Release the captive coda: the foot as a domain of phonetic interpretation[1]

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1 Introduction

An important general goal in furthering our understanding of the phonetics-phonology interface is to determine precisely the manner in which prosodic conditions influence the phonetic interpretation of segmental information. The specific goal of this paper is to demonstrate how the set of conditioning contexts can be advantageously constrained by abandoning ambisyllabicity — the device whereby a consonantal position is granted dual membership of neighbouring syllables. The phonetic interpretation of supposedly ambisyllabic consonants can be straightforwardly detailed by reference to their location within the independently necessary domain of the foot.

The paper starts in §2 by questioning some of the fundamental assumptions that ambisyllabic analyses typically make about the nature of the phonetics-phonology interface. §3 presents specific arguments for rejecting the device in favour of a foot-centred approach. §4 introduces a range of facts involving manner and source contrasts in Danish which would submit to a standard ambisyllabic analysis but which can be quite adequately characterised in terms of the foot. §5 outlines a theory of segmental form which allows explicit statements to be made about how foot-sensitive effects map onto the acoustic signal. §6 extends the analysis to Ibibio. §7 presents the main conclusions.

2 A minimalist take on the phonetics-phonology interface

One widely appealed-to justification for ambisyllabicity is that it defines a conditioning site for allophonic realisation. The best known example is surely *t*-allophony in English, where ambisyllabicity is often invoked as one of a set of conditions on the occurrence of such effects as aspiration, preglottalisation, plosive release and tapping (references to follow). The analysis embraces a deviation from what is undoubtedly the universally unmarked parse, in which an intervocalic consonant belongs uniquely to the second syllable. Under a standard derivational approach, the relation between the two patterns is captured by accommodating both in the grammar, with the ambisyllabic parse emerging as a result of resyllabification. Allowing for terminological variations, we can characterise the general model of the phonetics-phonology interface within which this type of analysis is situated as in (1).

(1) (a) Underlying phonology
↓
(b) Surface phonology
↓
(c) Categorical phonetics

⬃ ⬂
Articulation — Auditory perception

In this scheme of things, resyllabification can in principle take place either between the underlying lexical level (1)a and surface representation (1)b or between (1)b and categorical phonetics (1)c.

In recent years, the grammar-internal components of the model in (1) have come under fire from both top and bottom. On one side, the general shift towards output-orientation in phonological theory has raised serious doubts about the validity of the underlying-surface distinction. This has led to the development of arguably more restrictive theories which either dispense with the distinction altogether, as in fully monostratal theories such as Declarative Phonology (see Scobbie, Coleman & Bird 1996 and the references there), or at least downplay its role considerably, as exemplified by the increasing reliance in Optimality Theory on constraints which evaluate correspondences between output forms (McCarthy & Prince 1995).

On the other side, there is reason to question the justification for a post-phonological level variously referred to as systematic phonetics (SPE) or categorical phonetics (Keating 1990). Much current output-oriented theory continues to take the necessity of such a level for granted (see for example Goldsmith 1993, McCarthy & Prince (1993: 21), Mohanan 1995). However, there is a growing awareness of the conceptual and empirical advantages of embracing the simpler alternative assumption— surely the null hypothesis — that phonology maps directly to the quantitative values of articulation and auditory perception without having to pass through some intermediate categorical level (see for example Pierrehumbert 1980, 1990, Flemming 1995, Kirchner 1998).

In what follows, I will take the liberty of using 'minimalist' as an inclusive label for any theory of phonology which, as depicted in (2), simultaneously subscribes to monostratalism and direct phonetic mapping.

(2) Phonology

⇙ Articulation ⇘ Auditory perception

In the context of the present paper, it is pertinent to ask how allophonic regularities, such as those attributed to ambisyllabicity, are characterised in such a model. Without the luxury of a categorical phonetic level, there is perhaps a more obvious onus on the minimalist to be explicit about the articulatory, auditory and acoustic interpretation of such effects.

Actually, a moment's reflection will confirm that the very notion of allophony can have no formal status in an authentically minimalist model. How could it, when the model by definition lacks anything equivalent to the distinction between an underlying-phonemic and a surface-allophonic level? From a minimalist perspective, any given regularity formerly described as allophonic should fall into one of two types: either it is not phonological at all, in which case it is a matter for grammar-external quantitative phonetics; or it does have categorical status, in which case it is on a par with effects previously regarded as phonemic.

Assigning a given regularity to one domain or the other is an empirical issue. (It would not be too surprising if the allocation turned out to recapitulate the traditional distinction between intrinsic and extrinsic allophony.) As to how the outcome of each such decision is to be determined, the following two principles suggest themselves as reasonable yardsticks: a 'sub-phonemic' effect in a given language qualifies for categorical status if (i) it is paradigmatically contrastive in some other language and/or (ii) if it is syntagmatically informative to the extent that it delineates morphosyntactic or prosodic domains — in Firthian terms, if it has a demarcative function (see Robins 1970 for references and discussion). Aspiration in English plosives, for example, would be deemed phonological on both counts. Although not usually considered distinctive in phonemic analysis, the property indisputably has paradigmatic significance in languages such as Thai and Gujarati, where it contrasts with two or more other laryngeal terms. Moreover, one result of its prosodically sensitive distribution in English is that it cues information about foot and morpheme structure. (Think of the familiar example of **nitrate**, with aspiration extended to the *r*, versus **night rate**.) Several of the supposedly sub-phonemic phenomena to be discussed below qualify as categorical on the same grounds.

As even this rather brief example shows, adopting a minimalist perspective on the phonetics-phonology interface forces a radical reassessment of the very nature of phonological categories. It would be surprising if familiar categories, developed over a century or so of phonemic and generative research, could be neatly grafted onto a model that rejects the multistratal architecture around which they have been designed. Focusing for the moment on the nature of segmental categories, we might ask whether orthodox feature theory is compatible with a minimalist approach. There is no reason to assume in advance that it should be. The standard SPE-derived feature set, it can be argued, has been indelibly marked by the multistratal climate within which it was conceived.

The point can be illustrated by pursuing the aspiration example. Under a conventional feature account, two-way laryngeal distinctions are universally classified in terms of [±voice] during the initial stages of derivation. The difference between languages which implement this contrast in plosives as plain versus prevoiced (French, Dutch, Polish, etc.) and those that implement it as plain versus aspirated (English, Danish, northern German, etc.) is characterised at the categorical phonetic level. Here underlyingly bivalent [voice] specifications are translated into scalar values or into different features such as [slack vocal folds] or [spread vocal folds] (SPE, Halle & Stevens 1971, Ladefoged 1971, Keating 1984, 1990).

Representing plain obstruents as [–voice] in languages such as French but as [+voice] in languages such as English fails to capture the universally unmarked nature of this series: for example, they are acquired before the prevoiced and aspirated congeners (Jakobson 1968, Kewley-Port & Preston 1974, Macken & Barton 1980); they constitute the default reflex under neutralisation; unlike prevoiced and aspirated segments, they undergo laryngeal assimilation but fail to trigger it.

This asymmetric behaviour favours an alternative categorisation of laryngeal contrasts in which cross-language phonetic differences are transparently recorded in the phonology, for example in terms of the privative features [slack] and [spread], with the plain series remaining unspecified (cf. Harris 1994, Iverson & Salmons 1995, Jessen 1997). In dispensing with the stratal distinction inherent in the use of [±voice], this account is more obviously in tune with the minimalist perspective. Moreover, the classification it sets up meets both of the criteria for phonological category-hood outlined above: (i) languages such as Thai and Gujarati utilise the full distinctive potential offered by both [slack] and [spread]; and (ii) the prosodically conditioned distribution of these categories (exemplified by neutralisation patterns such as devoicing and the suppression of aspiration after *s*) bears witness to their syntagmatically demarcative significance. These considerations lie behind the treatment of laryngeal contrasts in Danish and Ibibio to be presented below.

