Emergent Stops

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Two of the most fundamental distinctions between classes of speech sounds is that between sonorants and obstruents and between continuants and non-continuants. Sonorants are characterized as sounds which have no constriction small enough to impede the flow of air to the point of creating any audible turbulence; obstruents, as sounds which have a constriction which does impede the flow of air to the point of creating turbulence a stop burst. Continuants are sounds which could be extended indefinitely whereas non-continuants involve a momentary and abrupt attenuation of the speech signal amplitude. This being the case, it is a rather remarkable phonological event when a stop, which is an non-continuant obstruent, appears as it were, “out of nowhere” surrounded by speech sounds which are either sonorants and/or continuants. Typically these are referred to in the phonological literature as ‘epenthetic’ or ‘intrusive’ stops, terms which reflect the belief that they were introduced by some external cause. Some examples are given in (1) (for references, see Ohala 1995, in press).

(1)	Engl.	*youngster* [ˈjʌŋkstɚ]	<	jʌŋ + stɚ
	Engl.	*warmth* [wɔɻmpθ]	<	*warm* + θ
	Engl.	*Thompson*	<	*Thom* + *son* (proper name)
	Engl.	*dempster* ‘judge’	<	deem + ster
	Sotho	*vontʃa* ‘to show’	<	*voniʃa (causative of ‘to see’)
	Cl. Greek	*andros*	<	*anē ros* ‘man’
	French	*chambre*	<	Latin *kamĕra* ’room’
	Spanish	*alhambra*	<	Arabic *al hamra* ‘the red’
	Latin	*templum*	<	*tem - lo ‘a section’

A common explanation for these stops is to characterize them as ways to make the transition easier between the flanking sounds or to “repair” ill-formed phonotactics (Piggot and Singh 1985). The repair analysis has been effectively refuted by Murray (1989). In some cases phonetically-based accounts have been given for some of the above cases but not for others, where the ‘repair analysis has been invoked instead (Wetzels 1985, Clements 1987).

In this paper I propose to give a unified phonetically-based account for these stops that crop up in the environment of sounds that are themselves neither stops or non-continuants. Furthermore, I will attempt to show that they are created out of phonetic elements present in the surrounding sounds and in that sense are not truly epenthetic or intrusive. I thus advocate calling them “emergent” stops, using the term ‘emergent’ as in evolutionary biology, i.e., a term applied to ‘a novel structure that develops out of the rearrangement of *pre-existing* elements’. I will show that the success of this enterprise contains lessons for us in how to view and to represent the features characterizing speech sounds and about the role of a fine-grained phonetic analysis in elucidating the sound patterns in language. (For further details, see Ohala 1974, 1995, in press.)

1. Earlier accounts of emergent stops

Given words of the sort in (2), Passy (1890:216) offered the following explanation for the emergent stops -- and this is typical of various accounts given from the early 19th century up to the present:

> Pour passer ... de (n) à (r), il faut que le passage du nez se ferme au moment même ou s’ouvre celui de la bouche. Pour peu que le fermeture du passage du nez ait lieu

> un instant trop tôt, il se produit un (d) transitoire, que peut ensuite devenir indépendant.

I believe this is essentially the correct interpretation. All I propose to do is to formalize it somewhat in more explicit phonetic terms and attempt to demonstrate its generality to a number of other cases.

2. A formalization of emergent stops

We start by defining an air space in the vocal tract which has two possible exit valves, A and B. When both valves are closed this air space must have an air pressure differential with respect to atomspheric pressure that is not equal to zero, $|\Delta P_{oral}| \neq 0$. Next we define an initial state (the first of two concatenated sounds), C1, which has valve A open and valve B closed. Next we define a final state (the second of the two concatenated sounds), C2, where the configurations of the two valves are reversed, A closed and B open. These are represented by the left and right schemas in Fig. 1. A transitional state, the middle schema in Fig. 1, between C1and C2 where both valves A and B are closed has some probability of occurrence. Given the P_{oral} in the air space, when the valve that was closed for the initial sound, B, is opened, a stop burst will be produced.

