factors that favor the voicing of high vowels over non-high vowels.

3.2.3. The case of Hpun

A particularly instructive case of vowel height conditioning laryngeal phenomena is that of Hpun (Hpon), a Lolo-Burmese language of Burma. It is significant, not only because it is closely related to one of the languages that has undergone POE (Maru) but because the particular pattern of laryngeal effect found in Hpun is very instructive in understanding how POE might take place.

Hpun is now highly endangered, but two dialects were studied by G. H. Luce in the mid-twentieth century: “Metjo” and a “northern” dialect. Some of the data from Metjo dialect were published in Luce (1985). The wordlist from the northern dialect was published later by Henderson (1986), with considerable editing. However, she did not attempt to reconcile the numerous variants recorded by Luce, and presented them more or less as she found them, which is crucial for our purposes here.

Luce noted that some vowels were terminated by a laryngeal gesture other than modal phonation. In some cases, this sounded to Luce like an [h]; in others, as he

described it, the vowel was followed by an abrupt “glottal catch” (though usually not a full glottal stop). Importantly, these sounds do not correspond to final consonants in other Burmish languages. Final stop codas in other Burmish languages correspond to true glottal stops in Hpun and were generally distinguished from them by Luce. Neither Luce nor Henderson claimed to know whether this phenomenon was structurally significant. Henderson suggested that it was a prepausal effect (it is largely but not exclusively word-final) and likened it to a similar phenomenon in a dialect of Karen. For convenience, I will refer to these whispered or laryngealized vowel termini as *laryngeally-defective off-glides*. These are probably identical in their origin to the epenthetic laryngeals (-[h] and -[ʔ]) that have been documented in numerous branches of Austronesian, including languages closely related to Lom and Singhi (Blevins 2008:89).

The distribution of laryngeally-defective off-glides differs somewhat between the two dialects. In the northern dialect, they occur after a wide range of vowels, but are most common after the high vowels and [a]. Within the wordlist, there are 541 instances of vowels in open syllables or syllables that would be open if not for the emergent codas. Of these 541, 113 are followed by emergent codas and 428 are not. 189 of the vowels are high vowels and 352 are non-high. However, of the syllables with emergent codas, 62 are high (compared to 51 non-high). This distribution is highly unlikely to be due to chance ($\chi^2 = 23.87$, $df = 1$, $p < 0.0001$). As in the case of French vowel devoicing, vowel height is not an absolute determinant of “laryngealization”. This is clearly right for the northern dialect, and was almost certainly right at the genesis of this phenomenon. Most of the defective off-glides occur word finally. Since Luce was eliciting individual words, it is likely that most word-final vowels are also phrase final and utterance final. However,

Luce recorded instances where his “glottal catches” occur within compounds (e.g. *ih¹sa⁴* ‘brother’) suggesting that these emergent segments have come to behave as part of the realization of phonemes or morphemes, rather than being only a secondary effect of phrasal prosody and phonetic constraints. I suggest that these laryngeally-defective off-glides are similar in their ontogeny to the devoiced termini of Parisian French vowels. On the one hand, factors like decreasing subglottal pressure and anticipatory relaxation of the laryngeal articulators lead to periodic failures in voicing during the final vowel of an IP. On the other, the aerodynamic properties of high vowels contribute additional difficulty to voicing. Both causes may lead to a relatively sudden cessation of voicing during the articulation of the vowel, which may be heard as either an [h], if the vocal folds are abducted, or a “glottal catch,” if, while the vocal folds are adducted, normal phonation stops due to an insufficient pressure differential across the vocal folds.

3.2.4. High vowel devoicing and its effects in Scandinavian dialects

Various dialects of Swedish display devoicing phenomenon similar to those described for Jutland Danish above. In dialects like Central Standard Swedish, long high vowels in syllables closed by stops have developed a very close off-glide which has may be pronounced as aspiration, a voiced fricative, voiceless fricative, or even a voiceless affricate. Thus *bit* ‘a bit, a bite’ may be pronounced as [bit], [biht], or [biçt], and *gud* ‘god’ may be realized as [kuβd], [kuϕd], or even [kupϕt] (Helgason 2002:88). This super-high off-glide is not restricted to closed syllables. Thus, *bi* ‘honey bee’ is realized as *bij*.

The Danish cases discussed by Anderson (Andersen 1972) and mentioned above take this development one step further. The word *bi* ‘honey bee’ has become [bij] in some dialects, [biç] in others, and [bic] in others still. Andersen suggests that these form a

progression, which he describes in terms of changes in the distinctive features of the second part of the vowel: first, in the feature [vocalic], then in the feature [consonantal], and finally in the feature [continuous]. Whether one accepts or rejects Andersen's analysis of the change in terms of distinctive features as an explanation for this innovation in Jutland Danish dialects, the progression he outlines provides a clear trajectory by which high vowel devoicing could lead to POE.