Another aspect to the categorial rethink required of the minimalist concerns the nature of the prosodic conditions under which segmental regularities occur. To return to the specific issue of ambisyllabicity, a reasonable first assumption would be that the device should be rejected on the grounds that the resyllabification with which it is usually associated is inextricably bound up with multistratalism. In fact, there are various ways in which the effects of resyllabification can be simulated without resort to serial derivation. One is to assume that some grammars just 'have' ambisyllabic parses of VCV and pass up the core option altogether (Local 1995). Another is to posit grammars in which a constraint favouring the core pattern is outranked by one favouring the ambisyllabic parse (Prince & Smolensky 1993). However, the deviation from core syllabification that all of these alternatives allow, whether given a serialist or an output-oriented spin, results in a loosening of syllable theory that is neither desirable nor necessary. The main reasons for reaching this conclusion are set out in the next section.

3 Against ambisyllabicity

CODA CAPTURE (Kahn 1976) refers to an operation which subverts core V.CV syllabification (the point marks a syllable boundary) by moving the consonant into the first syllable, thereby violating onset maximisation. Crisp capture results when the consonant severs all connection with the onset (see for example Hoard 1971, Selkirk 1982, Borowsky 1986). Ambisyllabicity, in contrast, implies sloppy capture: here the consonant is allowed to retain an affiliation with the onset (see for example Kahn 1976, Wells 1990, Giegerich 1992, Spencer 1996).

A favourite argument for ambisyllabicity is that it coincides with native-speaker judgments about syllabification. The judgments are supposedly revealed in tasks where subjects are asked to repeat, transpose, or insert pause-breaks between syllables in polysyllabic forms (see for example Fallows 1981, Giegerich 1992, Rubach 1996, Hammond & Dupoux 1996 and the further references there). The results of these tests are not exactly clear cut; indeed Derwing's (1992) application of the pause-break experiment shows a clear preference for the maximal-onset parse. Nevertheless, the fact that tests of this type sometimes do elicit responses where a word such as **pity** is chunked as *pɪt* plus *ti* is cited as evidence that the intervocalic consonant is ambisyllabic.

However, there is good reason to suppose that these judgments often tell us more about phonological words than about syllables. It is a well-known fact that the phonological word in English, as in many other languages, consists minimally of a (bimoraic) foot (McCarthy & Prince 1986). A monosyllable with a final short vowel is sub-minimal; hence the non-occurrence of words such as **tɪ*, **bɛ*, **lʊ*, or the like. The phonological word thus constitutes the minimal utterable domain in the production of English. If this constraint is allowed to carry over into the tasks in question, it is likely to mean that the sound chunks offered by subjects are in fact words rather than syllables. Under such circumstances, it is hardly surprising that a speaker splits **pity** as *pɪt* and *ti*, since *pɪ* is not a possible word. It is of course perfectly possible to produce individual tokens of the *pɪ* type — but only by switching out of English mode, in which case it is not at all clear what the judgments reveal about English syllable structure.

Another claim made for ambisyllabicity is that it accords with the observation that syllable edges are not neatly delimited in speech (see for example Treiman & Danis 1988). This is not a particularly convincing argument, because the observation, while undoubtedly correct, is hardly unique to syllable structure. No phonological category -— feature, segment, syllable, or whatever — consistently enjoys sharp delineation in speech. Thus, rather than providing specific support for ambisyllabicity, the observation more generally accords either (i) with a radically non-segmental view of phonology, in which all categories potentially overlap (cf. Local 1992, Coleman 1994), or (ii) with some clearly articulated theory of how categorical phonological information is mapped non-linearly and non-categorically onto the speech continuum.

A third argument mounted in support of ambisyllabicity has to do with syllable weight. Coda capture is typically only invoked when the syllable preceding the target consonant is stressed. The operation, it is argued, is necessary in order to guarantee that this syllable be heavy (see for example Giegerich 1992). This is most pertinent in the case of stressed syllables containing a short vowel, which would remain light if not closed by the captured consonant. With ambisyllabicity, this yields the moraic configuration in (3)a or its x-slot equivalent in (3)b.

(3) (a) (b)

The weight-based argument for coda capture is self-serving unless there is some independent reason for believing that languages which are alleged to operate the device are indeed subject to the requirement that stressed syllables be heavy. Among languages which indisputably are subject to this constraint, one independent sign that an intervocalic consonant contributes to the weight of the preceding syllable is that it is of greater duration than one that doesn't. In other words, languages of this type have a contrast between geminates and non-geminates in this context (with a stressed vowel being necessarily long before a non-geminate, as in Italian and Norwegian). In fact, the type of representation proposed in (3), whether couched in moraic or x-slot terms, coincides exactly with that usually proposed for geminates. This naturally leads to the prediction that no language will have a contrast between geminate and ambisyllabic consonants, a claim made explicitly by Borowsky, Itô & Mester (1984). This is demonstrably false. As we will see below, Ibibio not only has short intervocalic consonants that would qualify for coda capture in any ambisyllabicist's book, but it also has authentic geminates in the same context.[2]

Even if, in the absence of independent durational evidence, we were to persist with the notion that a single intervocalic consonant could behave as a covert geminate, we would have to contend with a further embarrassing fact. A fair proportion of the regularities ambisyllabicity is called on to deal with fall under the umbrella of lenition, as in the case of tapping and glottalling of *t* in English (references presently). This is exactly the opposite of what we find with honest-to-goodness geminates, which are renowned for their ability to fend off the lenitions their non-geminate congeners often succumb to — the phenomenon of 'geminate inalterability' (Hayes 1986).

A fourth argument for ambisyllabicity is the one mentioned at the outset of this paper: the configuration supposedly defines a unique and necessary conditioning environment for phonetic realisation (see for example Kahn 1976, Gussenhoven 1986, Wells 1990, Giegerich 1992 and the references there). One objection to this claim relates back to the issue of stress just discussed. Stipulating that a captor syllable must be stressed amounts to saying that the VCV context forms a trochaic foot, and indeed coda capture has been explicitly formalised in just these terms by a number of researchers (e.g. Borowsky 1986: 265).[3] This immediately raises the question of why the relevant patterns of phonetic realisation couldn't be more simply characterised by referring directly to the foot, without having to call on some intermediate mechanism of resyllabification. After all, the foot has impeccably independent credentials, confirmed by the indispensable role it plays in stress and weight relations. The same cannot be said of ambisyllabicity.

Precisely this point has been made in connection with *t*-allophony in English. (4) encapsulates the well known distributional facts pertaining to plosive, unreleased and tapped reflexes (‖ indicates utterance-finality).

(4)	Plosive:	**time, boutíque**
	Unreleased stop:	**get** ‖, **get Carl**
	Tap:	**letter, get ón**

Broadly speaking, coda-capturing analyses of the conditions under which tapping occurs share the following main components, expressed here in terms of ambisyllabicity (see for example Kahn 1976, Hoard 1971, Giegerich 1992). (A similar story can be told of the contextually related pattern of glottalling; see Wells 1982.) (i) Coda capture: within a foot, the onset of the unstressed syllable is attached to the coda of the stressed syllable (e.g. **pi.ty** → **pi.t.y**, where **.t.** indicates ambisyllabicity). (ii) Onset capture: a word-final coda is attached to an unoccupied onset at the beginning of a following word (e.g. **get. a** → **ge.t. a**). (iii) Tapping: *t* taps when ambisyllabic.