At this stage the emergent stop is purely epiphenomenonal and, indeed, such brief unintended stops are often observed in spontaneous speech. How does this transitional element become a full-fledged sound intended by a speaker, i.e., how does it lead to a sound change? This unintended stop can be reinterpreted by listeners as an intended stop; thus a new pronunciation norm arises and there will be an emergent stop between C1 and C2 (for an account of sound change, see my paper "Phonetics in Phonology" in this SICOL).[1]

3. Application of the formalism to specific cases

For each case of sound sequences , I will first refer to some phonological data showing the emergent stop and then, using a tabular format, identify the defined air space, its pressure relative to atmospheric, the origin of this pressure, the two valves involved and their states in C1 and C2.

3.1 Nasal + fricative

3.1.1 The basic example

Examples of emergent stops in sequences of nasal + fricative were given in (1), above. Here is the tabular representation of these, using [m] + [θ] as an example.

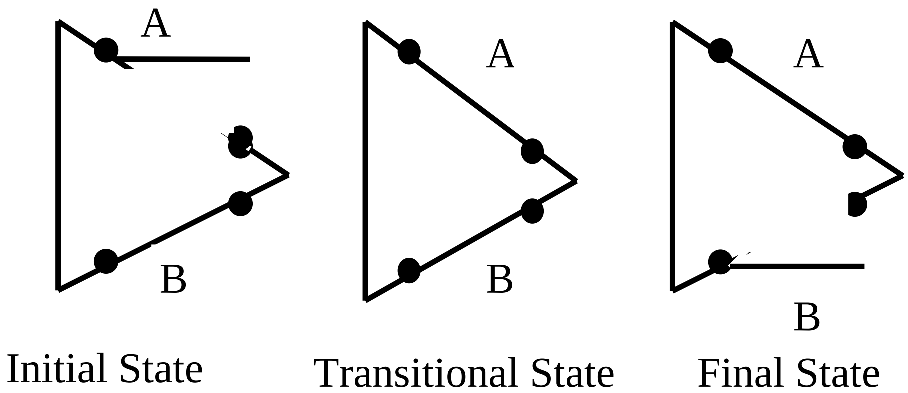

Fig. 1. Schematic representation of the vocal tract in three successive stages: left: the initial state with first of two valves closed, the second open; right: the final state with the second of two valves closed, the first open; middle: the transition between the initial and final state with both valves closed. See text for details.

Air space	Entire vocal tract from lungs to oral constriction
ΔP_{oral}	positive
Source of air pressure	lung volume decrement via pulmonic system

Consonants	**IPA**	**Valve A** velum	**Valve B** oral articulator
C1	[m]	open	closed
Emergent stop (= transitional element)	[p]	closed	closed
C2	[θ]	closed	open

The 'place of articulation' the emergent stop will be that of the first valve to be released which will always be the place of the first consonant in the sequence, C1 (with an exception to be discussed below). The mis-timing of the velic closure here is just anticipatory denasalization. The latter portions of the nasal are denasalized (and devoiced) in anticipation of the following oral and voiceless oral obstruent.

3.1.2 Some extensions

It is clear why oral obstruents like [θ s ʃ] etc. require velic closure -- these obstruents require a build up of oral pressure behind their constriction and nasal venting would prevent that. But what about [l] which seems to have triggered an emergent stop in Lat. *templum*, above? There is no aerodynamic requirement for velic closure. I claim, however, that there is an *acoustic* requirement for velic closure; allowing nasalization during [l] or the tap [ɾ] might create a sound that was too confusable with [n]. More generally, contrastively oral sonorants, including vowels, require an elevated soft palate. Thus emergent stops are seen as parts of post-stop nasals or pre-stopped nasals abutting on oral vowels in some languages, as in (2).