In order to set the necessary series of events into motion, a language must have high vowels that are produced with considerable dorsal constriction and enough tension in the walls of the vocal tract to prevent passive expansion of the oral cavity. Devoicing of these vowels is most likely if, as in Central Standard Swedish, the vowels are produced with closing off-glides. Since a constricted oral tract is hostile to voicing, terminal devoicing of high vowels will occur at a greater frequency than devoicing of other vowels, yielding the kind of pre-pausal variation seen in Parisian French. As suggested by the Hpun cases, this devoicing may be manifest as either a devoiced vowel or glide—a weak fricative—with the vocal folds abducted, or as an abrupt interruption in voicing (with the vocal folds adducted). At the same time, the devoicing may spread through the lexicon by a kind of analogical leveling to instances of morphemes and phonemes that are not phrase final, as illustrated in Metjo Hpun. The weak fricatives may be subsequently strengthened by listeners who assume that the weak articulation is accidental. This would yield Andersen's [biç] (< [bi̯]). A subsequent reanalysis of this fricative off-glide, or a direct reanalysis of devoicing failures, would lead to Andersen's [bic]. As argued below in Section 5, final obstruent that ultimately emerges is probably the result of an

interaction of psychoacoustic and language-internal factors. However, the phenomenon itself is a unified one and the differences in cases are matters only of detail.

4. An analogue to POE: tonogenesis

POE, as presented here, may seem to be an unusual change—a consonant “spontaneously” emerges out of a vowel. However, there are many analogous processes. Perhaps the best known of these is tonogenesis, the process by which segmental contrasts (usually of consonants) are reanalyzed as tonal contrasts. A prototypical (though not uncontroversial) example is that proposed by Haudricourt (1954) for Vietnamese and Chinese: *-ʔ and *-h (< *-s) are reanalyzed as rising and falling tones respectively. The coda is essentially “swallowed up” into the vowel. In some respects, this is the reverse of POE, where a vowel “spits out” a consonant coda^{iv}. In the following section, I will make a more detailed comparison between a comparable but more recent (and less controversial) example of tonogenesis—the origin of the Lahu high rising as presented in Matisoff (1970).^v

4.1. Tonogenesis in Lahu

Proto-Lolo-Burmese had three contrasting tones in smooth (non-stopped) syllables and two in stopped syllables. Lahu, prior to the development of the high rising tone, had undergone two tonal splits, yielding five contrasting tones in smooth syllables and two in stopped syllables. The only coda consonant was (and is) glottal stop, which reflects Proto-Lolo-Burmese *-p, *-t, and *-k. It also inherited a set of glottalized obstruents, contrasting with plain obstruents. In stopped syllables whose onsets were glottalized obstruents, glottal stop, or voiceless fricatives, the final glottal stop

disappeared, replaced by a high rising tone. The glottalized onstruents subsequently merged with their non-glottalized counterparts.

4.2. Phonetic precursors

Some phonetic researcher has indicated that glottal stops have a predictable effect upon the pitch of neighboring vowels, raising them (Hombert, John J. Ohala, and Ewan 1979). Consequently, syllables ending in glottal stops will, on average, have a higher terminal pitch than similar syllables with no final glottal stop. However, consonantal environment is only one of many determinants of pitch. Properties of the speaker's vocal tract, laryngeal coarticulation with other consonants, sentence intonation, preexisting tone or accentual systems, and even the intrinsic pitch of vowels also introduce variation into the "cloud" of examples from which learners of a language must infer the phonological function of pitch in their language. Speakers show a robust ability to compensate for most of these factors most of the time. However, syllables ending in glottal stops will be redundantly differentiated from syllables with open syllables by their higher pitch.

In the same way, the aerodynamic properties of high vowels skew the distribution of vowel-final voicing failures. Learners will encounter these in non-high vowels, and will encounter high vowels without them, but on the balance they will be more common in high vowels and high vowels will be more likely to display terminal devoicing than other vowels. As with pitch perturbations caused by neighboring consonants, these voicing perturbations introduce informational redundancy into the set of speech stimuli to which learners are exposed.

4.3. Consonant to tone, vowel to consonant

This redundancy affects the acquisition of phonology by learners. There is a substantial body of recent phonetic literature suggesting that stored phonetic representations are rich—they contain both redundant details and details specific to particular lexical items and even specific utterances of a lexical item (Tenpenny 1995; Goldinger 1996; Goldinger 2000; Johnson 1997; Pierrehumbert 2001a). This allows talkers to make use of multiple different cues for identifying a particular lexical or phonological item. This also means that the language learner has access to a wide range of phonetic variants from which to construct phonological representations. Under such conditions, listener would not necessarily know which of the variant properties they perceive and store are “intentional” and which are the accidental result of physical or psychophysical constraints, nor would they need to know in order to achieve communicative competence.