There is an alternative, foot-based treatment of these facts, first proposed by Kiparsky (1979), which dispenses with coda capture. In essence, it says: prevocalic *t* taps when not foot-initial (see also Harris & Kaye 1990, Jensen 1993, Harris 1994). The relevant contexts are illustrated in (5), repeated from (4), now with foot structure indicated (by double brackets).

(5)	Plosive:	**⟦time⟧, bou⟦tíque⟧**
	Unreleased stop:	**⟦get⟧** ‖, **⟦get⟧ Carl**
	Tap:	**⟦letter⟧, ⟦get⟧ ón**

Amongst other things, this treatment offers a simple account of why an uphill stress configuration hosts tapping across a word boundary but not word-internally: tapping affects *t* in **get ón**, where it is foot-final, but not in **boutíque**, where it is foot-initial.

Very similar sets of facts present themselves in Danish and Ibibio. As I will try to show below, a detailed specification of the phonetic effects involved can be formulated in essentially the same foot-based terms as those just outlined for English. These cases are representative of a cross-linguistic tendency for strong distributional similarities to hold between word-final consonants (VC]) and those in prevocalic foot-internal contexts (v́Cv̆). They also illustrate a tendency for these parallels to involve neutralisation (in the English case, for example, tapping also affects *d*). That is, they reflect an unequal division of contrastive potential across different positions within the foot. The distributional spoils are evidently apportioned to the advantage of the initial CV portion of the domain — the head of the foot. (In all of the cases under discussion here, the foot is trochaic, i.e. left-headed.) Thus, while the maximal system of consonantal contrasts in a language is free to appear in the onset of the foot head, it is usual to find that reduced subsystems show up in the onset of the weak or dependent syllable of v́Cv̆ forms. The fact that this curtailment of contrastive potential also afflicts a word-final consonant suggests that this position too should be deemed to fall within the weak sector of the foot. (For a detailed account of how foot-related neutralising parallels between VC] and v́Cv̆ can be established without resorting to coda capture, see Harris 1997.)

The contrastive imbalance within the foot extends to vowels. A typical scenario here is one in which the maximal inventory of vocalic contrasts is restricted to the head nucleus of the foot, while contracted subsystems show up in weak nuclei. Languages exhibiting this phenomenon include English, Bulgarian, Catalan, Neapolitan Italian and, as we will see below, Ibibio. Coda capture forces an intrinsically paradoxical treatment of this general asymmetry. With crisp capture, a consonantal position that is susceptible to reduction is moved out of the very syllable that promotes reduction in vowels. With both crisp and sloppy capture, the reduction-prone consonant fetches up in the very syllable where vowels resist reduction.

The conceptual advantages that a foot-centred approach enjoys over one based on ambisyllabicity are clear: it allows us to capture prosodically conditioned distributional parallels between nuclear and non-nuclear positions in a more natural way; and it is consistent with a more restrictive theory of prosodic structure which broaches no deviation from core syllabification. The question is whether the foot-based alternative is also empirically adequate. In particular, does it allow us to nail down the conditions on regularities otherwise attributed to ambisyllabicity? The following extended example from Danish will serve to show that it does.

4 Danish

Danish, here represented by the regional variety of South Fyn, possesses what looks like a normal Germanic-style laryngeal contrast between voiceless aspirated and unaspirated ('plain') plosives. The distinction is robustly maintained word-initially, as in (6)a, and word-internally before a stressed syllable, as in (6)b (see Fischer-Jørgensen 1968, Hutters 1985, Jessen 1997; accents mark stress).

(6)	(a)	**pil**	[p^h]**il**	‘arrow’	**bil**	[*p*]**il**	‘car’
		tale	[t^h]**ale**	‘to speak’	**dale**	[*t*]**ale**	‘valleys’
		ko	[k^h]**o**	‘cow’	**god**	[*k*]**od**	‘good’
	(b)	**kopi**	**ko**[p^h]**í**	‘copy’	**bebude**	**be**[*p*]**úde**	‘to foretell’
		atom	**a**[t^h]**óm**	‘atom’	**bedyre**	**be**[*t*]**ýre**	‘to proclaim’
		akut	**a**[k^h]**út**	‘acute’	**igen**	**i**[*k*]**én**	‘again’

The voicelessness of the plain stops is most consistently revealed utterance-initially (as in (6)a) and utterance-finally (examples below).

Outside of the contexts illustrated in (6), Danish is notorious for having laid waste to its historical stop contrasts, which are still recorded in the orthography and can be readily reconstructed on the basis of comparison with sister languages such as Norwegian. After a stressed vowel, the consonants in question have been subjected to a series of lenitions that have withered both the laryngeal and manner dimensions of the distinctions. The most damaging effect has been vocalisation (to be understood here and below as any process which weakens an obstruent to a resonant). This has resulted in one term of the original contrast being written out of the stop equation altogether. As illustrated in (7), it has affected historical coronals and velars word-finally and all three place categories intervocalically. (Here and below, *y* stands for a palatal glide.)

(7)	(a)	**mad**	**ma**[*ð*]	‘food’
		lag	**la**[*y*]	‘layer’
	(b)	**peber**	**pe**[*w*]**er**	‘pepper’
		modig	**mo**[*ð*]**ig**	‘brave’
		koge	**ko**[(*w*)]**e**	‘to cook’

Vocalisation of coronals has yielded a tongue-blade approximant (traditionally, if not entirely felicitously, transcribed as *ð*). The glide reflex of historical velars generally takes its place cue from the preceding vowel — *y* after a front unround vowel (as in *læy* ‘layer’) or *w* after a round vowel (as in k^h*owə* ‘to cook’, although here the medial glide can be suppressed altogether).

The stops that survive in the otherwise leniting contexts (typically the reflexes of historical geminates) can be described as plain in the sense employed above. The voicelessness this series displays when utterance-final (see (8)a) is also evident utterance-initially (see (6)a). Before an unstressed vowel, as illustrated in (6)b, the stops are subject to variable and gradient voicing, which can be interpreted as the passive interpolation of vocal-fold vibration through the VCV sequence (Hutters 1985).

(8)	(a)	**lap**	**la**[*p*]	‘patch’	**lab**	**la**[*p*]	‘paw’
		sæt	**sæ**[*t*]	‘set (imper.)’			
		læk	**læ**[*k*]	‘leak (n.)’			

(b)	**næppe**	**næ**[*b*]**e**	'hardly'	**ebbe**	**e**[*b*]**e**	'low tide'
	sætte	**sæ**[*ɾ*]**e**	'to set'	**bredde**	**bre**[*ɾ*]**e**	'width'
	frakke	**fra**[*g*]**e**	'coat'	**lægge**	**læ**[*g*]**e**	'to lay'

The assault on the Danish plosive system does not stop there. As indicated in (8)b, coronal stops are subject to tapping. The contextual specifics, set out in (9), are identical to those controlling tapping in English (cf. (4)).

(9)

	Stop		Tap	
Cv́	**tale** 'speech', **atom**		Cv̆	**sætte** 'to set'
C]‖	**sæt**	'set'	C]v̆	**sæt og** 'set and'
C]C	**sæt på**	'set on'	C]v́	**sæt op** 'set up'

Consistency would demand that any advocate of ambisyllabicity as a condition on tapping in English should extend the analysis to the same phenomenon in Danish. In fact, the entire set of neutralisation effects in Danish, including vocalisation and the suspension of laryngeal contrasts, might suggest a generalised ambisyllabic analysis, since the contexts involved are essentially parallel. However, for the same reasons as those outlined in §3, this parallelism can be expressed quite adequately without resorting to ambisyllabicity. As tabulated in (10), the prosodic conditions on Danish neutralisation can be captured by reference to the foot.