(2)	Parintintin	/õmoapi/	[õ^{m}boapi]	‘he cooks’
		/ɲãnu/	[ɲã^{n}du]	‘spider’
	Tenango Otomi	/nĩne/	[nĩ^{n}de]	‘your mouth’

In fact, even in languages without oral-nasal vowel contrasts, vowels with low F1 (i.e., high vowels) seem to require an elevated soft palate since added nasalization primarily manifests itself acoustically in the lower region of F1’s range (Ohala 1975). It is this factor which apparently explains Chen and Clumeck’s (1975) report of post-stopped nasal allophones of simple nasals in Korean when appearing before high vowels, as exemplified in (3).

(3)	Korean	/mul/	~	[m^{b}ul]	‘water’
		BUT:			
		/mɑl/	only	[mɑl]	‘language’

3.2. Fricative + nasal

Emergent stops between fricatives and following nasals seem to be far less common than in the reverse order but there is suggestive evidence that they can occur. As shown in (4), prescriptive Sanskrit grammarians recommended a pronunciation of some clusters of this sort with an intervening stop homorganic to the nasal. In some cases, dialectal forms of the same words suggest that such stops were actually pronounced.

(4)	**Original Sanskrit**	**Prescribed**	**Dialectal Forms**	**Translation**
	gr̄iṣma-	gr̄iṣpma-		‘heat’
	viṣɳu-	viṣʈɳu-	viʈʈhala biśʈu	‘Vishnu’

I also suspect that a similar process of emergent stops may have given rise to non-standard English forms such as [ɪdn̩t] for [ɪzn̩t] *isn’t* and [wʌdn̩t] for [wʌzn̩t] *wasn’t.*

In this case the air space affected is the same as in 3.1 and just the configuration and sequence of the valvular states is reversed.

Consonants	**IPA**	**Valve A** velum	**Valve B** oral articulator
C1	[s]	closed	open
Emergent stop (= transitional element)	[p]	closed	closed
C2	[m]	open	closed

In these cases the emergent stop is released nasally, i.e., the air pressure build up is vented through the nose. The notion of “place” of articulation in these cases is a bit hard to specify but listeners and linguists seem to associate the place of the stop with that of the nasal which, unlike the other cases discussed here, is C2.

3.3 Homorganic cluster of lateral + fricative

Emergent stops in homorganic lateral + fricative clusters are well known in English and have also been noted by Boas (1947) in Kwakiutl (transcription modified), as exemplified in (5).

(5)	Engl.	*else*	[ɛlts]		
		Ilse	[ɪltsə]		
	Kwakiutl	k’wēɬtsoʔ	<	k’wēɬ + soʔ	‘to be feasted’

Here is the tabular representation of the relevant phonetic facts:

Air space	Entire vocal tract from lungs to apical constriction
ΔP_{oral}	positive
Source of air pressure	lung volume decrement via pulmonic system

Consonants	**IPA**	**Valve A** tongue side(s)	**Valve B** tongue midline
C1	[l]	open	closed
Emergent stop (= transitional element)	[t]	closed	closed
C2	[s]	closed	open

Typically the tongue sides are not thought of a valvular structures but functionally they are and when closed (for example, during an [s]) help to channel the air through the midline opening between the tongue apex and the teeth ridge. This is an interesting case of emergent stops because virtually all feature systems agree that both [l] and [s] are continuants; yet here a non-continuant stop emerges from the coarticulation of the two.

3.4 Homorganic cluster of fricative + lateral

Emergent stops from the reverse order of sounds from that in 3.3 is well documented (see Phelps 1937, Wetzels 1985, Murray 1989, and M. Ohala’s paper at this SICOL). Some examples are given in (6).

(6)	Ital.	*Ischia*	[iskja]	<	iskla < istla < isla ‘island’
	Greek	*hesthlos*		<	*heslos*

In fact, the familiar Italian greeting *ciao* [tʃao] derives, after many peregrinations through the phonological space, from a phrase that included the word *slavo* ‘slave’, where an emergent stop arose in the initial cluster.

I omit the tabular representation here in the interest of space. The emergent stop in this case is a laterally-released [t].