I will assume that speech episodes are organized into categories at various levels. Specifically, I will make reference both to stored instances of lexical items and stored instances of utterances which are related to a system of cross-classifying relations (Pierrehumbert 2001b; Pierrehumbert 2003; Wedel 2003). This implies that higher-level units like words are related to lower level units by a symbolic, rather than purely stochastic, relations, e.g. the percept [ʔwàʔ] might be analyzed as including instances of /ʔw/, /a/, /ʔ/, and / ʔ/. This parsing should not be seen as a linear, chronological “slicing up” of the acoustic signal—this would be especially problematic in the case of suprasegmentals—but as the as-exhaustive-as-possible assignment of perceptual cues to segmental categories. Pierrehumbert (2003) argues persuasively that segmental categories originally form around “phonetic modes”—local concentrations of phonetic properties—

which can be observed independently of lexical distinctions. Older learners, however start making use of generalizations over the lexicon in constructing segmental categories. Segmentation, she points out, can be particularly experience-dependent, with different learners arriving with different segmentations for the same lexical items. In such a model, the relation between levels is dynamic and, as the set of stored episodes changes (through the introduction of utterances and the decay of old utterances) the analysis of a lexical items into segments may also change. I suggest that segmental categories compete for instances in such a way that they promote the minimization of information. Categories that encode little or no content are not able to compete for potential members with similar categories that do. On the other hand, large categories that “disguise” information by encompassing correlated multimodal distributions of form and content will tend to lose parts of their membership to more coherent, smaller categories. In effect, the cross-categorization model becomes optimized over the lifetime of the speaker, minimizing both the number of categories and the internal variance within categories.

In the Lahu tonogenesis case, as described above, speakers would be exposed to a range of variants for syllables like /^hwàʔ/, including perhaps [^hwàʔ²¹], [^hwàʔ¹³], [^hwàʔ⁴⁵], [^hwàʔ³⁵], and so on (where the superscript numerals are Chao tone numbers indicating the pitch contour of the syllable). It would not be clear to speakers whether the tenseness or glottalization that is spread across the syllable is due to the onset or a coda (which, lacking oral place features, would be difficult to perceive apart from its effect of the preceding vowel). Some speakers may posit phonological representations (segmentations) that lack the glottal stop coda (attributing the glottalization of the whole syllable to the onset). However, even for such speakers, the exemplar cloud for historical

/ʰwàʔ/ would differ from that for historical */ʰwà/*, since it would have a larger share of high toned exemplars. If, however, learners posited a new tone category, under the pressure of phonetic difference, this category would rapidly accumulate members like historical */ʰwàʔ/*, reducing the internal variance of the other tonal categories. This would not affect syllables like historical */wàʔ/*, since the glottal tension during the production of the vowel can only be attributed to the final glottal stop, to which the pitch excursion can also be attributed. In this way, a privative contrast between the presence or absence of glottal stop was transformed (for syllables with glottalized, glottal, or voiceless fricative onsets) into a qualitative, paradigmatic contrast between tones.

POE represents a different, but comparable, transformation of contrasts. Articulatorily and aerodynamically induced errors contribute to the field of exemplars from which a learner can draw. In some of these, voicing stops while the oral articulators are still producing a vowel, resulting in an abrupt cessation of airflow, a continuation of airflow through open vocal folds, or even a weak fricative (if the oral constriction is close enough). Because aerodynamic factors particularly disfavor voicing during high vowels and close glides, high vowels are particularly likely to be affected. The effect would be especially strong if the articulators move closer together during the production of the vowel. Learners are then left with at least two different phonetic dimensions in which exemplars of categories like */u/* and */o/* systematically vary: the frequency of F1 and the laryngeal properties of the last portion of the vowel. Also, they are left with two ways the instances of */u/* can be analyzed into categories: as a unit */u/* with the variants [u], [uw], [uɰ], [ux], and [uʔ], or as a sequence of a back vowel (*/u/* or */o/*), followed by a consonant (the source of the laryngeal disruption). The change occurs when it becomes more

informative for learners to analyze lexical items containing final high vowels as sequences of a vowel and consonant rather than unit vowels. Just as parsing the pitch effects of the glottal in Lahu to an additional tonal category allowed for the reduction of variance in other tonal categories, assigning laryngeally-defective off-glides to following obstruent consonants in POE languages allows for the reduction of variance with the high vowel categories. Once the defective off-glide is factored out as a different segment, the difference between former high vowels in word-final open syllables and high vowels elsewhere is greatly reduced. The difference between these vowels and mid vowels in open syllables may also be reduced, allowing for a model with both fewer and more homogenous categories. POE, in its full-blown form, results when learners are seduced by the economy of such a model and its sublexical implications influence the production of lexical items. Over time, the lexical instances of laryngeally defective off-glides that have been assigned to an existing obstruent category, and the instances of historical obstruents that already composed the category, converge in production. As detailed in section 5.1, the identity of this consonant is heavily influenced by the existing inventory of consonant codas for which the learner would already have a collection of exemplars.

On a high level, POE can be taken as a mirror image of tonogenesis. Tonogenesis (of the type discussed in the example) takes a privative contrast, the presence of a consonant, and replaces it with a qualitative contrast, a new addition to the paradigm of tones than can be born on a syllable. POE takes a qualitative contrast, vowel quality of the syllable nucleus, and replaces it with a privative contrast, the presence or absence of an obstruent coda.