(10) Danish

Foot-initial		Non-foot-initial			
[C		v́Cv̆		VC]	
p^h	*p*	*p*	*w*	*p*	
t^h	*t*	*ɾ*	*ð*	*t/ɾ*	*ð*
k^h	*k*	*k*	*w/y*	*k*	*w/y*

Summarising (10), we can say (i) that aspiration is supported foot-initially but suppressed elsewhere and (ii) that elsewhere tapping additionally robs coronals of the closure and accompanying release burst which are supported by other place values.[4]

We turn now to the task of identifying the phonological categories that are implicated in each of these distributional patterns.

5 Source and manner categories

5.1 Elements

This section outlines a theory of segmental categories that has been specifically tailored to the minimalist requirements described in §2. It arises out of a broad tradition initiated by Dependency Phonology (Anderson & Jones 1974), which has been developed along minimalist lines by, among others, Kaye, Lowenstamm & Vergnaud (1990) and Harris & Lindsey (1995).

The theory subscribes to the increasingly accepted view that phonological oppositions are defined privatively in terms of monovalent categories, rather than equipollently as in SPE-derived feature systems. Moreover, each monovalent category — an ELEMENT — can be phonetically expressed in isolation. In other words, some segments are 'primitive' in the sense that they represent solo interpretations of single elements. For example, on its own the element (U) is interpreted as a labial vocoid (transcribable as *u* or *w*, depending on its syllabic position). Uniting privativeness with stand-alone interpretability rids phonological representations of anything resembling redundant feature values. This in turn means that the theory dispenses with blank-filling operations and the corresponding need for separate categorical levels exhibiting differing degrees of segmental specification.

The theory takes to heart the standard Jakobsonian observation that the status of the speech signal as the shared communicative experience of speakers and listeners establishes it as the starting point for detailing the phonetic expression of phonological categories. Articulatory and auditory-perceptual definitions are then framed in terms of the continuously varying neural and motoric mechanisms that speakers and listeners activate in order to achieve the signal mappings of these categories. This view is consistent with the idea that segmental categories have invariant acoustic signatures (Blumstein & Stevens 1981). (In light of Neary's well-taken remarks (this volume), IDEA here should really read IDEAL).

(11) lists phonetic specifications (essentially those given in Harris & Lindsey 1995) of the source and manner elements that will figure prominently in the discussion below.

(11)

Element	Acoustic interpretation	Articulatory execution
(?) 'edge'	Abrupt and sustained drop in overall amplitude	Occlusion
(h) 'noise'	Aperiodic energy	Narrowed stricture producing turbulent airflow
(H) 'high source'	Long-lag VOT	Spread vocal folds
(L) 'low source'	Long-lead VOT	Slack vocal folds

Of the two manner elements, (?) represents the closure component of oral and nasal stops, while (h) represents the steady-state noise component of fricatives and the noise burst that accompanies the release of plosives.[5] In plosives, the source elements [L] and [H] represent active prevoicing and aspiration respectively. Plain oral stops lack any independent source specification, leaving them susceptible to ambient voicing.

Although neutralisation in Danish and Ibibio specifically affects the manner and source dimensions of segments, it is necessary for the purposes of the following demonstration to say at least something about the elementary categorisation of resonance contrasts. The main exemplification can be supplied by labials, represented in terms of the element (U) mentioned above. The signal specification of this element is a target formed by a low-frequency spectral peak (representing the convergence of F1 and F2), produced by a trade-off between an expansion of the oral and pharyngeal tubes (Harris & Lindsey 1995). The pattern may manifest itself in a steady state (in rounded vowels) or as an inter-segment transition (the 'diffuse-falling' configuration of labial consonants described by Blumstein & Stevens 1981).

(12) lists the elementary expressions that characterise labial plosives and the various reflexes they adopt when lenited.

(12)	(a)	Aspirated labial plosive	(U, ?, h, H)
	(b)	Prevoiced labial plosive	(U, ?, h, L)
	(c)	Plain labial plosive	(U, ?, h)
	(d)	Unreleased labial stop	(U, ?)
	(e)	Labial fricative	(U, h)
	(f)	Labial approximant	(U)
	(g)	Glottal stop	(?)
	(h)	Glottal fricative	(h)

This line-up illustrates the autonomous interpretability of elements. Any element-targeting constraint effecting lenition defines a phonological representation that can be immediately submitted to articulation/auditory perception without having to transit through some categorial component where missing phonological information is filled in. For example, the vocalisation of a plain labial plosive ((12)c) reflects the absence of (?) (stopness) and (h) (noise). The residual element, (U), is independently interpretable as a labial approximant ((12)e).

There is a clear sense in which lenition degrades the phonetic information signalled by a segment: the information-rich spectral discontinuities (abrupt amplitude shifts, rapid formant transitions, noise bursts, F0 perturbations, etc.) associated with an unweakened consonant are partly or wholly absent from a weaker counterpart. The interpretational autonomy of elements allows this difference in informational capacity to be represented in a direct manner: an unlenited segment is elementally more complex than a lenited reflex.

Compare this with an SPE-type feature treatment of the same facts. The primary featural effect of vocalisation is the rewriting of [–continuant] as [+continuant]. On its own, however, this is not sufficient to define a phonetically interpretable segment. Supplementary adjustments have to be made at some 'later' categorical level in order to derive the required glide, including [+consonantal] → [–consonantal], [–sonorant] → [+sonorant] and [–voice] → [+voice]. Fully specifying all feature values in this way gives the misleading impression that the informational load borne by lenited and unlenited congeners is equal. This basic design flaw persists regardless of whether feature-based approaches to lenition are couched in terms of rules or, as more recently, ranked constraints (Kirchner 1998).

5.2 Signal mappings of elements: Danish

The reduction in elementary complexity that accompanies consonantal neutralisation, it can be shown, goes hand in hand with a reduction in signal complexity. The exclusion of any given element from a given context correlates directly with an absence of a particular frequency- and/or time-domain pattern from the speech signal. This can be demonstrated by detailing the elementary and signal correlates of the Danish neutralisations described in §4.

Consider first the nature of the full contrast between plain and aspirated plosives that is maintained foot-initially in Danish, illustrated by the pair **bille** and **pile** in Figures 1 and 2. Each of these figures, like all of those that follow, contains a speech pressure waveform (top), a laryngographic trace (Lx, middle) and a broad-band spectrogram of a target word (located between cursor points), uttered in a carrier phrase.[6] The spectrograms are annotated to pick out those signal ingredients that are proposed as the exponents of particular phonological elements.

Figures 1 & 2 about here

The formant transitions in the approach and getaway phases of both labial plosives in **bille** and **pile** are directed towards the low spectral peak target associated with the element (U). Both plosives exhibit the sustained amplitude drop attributable to the element (?). On release, both display the noise burst associated with the element (h). The closure phase of neither stop shows any significant presence of periodic energy, indicating an absence of vocal-fold vibration (clearly evident in the Lx traces). The main distinction between the consonants is carried by the timing of voice onset in the following vowel. In the case of **pile**, there is a long time lag between the release of closure and the onset of voicing, symptomatic of aspiration and attributable to (H). In **bille**, in contrast, the release is more or less simultaneous with voice onset, the pattern typical of a plain stop and interpretable as the absence of a source element.