Emergent stops arise only with *homorganic* clusters of lateral and fricative, not, for example, in [lx] or [lf] clusters, because in the latter cases we could not ‘defin[e] [a single] air space in the vocal tract which has two possible exit valves, A and B’.

3.5 Oral stop + glottal stop

There is evidence that an oral constriction can coarticulate with a glottal closure to produce not an emergent stop as such but to change a pulmonic stop into a glottalic one, i.e., an ejective. But the basic mechanisms I have been discussing applies in the same way. An example is given in (7), from Applegate (1972).

(7)	Chumash	k + ʔap	1st pers. + ‘house’	>	k’ap	‘my house’

The phonetic details in tabular form:

Air space	Air space between glottis and oral constriction
ΔP_{oral}	positive
Source of air pressure	decrement of oral volume (from larynx raising?)

Consonants	**IPA**	**Valve A** glottis	**Valve B** oral constriction
C1	[k]	open	closed
Emergent ejective (= transitional element)	[k’]	closed	closed
C2	[ʔ]	closed	open

There are some uncertainties in this case. The above schema would predict a sequence of [k] + [k’] but we have no independent evidence for these two co-existing, not even a hybrid segment such as [k͡k’]. However, if such a segment were formed it would probably be perceptually indistinguishable from a simple [k’]. Second, there is uncertainty whether this emergent ejective would have the typically high oral pressure found in some ejectives. There is no reason to posit larynx raising. On the other hand, some of the perceptual cues for ejectives come simply from the fact that the burst originates from a vocal tract with a glottal closure.

3.6 Non-homorganic nasal clusters

One of the most remarkable (and rare) potential cases of emergent stops are those that arise from sequences of two non-homorganic nasals, as in (8) (see Ohala 1995 for additional examples and references).

(8)	Middle Engl.	*nempne*	<	OEngl. *namna* ‘name’
		sompnour	~	*somnour* ‘summoner’
	Landais French	*dampnadge*	<	*damnaticu* ‘damning’
		fempne	<	*femina* ‘woman’
	Old Swedish	*hämpna*	<	*hämna* ‘revenge’

I posit that phonetically these emergent stops were clicks, i.e., ingressive velaric stops akin to Zulu and Xhosa [ǀ ǂ]. If the [m] and [n] were coarticulated, a small body of air would be trapped between these two places of articulation. This air cavity would undoubtedly undergo some expansion of its volume as the lip lowered for its release such that by the time of the actual release a negative pressure would have been created in the air space and a click-like ‘pop’ would occur. Listeners, I suggest, would have interpreted this as a [p], the only other acoustically similar sound that they would be familiar with. I have demonstrated that such epiphenomenal clicks can occur in English words having [-mn-] clusters such as *damnation*. Similar epiphenomenal clicks have been demonstrated for non-homorganic stop clusters in French (Marchal 1987) and Korean (Silverman and Jun 1994). In fact, it should be made clear that such emergent clicks are not limited to sequences of non-homorganic nasals; any non-homorganic complete closures would do the same. It is possible that this mechanism lies behind such emergent stops in English *dremt* [dɻɛmpt] (< *dream* + past suffix /t/).

The phonetic details for this are given here:

Air space	Air space between the two non-homorganic oral constrictions
ΔP_{oral}	negative
Source of air pressure	increase of this space's volume by lower lip movement

Consonants	**IPA**	**Valve A** apical constriction	**Valve B** labial constriction
C1	[m]	open	closed
Emergent click (= transitional element)	(no symbol)	closed	closed
C2	[n]	closed	open

An additional constraint on emergent clicks is that the order of the non-homorganic oral constrictions must be: a more forward closure followed by a more rearward constriction. Clusters where this is not the case, e.g., [nm], [tp], [ŋm], etc., might still give rise to a click but when this was released the sound that results will be released inside the closed oral cavity; 'closed', since the outermost constriction is still in place. It is unlikely that listeners would hear this click and thus it could have no impact on the phonology.