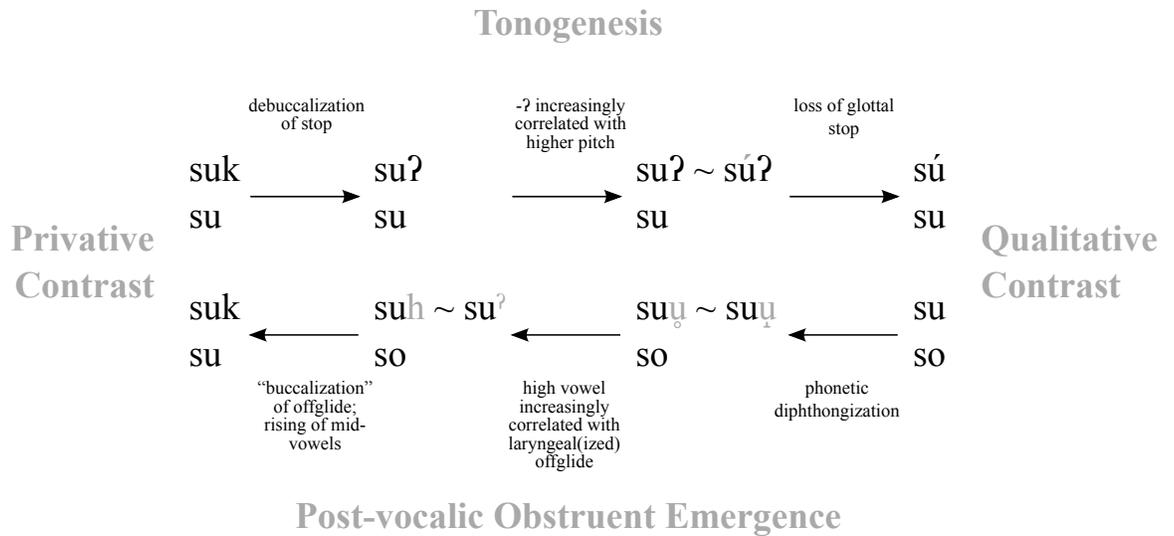


Figure 1 A comparison of schematic models of tonogenesis and POE.

Both kinds of changes are mediated by perturbations at the laryngeal level. For the tonogenesis example, the perturbing agent is a glottal consonant (from an earlier oral stop) and the mediating factor is articulation; in the POE example, the perturbing agent is a close oral constriction and the mediating factor is aerodynamic. In the POE model, the learner infers the presence of a voiceless obstruent from syntagmatic characteristics that would be consistent with the presence of an intentional voiceless obstruent: the cessation of voicing, onset of weak friction, and so on. Likewise, in the tonogenesis model, the learner infers the existence of a tonal contrast from a paradigmatic characteristic that would be consistent with the existence of an additional tonal category: relatively higher pitch.

5. Self-organization and POE

In Section 3, it was argued that POE was a unified phenomenon, occurring after high vowels, and that this phenomenon is related to the type of high vowel devoicing found in French, Scandinavian dialects, and Hpun. In Section 4, it was suggested that the

transfer of contrasts demonstrated in POE is parallel in some respects to that which occurs in tonogenesis: Phonetically conditioned biases in the production of categories were held to shift the center of gravity of their exemplar clouds in quasi-systematic ways, leading ultimately to the transfer of contrast from one characteristic (formerly primary) to another characteristic (originally accidental). What has not been address is the diversity of obstruents that result from POE (limited though it is). The table below illustrates the attested possibilities, including for completeness the Danish devoicing phenomenon described by (Andersen 1972:27) and the Trengau Malay development:

	Historical Source	
Language	-i	-u
Huishu	-ik	-uk
Fomopea	-ik	-uk
Moghamo	-ek	-ok
Trengau Malay	-əyk	-əwk
Maru	-it > -ik	-uk
Singhi	-is	-ux
Belom	-ic	-ək
Jutland Danish 1	-iç	-ux
Jutland Danish 2	-ic	-uk

A few generalizations emerge from this table. First, the obstruents that emerge from -u always have a velar place of articulation. Second, the obstruents from -i may have a coronal, palatal, or velar place of articulation, with a relatively even split among possibilities (three independent cases of velars, two of coronals, and two of palatals). However, if the scenario presented in the preceding sections is correct, one might expect palatal and velar fricatives to predominate, since they would be the immediate products of the “French” type of high vowel devoicing.

In this section, I argue that the ultimate products of POE are the result, in part, of the self-organizing properties of phonological categories. Phonological categories at the

segmental level, I propose, compete for instances in a way that tends over time to minimize both the number of categories and the internal variance of each category. Re-segmentation will only occur, for a particular speaker, as a response to new speech episodes that render the former segmentation model unstable and will tend to be incremental and conservative in nature. It is sometimes preferred to add outliers to an old category rather than to posit a new category. This conservatism is magnified through its interaction with motor entrenchment and learned perceptual biases. As a result, the segments resulting from POE in a given language often differ phonetically from a laryngeally-defective off-glide but tend to be very similar to the segments already allowed by its phonology.