Compare these patterns with what is found foot-internally, illustrated by the pair **tropisk** and **købe** in Figures 3 and 4. The medial consonant of **tropisk** shows evidence of a drop in overall amplitude and a noisy release burst, indicative of (?) and (h) respectively. It also exhibits continuous periodic vibration, an effect that can be interpreted in this context as the passive voicing of an intervocalic plain stop (see Hutters 1985). This interpretation is consistent with the conclusion that the segment lacks an independent source element. The "**b**" of **købe** (Figure 4) displays essentially the same source characteristics. In the absence of any edge or noise pattern that would be traceable to (?) or (h), the segment can be deemed to contain only (U), signalled by the expected formant transitions. This collection of effects reflects how the foot-internal contrast between historically aspirated ('fortis') and plain ('lenis') plosives in Danish has been reduced to one between plain stops and approximants. In the case of coronals, the tapping illustrated in (9) further robs the original fortis member of this distinction of its stop and noise components, exposing a bare coronal element.

Figures 3 & 4 about here
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(13) summarises the distribution of source and manner elements across different positions within the Danish foot, represented by the particular case of coronal stops and their historical reflexes (illustrated in (9)).[7]

(13) Danish coronals

	Foot-initial	Non-foot-initial	
(H)	✓	✗	
(h)	✓	✗	
(?)	✓	✗	_V

The display in (13) illustrates how the element model allows neutralisation to be uniformly expressed as the exclusion of particular segmental categories from particular positions. One immediate advantage is that the ability of a position to license segmental material is transparently reflected by the complexity of the elementary expressions it can sponsor. And this ability can be directly related to the position's place in the prosodic hierarchy: all other things being equal, a prosodic head can bear more segmental information than a dependent position. (For a detailed development of this integrated approach to neutralisation, see Harris 1997.)

The following section extends this overall account to Ibibio.

6 Ibibio

The first thing to establish before embarking on a foot-based account of neutralisation in Ibibio is whether the language has feet at all.[8] This is perhaps not immediately obvious, since the foot is usually predicated on stress, a property that Ibibio, a language with lexical-grammatical tone, lacks (accents below mark tone).

Stress prominence is of course not the only symptom of foot-hood. As remarked on in §3, segmental and quantitative factors can also be in play, showing up in the asymmetric distribution of contrast and weight between head and dependent syllables. Both of these effects are abundantly evidenced in Ibibio, supporting the view that the foot has a vital role to play in the phonology of the language (Connell 1991, Akinlabi & Urua 1992; cf. Cook 1985 and Hyman 1990 on the cognate phenomenon in Efik).

The basic shape of the Ibibio verb, comprising a root plus an optional suffix, is circumscribed in various ways by a phonological template of the form CVXCV — a configuration that coincides with the heavy-light trochaic foot favoured by many stress languages. Amongst other things, the template places an upper bound on the size of the verb and a lower bound on certain verbal paradigms. Potentially oversized morphological material is accommodated to the trochee through segment truncation. For example, the attachment of a CV suffix to CVVC roots such as those in (14)a results either in vowel shortening, as in the forms in (14)b, or consonant degemination, as in the forms in (14)c (all data from Urua 1990).

(14)	(a)	*sí́ít*	'block'
		fááḱ	'wedge'
		kɔ́ɔ́ŋ	'hang on hook'

(b) Reversive: root + C*á*
sɨ́tté ‘unblock’
fákká ‘remove wedge’
kɔ́ŋŋɔ́ ‘unhook’

(c) Frequentative: root + N*á*
sííŋé ‘unblock (freq.)’
fááŋá ‘remove wedge (freq.)’
kɔ́ɔ́ŋɔ́ ‘not hang on hook (freq.)’

Another weight-related function of the heavy-light trochee is to define a fixed template for certain verbal paradigms. In this case, undersized roots are subject to vowel augmentation, as in the frequentative examples in (15).

(15) *nɔ̀* ‘give’ *nɔ̀ɔ̀-ŋɔ̀* ‘give (freq.)’
k͡pá ‘die’ *k͡páá-ŋá* ‘die (freq.)’

The Ibibio foot also serves as a distributional domain, exhibiting contrastive asymmetries strongly reminiscent of those associated with trochees in stress languages. While the first syllable of the trochee sponsors the full panoply of vowel and consonant distinctions in Ibibio, the contrastive potential of the last syllable is greatly curtailed, its segmental identity being to a large extent picked up from the first. This is illustrated in the following forms by the negative suffix, the onset of which assimilates completely to the final consonant of the root, while the nucleus harmonises with the root vowel.

(16) *dɨ́p-pé* ‘not hide’ *dɔ́m-mɔ́* ‘not bite’
yét-té ‘not wash’ *màn-ná* ‘not give birth’
kɔ̀k-kɔ́ ‘not spew’ *kɔ̀ŋ-ŋɔ́* ‘not knock’

These distributional patterns indicate that the Ibibio foot is left-headed. This conclusion is further strengthened when we study the facts of consonantal neutralisation in more detail.

(17) summarises the distribution of oral stops and related segments in Ibibio.

(17) Ibibio

Foot-initial		Non-foot-initial		
[C		VCCV	VC] {‖/C}	VC(])V
k͡p	*b*	*pp*	*p˺*	*β*
t	*d*	*tt*	*t˺*	*ɾ*
k		*kk*	*k˺*	*ɣ*

The initial onset of the Ibibio foot supports a two-way laryngeal contrast amongst plosives, at least in labials and coronals. Unlike Danish, the distinction manifests itself as plain versus prevoiced (Connell 1991). This is illustrated by the forms *k͡pa* and *ba* in Figures 5 and 6. (Except where indicated otherwise, the carrier phrase in the Ibibio figures is *ḿbô _ ǹnɔ̀* ‘I say _ for myself’.) As is to be expected, these plosives share an interval of zero or greatly reduced overall amplitude, a noise burst on release and the formant transitions associated with labiality, properties attributable to the elements (?), (h) and (U) respectively. The distinction between them resides primarily in their differing VOT configurations.[9] In *k͡p*, periodic vibration commences more or less at the same time as the release of closure, confirming the segment as plain and therefore, in element terms, devoid of a source element.[10] In contrast, *b* displays uninterrupted periodic vibration throughout closure. This long-lead VOT property is also evident in utterance-initial position, indicating that the laryngeal component here has some independent phonological basis (in element terms, low-source (L)), rather than being due to the passive extension of vocal-fold vibration from the surrounding vowels.

Figures 5 & 6 about here

Outside of the foot-initial site, the Ibibio stop system yields to neutralising pressures in a manner that is similar to Danish. As shown in (17), stops are also to be found intervocalically as geminates and word-finally before a consonant or pause. In the absence of a contrast between geminate and non-geminate stops in this context, it might initially be tempting to view the segments in question as single-position Cs (see the references in Connell 1991: 47ff.). However, this would miss the clear quantitative parallel between CVCCV and CVVCV in paradigms where the heavy-light trochee defines a fixed prosodic template; see for example the frequentative forms in (14)c and (15).

Irrespective of what follows, non-foot-initial consonants fail to support a laryngeal contrast. Geminate stops are plain, exemplified by the word *dáppá* in Figure 7. As illustrated by the word *déép* in Figure 8, word-final stops are unreleased and characterised by rapid decrescendo voicing from the preceding vowel (cf. Connell 1991). The signal manifestations of these consonants are consistent with the elementary representations in (12)c and (12)d. That is, both can be considered to lack the source element (L) which characterises prevoiced plosives in foot-initial position, while the absence of a release burst in the word-final stop indicates a lack of (h).