4. Conclusions

The kind of coarticulation that gives rise to stops in words such *warmth* [wɔɻmpθ] can be formalized and generalized so it accounts for a host of other cases where stops arise (as well as accounting for why stops don't emerge in what would seem to be superficially similar cases). I call these 'emergent' stops (borrowing the term from evolutionary biology) since the novel element comes about through a rearrangement of *pre-existing* elements. In fact, one lesson we can derive is that features like [sonorant] and [continuant] are of little use in helping us understand these cases. What we saw were stops (pulmonic, glottalic, and velaric), which are [-sonorant, -continuant], arising from parts of segments that were [+sonorant] and/or [+continuant]. These features obscure the true nature of the mechanism involved. The problem is that features like [sonorant] and [continuant] are not primitive features for this purpose. They are, in fact, derived from more primitive features which include a specification of the valves and their states in the vocal tract. Once analyzed in terms of the more primitive valves, the emergence of the stops is no longer a mystery.

These cases also illustrate once again that it is only through a fine-grained phonetic analysis that a true and general account of phonological processes may be gained.

Notes

[1] There is also some probability that the opening and closing of the valves will be perfectly synchronized at the transition such that there will be no temporal overlap of the two valves' closings, or that in the transitional state both valves will be momentarily open. In both of these latter cases, no emergent stop will be created. These possibilities are not covered in this paper.

References

Applegate, R. B. 1972. *Ineseño Chumash grammar*. Doc. Diss., Univ. of California, Berkeley.

Boas, F. 1947. "Kwakiutl grammar with glossary of the suffixes," *Transactions of the American Philosophical Society*, vol. 37, pt. 3.

Chen, M. and H. Clumeck. 1975. "Denasalization in Korean: A search for universals," In C. A. Ferguson, L. M. Hyman, and J. J. Ohala (eds.), *Nasálfest: Papers from a symposium on nasals and nasalization*. Stanford, CA: Stanford University Linguistics Dept. 125-131.

Clements, G. N. 1987. "Phonological feature representation and the description of intrusive stops," *Parasession on Autosegmental and Metrical Phonology*. Chicago: Chicago Linguistic Soc. 29-50.

Grandgent, C. H. 1896. "Warmpth," *Publications of the Mod. Lang. Assoc*. 11 ([New Series 4.) 63-75.

Marchal, A. 1987. "Des clics en français?" *Phonetica* 44, 30-37.

Murray, R. W. 1989. "On epenthesis," *Folia Linguistica* 23, 293-316.

Ohala, J. J. 1974. "Experimental historical phonology," In: J. M. Anderson & C. Jones (eds.), *Historical linguistics II. Theory and description in phonology.* Amsterdam: North Holland. 353 - 389.

Ohala, J. J. 1975. "Phonetic explanations for nasal sound patterns," In: C. A. Ferguson, L. M. Hyman, & J. J. Ohala (eds.), *Nasálfest: Papers from a symposium on nasals and nasalization*. Stanford: Language Universals Project. 289 - 316.

Ohala, J. J. 1995. "A probable case of clicks influencing the sound patterns of some European languages," *Phonetica* 52, 160-170.

Ohala, J. J. In press. "Emergent obstruents," To appear in D. Demolin & M. Dominicy (eds.), *Studies in sound change*. Amsterdam: Benjamins.

Passy, P. 1890. *Étude sur les changement phonétiques.* Paris: Librairie Firmin-Didot.

Phelps J. 1937. "Indo-european initial *sl*," *Language* 13, 279-284.

Piggot , G. L. and R. Singh. 1985. "The phonology of epenthetic segments," *Canadian J. of Linguistics.* 30, 415-451.

Silverman, D. and J. Jun. 1994. "Aerodynamic evidence for articulatory overlap in Korean," *Phonetica* 51, 210-220.

Wetzels, W. L. 1985. "The historical phonology of intrusive stops. A nonlinear description," *Canadian J. of Linguistics*. 30, 285-333.

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