5.1. Correlations with phonotactic restrictions

POE seems to have a tendency towards structure preservation (in a broad sense). That is, the segments that emerge, in a particular language, tend to already be allowed as codas in the language or to be like licit codas in the language. These facts can be summarized in a few general statements:

1. When obstruent codas emerge in a language, the language already has obstruent codas.
2. When fricatives emerge, the language already has fricative codas.
3. When coronals emerge, the language already has similar coronal codas.
4. Palatals are less likely to emerge if a language lacks palatal codas (but cf. Jutland Danish).

The following table illustrates these patterns; coda consonants that were not licit prior to POE are indicated in boldface:

Language	Historical Source		Coda manners		Coda places		
	-i	-u	obs	fric	cor	pal	vel
Huishu	-ik	-uk	X				X
Fomopea	-ik	-uk	X		X		X
Moghamo	-ek	-ok	X		X		
Maru	-it > -ik	-uk	X		X		X
Singhi	-is	-ux	X	X	X		X
Belom	-ic	-ək	X	X	X	X	X
Jutland Danish 1	-iç	-ux	X	X	X		X
Jutland Danish 2	-ic	-uk	X	X	X		X

These facts are consistent with a current perspective on language change that sees life-long language acquisition as involving a feedback loop where the classification of percepts is never independent of the previous history of perception. As numerous perceptual studies have demonstrated, that speech perception is heavily influenced by a listener’s native language (reviewed in Hume and Johnson 2001; see Huang 2004 for an especially compelling study). This does not simply mean that a learner’s perception of an L2 will be filtered through her experience of her L1, but also that her *future* perception of her L1 will be filtered through her *past* experience of her L1. If such a feedback loop exists, the coherence of a set of linguistic categories should, on the balance, increase over time. The new categories that are added will tend to fit comfortably in the perceptual space that has been warped by the established categorization of percepts. Likewise, motor routinization effects mean that the variants of lexical items most likely to be produced are those consisting of gestures common in other lexical items. In effect, sound changes will be “canalized” by the phonologies of the languages they affect. This general class of effects is termed “structural analogy” by (Blevins 2004:154).

5.2. Generalizations following from reanalysis

The laryngeally-defective off-glides that give rise the reanalysis of high vowels as vowel-obstruent sequences are themselves of variable and ambiguous quality. At times,

they are weak fricatives; at other times, they may sound something like weak glottal stops. Because they do not necessarily involve an oral articulation distinct from that of the vowels from which they arise, their place features may be ambiguous as well. They differ enough from the termini of high vowels that are not domain final that parsing them as the exponent of a segment other than the vowel will greatly increase the internal coherence of the vowel category (making the instances relatively more similar to one another), but the off-glides themselves are, as a category, not exactly like fricatives, stops, or any other common consonant type. While off-glides from /i/ are likely to have spectral cues similar to those of palatals and those from /u/ are somewhat likely to sound like velars, the unusual manner properties of the off-glides will mean that they will always sound like one-another (as aggregates) in ways that they sound unlike any of the other consonant sounds. This means that the off-glides are likely to be treated different ways, during reanalysis, depending on the existing consonant inventory of the language.

In most of the cases examined—Maru, Fomopea, Singhi, and Belom—POE does not introduce new consonant segments into the language. Instead, laryngeally-defective off-glides are reanalyzed as instances of existing consonants. In most of these cases—Maru, Singhi, and Belom—off-glides from front and back vowels have been reclassified as obstruents at different places of articulation. In cases where POE introduces new obstruent codas, Huishu and Moghamo, it only introduces one. These observations follow straightforwardly from the assumption that learners adjust their segmentation continuously, in response to new data, but in a conservative fashion that minimizes both the number of categories and the internal variance (in both form and function) within categories. Under such a model, if a learner reanalyzes what she had considered a single

segment into a sequence of two segments, she will always prefer to reuse existing categories *unless* one of the new segments is so different from any existing category that it would be less “informationally expensive” to treat it as an independent category.

This helps us to resolve two apparent paradoxes:

1. Although laryngeally-defective off-glides with fricative-like characteristics are probably more frequent than those with stop-like characteristics, many cases of POE produce stops rather than fricatives.
2. Although laryngeally-defective off-glides from /i/ probably have perceptual properties more like palatals than coronals and more like coronals than velars (see Manjari Ohala and John J. Ohala 2001 for a relevant perceptual study), their segmental reflexes are usually coronal or velar.