Figures 7 & 8 about here

Non-foot-initially before a vowel, non-geminate consonants are subject to lenition. This gives rise to root-final alternations such as the following:

(18)	(a)	*dɨ́p*	‘hide’	*dɨ́βé*	‘hide oneself’
		déép	‘scratch’	*dééβé*	‘not scratching’
	(b)	*bèt*	‘push’	*bèɾé*	‘push oneself’
		kóót	‘read/call’	*kóóɾó*	‘not reading/calling’

(c)	*fʌ́k*	'cover'	*fʌ́ɣɔ́*	'cover oneself'
	fáák	'wedge'	*fááɣá*	'not wedged'
(d)	*kɔ̀p*	'lock'	*kɔ̀β úsʌ́ŋ*	'lock the door'
	bèt	'push'	*bèɾ ówó*	'push someone'
	kʌ̀k	'shut'	*kʌ̀ɣ úsʌ́ŋ*	'shut the door'

Note that lenition occurs irrespective of whether the following vowel falls within the same word (as in (18)a, (18)b, (18)c) or not (as in (18)d). The weakened reflexes have been described as frictionless continuants or 'tapped approximants' (Connell 1991). (The symbols *β* and *ɣ* are thus not being used here with their IPA fricative values.[11]) The absence of a noise component (and thus of the (h) element) from the lenited segments is confirmed by the form *díβé* in Figure 9. The mild degree of energy reduction observed in the intervocalic labial of this example does not match the radical amplitude drop associated with (?) in the stop alternant. The residue of vocalisation is thus bare resonance, in this case represented by (U).

Figure 9 about here

The vocalisation site in Ibibio can be specified as follows: the target segment must (i) be intervocalic and (ii) occur within the weak sector of a foot. (The second of these conditions also governs the consonantal place assimilation illustrated in (16).) Confirmation of the necessity of the foot-based condition is provided by the examples in (19). The forms in (19)a contain prefixes or proclitics which are not part of the verbal domain. Although the root-initial consonants here are intervocalic, they resist vocalisation because they occupy the head syllable of the foot.

(19)	(a)	*ú*-⟦*táŋ*⟧	**úɾáŋ*	'plaiting'
		ú-⟦*kʌ́p*⟧	**úɣʌ́p*	'covering'
		í-⟦*bàt-tá*⟧	**íβàttá*	'(s)he is not counting'
	(b)	⟦*séé-ɣé*⟧		'not look'
		⟦*dáá-ɣá*⟧		'not stand'
	(c)	⟦*dáppá*⟧-*ké*	**dáppáɣé*	'not dream'
		⟦*fááŋá*⟧-*ké*	**fááŋáɣé*	'not argue'

A similar result is observable when we compare the fate of the negative suffix in (19)b and (19)c. In (19)b, the suffix lies within the ambit of the verbal trochee, where its onset falls prey to vocalisation. In (19)c, in contrast, the same suffix lies outwith the template, which is saturated by an internal trochee; as in (19)a, the consonant is thus immune to vocalisation.

There are striking parallels between lenition in Ibibio on the one hand and Danish and English on the other. Aside from the obvious stress and tone differences, the contextual and segmental details of tapping, for example, are more or less identical across the three languages. Note how in all three languages tapping fails foot-initially in **bou⟦tíque⟧** (English), **a⟦tóm⟧** (Danish), *ú⟦táŋ⟧* ‘plaiting’ (Ibibio) but goes through foot-finally in **⟦get⟧ Anne**, **⟦sæt⟧ op** (Danish), *⟦bὲɾ⟧ ɔ́wɔ́* ‘push someone’ (Ibibio), even though the context is intervocalic in both sets of cases.

These similarities might initially bring a gleam to the ambisyllabicist’s eye, but Ibibio has a major disappointment in store. The same consideration of consistency that would require lenition in English and Danish to be treated to a unitary ambisyllabic analysis would have to be extended to Ibibio. Now recall the claim, embodied in the representations in (3), that no language will contrast single ambisyllabic consonants with geminates. Well, Ibibio clearly does. And while the single consonants in Ibibio are subject to lenition, the geminates remain inalterable. Examples are scattered throughout the data presented above; just to drive the point home, here are a few more:

(20)	*áà-fɨ̀ɪβè*	‘who sucks’	*fɨ́ppé*	‘remove from mouth’
	áà-sɨ̀ɪɾè	‘who blocks’	*sɨ́tté*	‘unblock’
	áà-fààɣà	‘who wedges’	*fákká*	‘remove wedge’

To conclude, (20) presents a foot-based summary of the distribution of source and manner elements in Ibibio.

(21) Ibibio

	Foot-initial	Non-foot-initial
(L)	✓	✗
(h)	✓	✗
(?)	✓	✗ (_V)

In spite of the fact that the source contrast is carried by (H) in Danish and by (L) in Ibibio, there are clear distributional parallels between the two languages, as a comparison of (13) with (20) confirms. In both cases, only the foot head is able to support the full set of source and manner elements; in the foot’s weak sector, we find a total embargo on source and selective bans on manner.

7 Conclusion

I conclude by picking up on two general issues raised by the analyses offered above.

The first concerns the neutralising aspect of the phonological effects discussed here and the impact this has on the way we spell out their phonetic interpretation. Terms such as LENITION, WEAKENING, VOCALISATION and DEVOICING can all be understood as ways of describing the fact that certain bits of phonetic information which are available in some phonological contexts are excluded from others. Are these effects derivationally destructive? That is, is it necessary to conceive of them as involving the obliteration of lexically represented information? The descriptive terms themselves do indeed conjure up images of destruction. Their use is undeniably steeped in a derivational tradition which sets up underlying phonemes and allows them to be deleted or rewritten in various ways. Against this background, it is understandable that declarative phonologists, their eyes fixed firmly on output, have often felt uncomfortable with the very notion of neutralisation (even to the point of questioning whether it exists at all — see Bird 1995).

Nevertheless, it is possible to conceive of neutralisation in non-destructive terms. Even in input-oriented derivational theory, it has long been acknowledged that static distributional regularities, including those implicated in neutralisation, can be treated in a non-procedural manner, for example by means of vacuous rule application. The real question comes down to whether it is possible to characterise dynamic phonological alternations non-destructively, without losing sight of the fact that neutralisation, like most segmental regularities, often has both static and alternating effects.

In non-derivational theory, constraints with neutralising consequences are expressed over output as bans on particular segmental categories from appearing in particular contexts. (From a vigorously minimalist viewpoint which denies the existence of an independent input level, ‘output’ should really just read ‘phonology’.) There is no need for such constraints to refer to an underlying or canonical shape of a segment. Alternating forms of a morpheme can be linked non-derivationally and non-destructively by means of constraints which evaluate the degree of phonological correspondence between them — output-output constraints, in Optimalist parlance. With the segmental model outlined in §5, how this evaluation is performed is quite straightforward. In the case of lenition, the correspondence between an alternant containing a ‘strong’ segment and one containing a ‘weak’ counterpart takes the form of a subset relation. This is evident in (12), where we can compare the representation of full-blooded plosives with that of their lenited relatives. For instance, the elementary expression (U) representing the medial glide in Ibibio *dééßé* ‘not scratching’ is a subset of the expression (U, ?) representing the final consonant of *déép* ‘scratch’.

To return to a theme struck up in §2, a second general question concerns the nature of the segmental categories invoked in the analyses presented above. From an input-oriented perspective, some of the phenomena discussed — for example, aspiration in Danish, prevoicing and vocalisation in Ibibio, plosive release in both languages — would count as sub-phonemic or ‘low-level’. An output-oriented, non-phonemic theory, in contrast, gives full recognition to the information-rich potential of these effects as demarcating cues for prosodic and morphological domains. For example, the categories (L) and (h) in Ibibio consistently mark the left edge of a foot (and thus of a root); (H) marks the left edge of the Danish foot.

Moreover, by referring to different locations within the foot, it is possible to characterise the prosodic conditions on the phonetic interpretation of the regularities in question without subjecting onset consonants to coda capture.