In other words, they help us to explain why the phonetically expected development *-i/, -u/ > -iç/, -ux/* (Jutland Danish) is attested but apparently not as common as *-i/, -u/ > -ik/, -uk/* (Huishu, Fomopea, Moghamo). If learners are more likely to reinterpret devoiced off-glides as instances of an existing segment than to posit the existence of a new segmental category, and if, as argued by (Pierrehumbert 2003), positional variants of phonemes (rather than phonemes themselves) serve as the basic locus of classification for segments, it follows that laryngeally-defective off-glides are unlikely to be reanalyzed as fricatives except in languages that already allow fricative codas. Thus, in Singhi, POE gives rise to instances of *-s/* and *-x/* because these segmental categories were already present in the language; in Grassfields Bantu languages—which typically lack phonemic fricative codas but allow stop codas—short high vowels may appear with predictable fricative off-glides *prior* to reanalysis but full POE

seems always to produce stops. Additionally, the absence of final fricatives in these languages may mean that perceptual spaces of these speakers are “warped” such that coda fricatives and coda stops are relatively close together. This is almost certainly exacerbated by the fact that the accidental fricative off-glides are non-sibilant fricatives, which may be confused with stops even when fricative categories are available. Thus, English speakers may hear *Bach* and *loch* and perceive final velar stops instead of fricatives, or that Dutch speakers may perceive English /θ/ and /ð/ in final position as /t/ and /d/ (Wester, Gilbers, and Lowie 2007).

Similar logic applies to the off-glides from /i/: when a language allows palatal obstruent codas, these are likely to be reanalyzed as palatals, as in Lom, and are likely to be distinguished from the off-glides from /u/. When a language, like Huishu, lacks coronal, palatal, and velar obstruent codas, we predict correctly that the off-glides from front and back vowels will be categorized together and for the category to contain a range of palatal and velar-like exemplars. There is compelling evidence from various domains that motor routines which are frequently repeated become entrenched, and act as attractors for similar motor routines (Zanone and J A Kelso 1992; Zanone and J A Kelso 1997; J. A. Scott Kelso 1995). Effectively this means that exemplars within this cloud that approximate motor routines employed for other segments are more likely to be reproduced. Thus, for Huishu, which has nasal codas with a velar closure, but no palatal codas whatsoever, the velar region in the exemplar cloud will gradually grow denser through reinforcing feedback, while the palatal region will gradually grow more diffuse as old exemplars decay.

A more difficult question is raised by languages like Maru and Fomopea, which had coronal and velar stop codas at the time of POE, but which display different outcomes: In Maru, the “place” variance was minimized by distributing the off-glides from /i/ and /u/ between -/t/ and -/k/ respectively; in Fomopea, the “manner” variance was minimized by placing all the off-glides in the same -/k/ category. Both of these outcomes are plausible under our model, depending on a number of chance variables: the distribution of phonetic properties among exemplars with laryngeally-defective off-glides, the order in which high vowels are resegmented (front first, back first, roughly simultaneous), and so on. For example, if the back vowels were re-segmented first, as may have been the case in Momo (Moghamo, Ngie), the resulting velar obstruent category would provide a strong “attractor” for re-segmenting the front vowels (since it would already contain a large number of defective off-glides). At the same time, the new off-glides from the front vowels would not be sufficient in number or level of activation to shift the place of the category as a whole.

The fact that POE tends to minimally multiply segmental categories need not be attributed to any global optimization of phonological systems, promoting symmetry of inventories or ensuring maximal perceptual distance between categories within a system. Instead, these properties can be derived from learning model where members of a speech community are only striving to reproduce the code already used within the community.

5.3. Chain shifts, dispersion effects, and POE

Just as the influence of the existing inventory of coda consonants upon the codas that emerge in POE can be understood purely as a byproduct of learning optimizations, the wider effect of POE on a phonological system can be understood in the same terms.

For example, there are multiple cases where mid vowels are raised to high vowels after high vowels become VC sequences via POE (e.g. Huishu and Maru). From a post hoc perspective, the components of these chain shifts may appear to be casually related or part of a system of changes. It is, indeed, possible to view these changes as the produce of dispersion effects that serve to maximize the perceptual distinctness of categories within a phonological inventory, a view that has seen considerable application both to the diachronic and synchronic study of phonological inventories (Liljencrants and Bjorn Lindblom 1972; B. Lindblom 1986; Flemming 2002; Flemming 2005; Padgett 2001; Padgett 2004; Padgett and Tabain 2005). While there is little reason to doubt that dispersion effects exist both in individual speakers and in the history of phonological systems, it is unnecessary to appeal to global optimizations in order to understand the dispersion like effects produced by POE. Instead, they can be derived from the same principles of exemplar-based learning introduced in the preceding sections.

For purposes of illustration, consider the series of phonological developments surrounding POE in Huishu, illustrated in Figure 2. The area inside the square represents the vowel space of open-syllable rhymes. The area outside the square represents closed syllable rhymes. Arrows represent historical movements in phonological categories within phonetic space:

Figure 2 Chain shifts in Huishu rhymes.

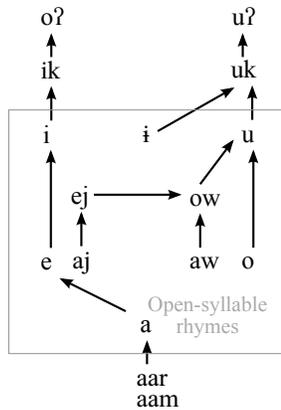


Table 7 provides evidence for the debuccalization that occurred prior to POE and

Table 8 provides evidence for the raising of mid-vowels, which occurred after POE.

Table 7 Data illustrating that Proto-Tangkhal *-ik, *-uk > Huishu -o?, -u?.

Proto-Tangkhal	Ukhrul	Kachai	Tusom	Huishu	
*-mik	-mik	-mæk	-mĩ	-mo?	‘eye’
*-hrik	-rik	-ræk	-hri	-ro?	‘louse’
*-tsik	-tsik	-ðæk	-zi	tso?	‘black’
*-buk	-vuk	-wuk	-pu	-wu?	‘stomach’
*-t ^h uk	-t ^h uk	-t ^h uk	-t ^h u	-tu?	‘deep’
*-k ^h uk	-k ^h uk	-k ^h uk	-kxu	-k ^h u?	‘knee’
*-ruk	-ruk	-ruk	-ru	-ru?	‘six’

Table 8 Data illustrating that Proto-Tangkhal *-o > Huishu -u and that suggesting that *-e > -i.

Proto-Tangkhal	Ukhrul	Tusom	Huishu	
*-lo	-lo	-lu	-lu	‘buy’
*-ko	—	-ku	-ku	‘nine’
*-fo	-fo	-sxu	-su	‘open’
*-bo	-wo	-pu	-vu	‘crawl’
*-p ^h e	-p ^h e	pfi	—	‘slap’
*-hwe	—	xwi	hwi	

As illustrated, POE was preceded by the debuccalization of most coda stops (including all instances of *-k and *-t) and was followed by the raising of earlier mid vowels to the high position. While the evidence is fragmentary, *-e probably became /i/. Much stronger evidence shows that *-ow and *-o merged to become /u/, after which *-ej

and *-aw merged to become /ow/. *-a and *-aj were raised to become /e/ and /ej/ respectively. Finally, the place vacated by *-a was filled when formerly closed rhymes like *-aar and *-aam became /a/. Since these changes are not paralleled in any of the closely related Tangkhulic languages, they are like to be fairly recent and to have occurred over a relatively brief period of time. As an aggregate, they leave Huishu with a smaller and better-dispersed inventory of six open-syllable rhymes: /i e u a ej ow/ while filling a gap in the coda inventory. To what extent does POE need to be seen as a casual or facilitating factor for these changes?

Debucallization of coda stops is extraordinarily common, probably for perceptual reasons, and requires no independent systemic explanation. According to the model presented above, it probably affected the outcome of POE, by eliminating the contrast between /t/ and /k/, making an outcome like that in Maru less likely. It could plausibly have contributed to the fact that POE occurred at all in Huishu, by “freeing up” an area in phonetic space. If this is the case, it need not be understood in terms of systemic optimization, since alternative accounts stated in purely in terms of exemplar-based learning exist. Ettliger (2007) was able to demonstrate both push-chain and pull-chain behavior in a computer model that only categorized percepts (with no systemic optimization). Push-chain behavior occurred, as predicted by Labov (1994), when one category encroached upon the phonetic space of another, shifting the center of gravity of the first category and thus affecting subsequent productions. Pull-chains, of interest here, occurred because empty regions of the phonetic space presented no competition for percepts. Similar results were reported by Wedel (2004). It is possible that the encroachment of Huishu mid vowels on high vowels encouraged a shift of the phonetic

center of gravity for the high vowels such that exemplars with laryngeally-defective off-glides were better representatives of these categories than would have otherwise been the case. This would have been facilitated by the absence of competition from sequences like *-/it/*, *-/ut/*, *-/ik/*, and *-/uk/*. However, the case of Maru shows that the absence of such sequences is not necessary to POE. Indeed, as was argued above, pre-existing obstruent codas that are perceptually similar to the defective off-glides actually facilitate POE.

Leaving aside the issue of causes of POE, the model of segmental reanalysis sketched above actually predicts the next step in the chain-shift, the raising of the former mid-vowels. If aerodynamic biases shifted the center of gravity of /u/ such that the prototypical exemplars had defective off-glides, *-/o/* would face relatively little competition with *-/u/* for instances with a relatively low F1 (as long as they lacked a defective off-glide). As a result, many exemplars of *-/o/* would be minimally different from exemplars of /u/ in closed syllables and the portion of exemplars of *-/u/* modulo any defective off-glides. In reanalysis, a rational learner would be strongly predisposed to characterize the instances of /o/, the instances of /u/ in closed syllables (including new closed syllables from POE) as members of a single category.