Endnotes

1. March 1990, to appear in *Papers in Laboratory Phonology VI.* Many thanks to Thomas Hansen, Pierre Millinge and Eno Urua for supplying and discussing the speech data presented in this paper and to Bruce Connell, Phil Harrison, Geoff Lindsey, Moira Yip and three anonymous *LabPhon* reviewers for their comments. I'm especially indebted to Eno Urua for also sharing with me her phonological insights into Ibibio.

2. The moraic status of the first part of a geminate reflects the assumption that it receives 'weight by position' (Hayes 1989). In an approach bent on asserting the formal independence of ambisyllabicity, it might seem tempting to propose that an intervocalic consonant could be captured into a coda without acquiring weight by position; that is, the resyllabified consonant would lack a mora and would instead be linked directly to the matrix node of the first syllable. Unsurprisingly, Borowsky *et al* (1984) decline to pursue this possibility. While it would allow geminates and ambisyllabic consonants to contrast within the same language, it would also immediately undermine any weight-based argument for ambisyllabicity. Besides, any move towards allowing weight by position to be simultaneously switched on and off within the same grammar represents a bold step in the direction of unfalsifiability.

3. In principle, coda capture could be extended to supposedly iambic contexts, specifically to consonants which immediately follow the stressed nucleus of an iambic foot, yielding ⟦v̆.C_1v́.⟧C_2v̆ → ⟦v̆.C_1v́C_2.⟧v̆ (feet indicated by double brackets). I am unaware of any convincing examples of constraints on C_2 which could be exclusively attributed to this hypothetical configuration. In any event, the initial footing assumed by such an analysis is itself open to question, given the disputed validity of iambs (see van de Vijver 1998 for discussion and references).

4. Aspiration is also supported in a word-initial unstressed syllable in Danish, as in [k^h]**abín** 'cabin'. A unified distributional statement favours the view that the first syllable in forms with this stress configuration constitutes a degenerate foot.

5. The use of the terms HIGH and LOW as labels for source elements in consonants alludes to the well-known correlation between phonation type and fundamental frequency perturbations in the transition to a following vowel. Whether this correlation justifies representing phonation and tone contrasts in terms of the same phonological categories (as suggested by the facts of tonogenesis, for example) is not germane to the present discussion.

6. The Danish carrier phrase is **Jeg siger _ sådan** 'I say _ like this'. The figures are generated using the SFS software developed by Mark Huckvale at University College London (http://www.phon.ucl.ac.uk/resource/sfs.html).

7. The precise formulation of the constraints which deliver the distribution in (13) is not central to the discussion here. Applied to both Danish and English (see (9) and (5)), an Optimality-theoretic account might run something like this: a constraint requiring the faithful preservation of features in the foot head outranks constraints penalising the appearance of (H), (?) and (h) (cf. Kirchner 1998).

8. This section draws on work in progress with Eno Urua (Harris & Urua 1998).

9. In element theory, the distinction between labial and labial-velar is captured by means of differing segment-internal dependency relations.

10. The gross movement of the larynx suggested by the jump in the Lx trace during the closure phase might indicate glottalic articulation, which would be consistent with Connell's (1991) findings for the labial-velar.

11. The transcriptional tradition I am following here reflects the impression that the weakened labial typically remains phonetically distinct from *w*. In fact, the nature of the weakening varies dialectally and stylistically: besides the frictionless continuant illustrated in Figure 9, variants have been described as 'tapped fricatives', 'tapped stops' and 'fricated trills' (Connell 1991: 65). The dorsal articulation of *ɣ* varies between velar and uvular.

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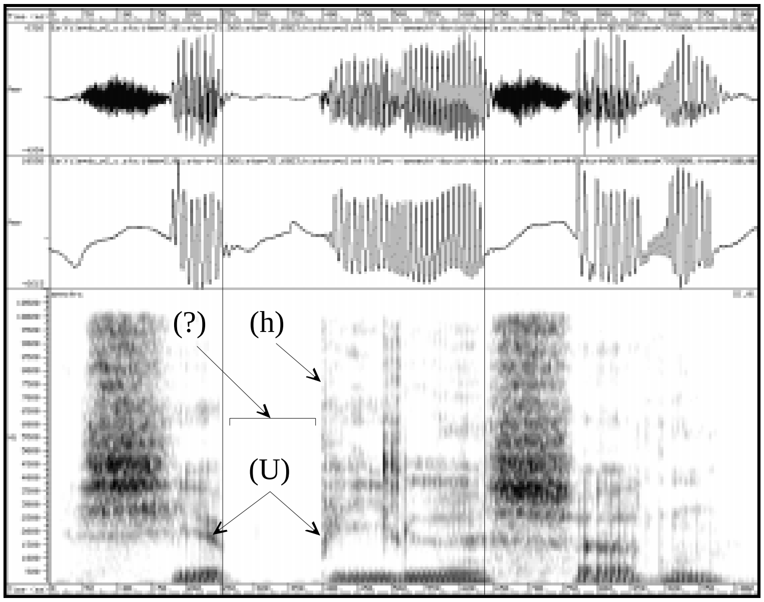

Figure 1. Danish **bille** (between cursor points): speech pressure waveform (top), laryngographic trace (middle), broad-band spectrogram (bottom).

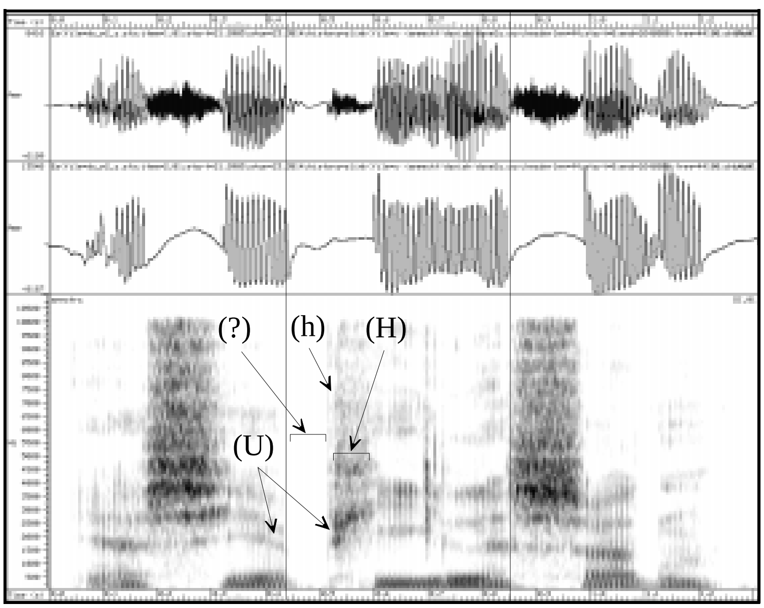

Figure 2. Danish **pile** (between cursor points): speech (top), Lx (middle), broad-band spectrogram (bottom).