The other changes show in Figure 2, while less closely related to POE, all can be attributed to the same casual mechanisms as those discussed so far (apart from the rather unexpected merger of **-ej* and **-aw* as *-/ow/*). Speech production and perception introduce variation into the range of exemplars stored by speakers. Much, but not all, of this variation is subject to physical and psychophysical biases. For example, there appears to be a general bias towards raising in long and peripheral vowels (Labov 1994:601). Since categories compete with one another for individual percepts, the probability of a

percept being stored as an exemplar of the target category is directed related to its distance, in perceptual space, from non-target categories. The center of gravity of categories will tend to shift towards areas where a greater percentage of exemplars are successfully identified and therefore away from other categories. If categories are relatively diffuse, categories will tend to survive encroachment events, but with shifted centers of gravity; if categories are relatively compact, mergers will occur instead (Ettlinger 2007). The diffusing tendencies of these forces is balanced, of course, by perceptual and motor biases. In such a model, there is no need to talk about push-chains and pull-chains per se, or to discuss perceptual optimizations mandated by either the grammar or ameliorative predispositions on the part of language learners. Instead, changes in the system emerge from interactions between learners, each of them acting in good faith, attempting to reproduce in their speech what they have heard from other members of their community and have themselves said to good effect. POE, when it is understood as the consequence of universal aerodynamic constraints, follows as cleanly from such a model as more widely studied phonological changes.

6. Conclusion

Although the emergence of obstruent codas after high vowels is uncommon enough to have escaped widespread attention from theoretical linguists concerned with the general mechanism of sound change, its independent attestation in multiple language families and geographic regions suggests that it cannot be treated as a historical curiosity. Instead, it must be seen as a universally possible sound change, as relevant to our understanding of phonology and phonological change as any other recurrent sound change. Although POE operates in an apparently perverse fashion from the standpoint of

common assumptions about phonology, inserting word final obstruents rather than deleting them and converting open syllables into closed syllables, it has clear phonetic precursors and its progress can be understood straightforwardly in terms of independently motivated assumptions about language acquisition, variation, and change. A close examination POE and similar innovations show that sound changes do not necessarily improve a linguistic system according to some universal set of criteria, but also cannot be understood apart from the phonological systems which they affect. POE, for example, takes the divergent paths it does due to the interaction of chance and the biases that the existing phonological system impose upon the language learner.

Such biases may also play a role in determining whether, given an appropriate field of phonetic variation, POE occurs at all. This, in turn, may help to answer a larger and more difficult question: why isn't POE more common than it is? After all, the fundamental phonetic requirements for POE are not complicated—voicing must fail at an above chance rate during the production of phrase-final vowels. It is, however, subject to certain limiting factors: It is only likely in languages with tightly constricted vowels and is, therefore, more likely to occur in languages with widely dispersed vowels systems (e.g. those with three or more height distinctions) than in those with more compact vowel systems. It is also more likely when these close vowels have an even closer off-glide. However, satisfying these requirements does not guarantee the emergence of coda obstruents. This will only occur, I have argued, if the single vowel is reanalyzed as a vowel-obstruent sequence, and this reanalysis (like other parsing errors) can only happen if there is a structural analog for the new structure elsewhere in the system. Therefore, my

model predicts that POE should only occur in languages having already codas perceptually similar to the devoiced off-glides of vowels.

If POE fails to occur where it would introduce novel types of structures, when it actually does occur, its effects are unlikely to draw attention to themselves. This is compounded by the expectation, shared by many historical linguists, that final obstruents are likely to be deleted but unlikely to be inserted in the history of a language. I submit that comparative linguistics, like speech perception, is exemplar-driven behavior and that practitioners are most likely to recognize a phenomenon in the wild when they have in mind a cloud of similar instances. The high frequency of final obstruent deletion and the relative rarity of POE means that a normal historical linguist will usually have highly “activated” exemplars of the first in mind but may have few or no exemplars of the second, meaning that cases of POE are likely to be miscategorized as obstruent deletion except when the evidence otherwise is overwhelming.

Thus, the apparently rarity of POE probably results from the interaction of two factors: the fact that both phonetic and structural prerequisites must be satisfied in order for it to take place and the fact that it is likely to be ignored or misdiagnosed by linguists who are not familiar with POE and the cluster of related phenomena. It is to be hoped that this study will help linguists working in language families outside of Tibeto-Burman, Austronesian, Bantu, and Germanic to identify further cases of this theoretically interesting sound change.

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ⁱ In at least one dialect, *-it* has subsequently become *-ik*, regardless of its historical origin.

ⁱⁱ The nature of the final consonant that is transcribed as “c” in the Ngie data is uncertain, and appears as both “j” and “dʒ” (and possibly “f”) in the list provided by Gregg (2002), probably as a result of inconsistencies in the retranscription of the data from its original source (a word list attributed to Jean-Marie Hombert). Based on the available evidence, it seems most likely that the segment in question was a palatal stop or affricate.

ⁱⁱⁱ The Fomopea data are from undated field notes to which Larry Hyman graciously provided me access.

^{iv} I would like to thank one of the anonymous reviewers for suggesting this analogy.

^v While the general outline of this scheme has been accepted by many scholars for both Vietnamese and Chinese considerable controversy remains about how direct the relationship between coda consonants and tone was, with certain scholars emphasizing the role of phonatory registers as diachronic mediators between earlier consonants and later tones (Thurgood 2002). In order to sidestep these complicated questions, I have chosen to concentrate on the Lahu tonogenesis case instead.