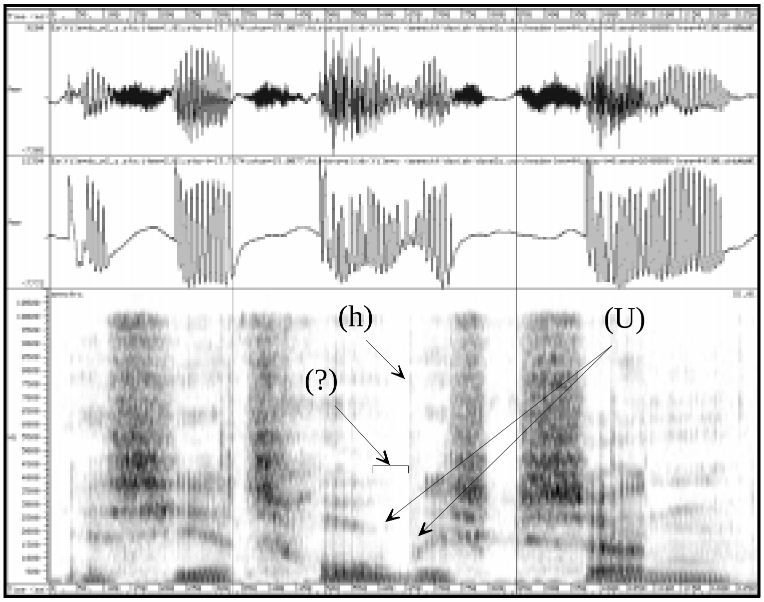

Figure 3. Danish **tropisk** (between cursor points): speech (top), Lx (middle), broad-band spectrogram (bottom).

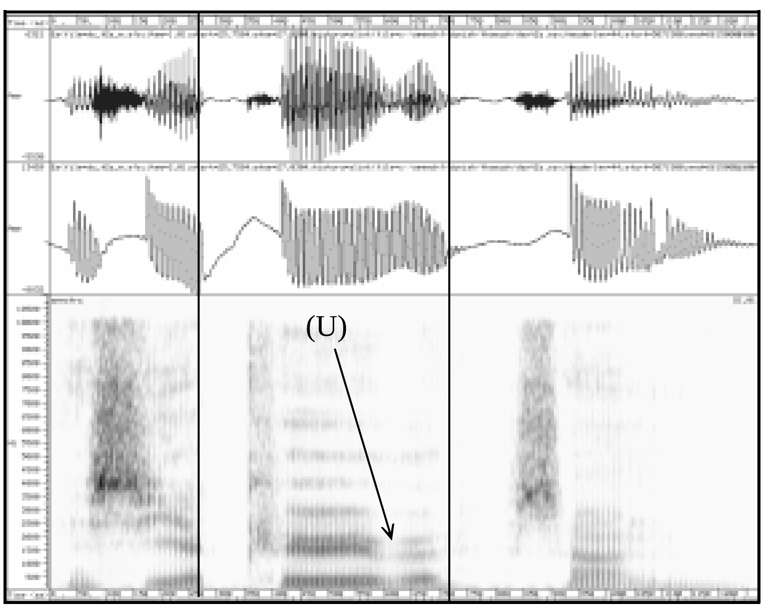

Figure 4. Danish **købe** (between cursor points): speech (top), Lx (middle), broad-band spectrogram (bottom).

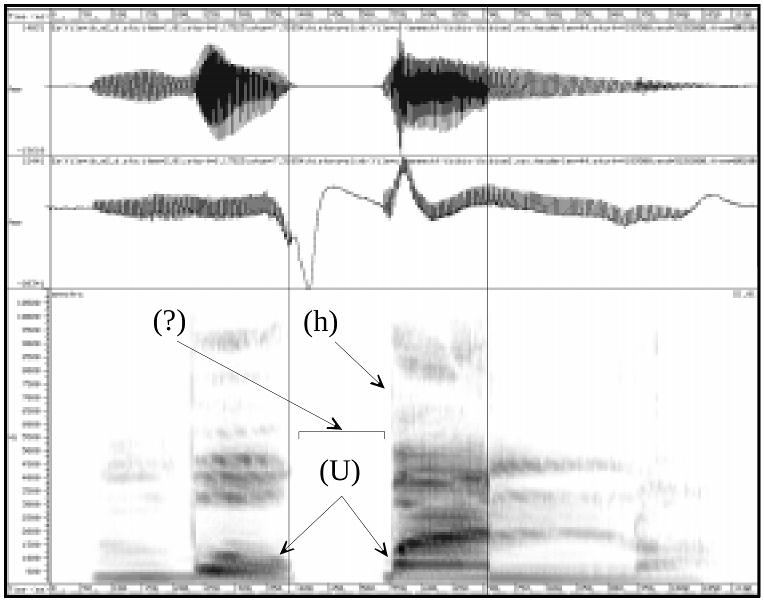

Figure 5. Ibibio *k͡pá* 'die' (between cursor points): speech (top), Lx (middle), broad-band spectrogram (bottom).

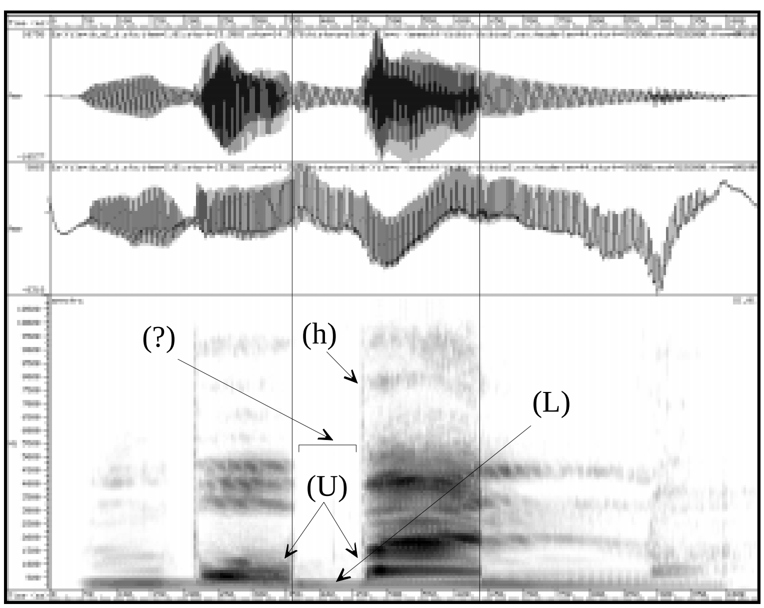

Figure 6. Ibibio *bá* 'exist' (between cursor points): speech (top), Lx (middle), broad-band spectrogram (bottom).

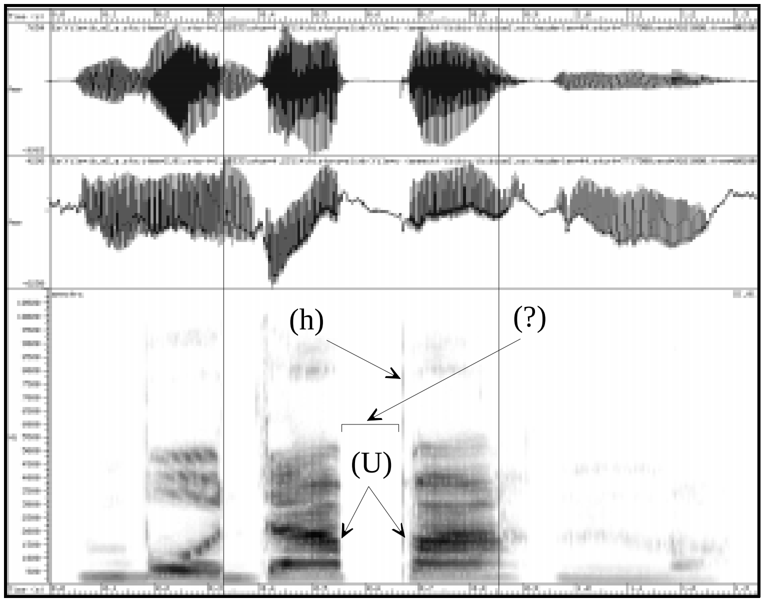

Figure 7. Ibibio *dáppá* ‘dream (vb.)’ (between cursor points): speech (top), Lx (middle), broad-band spectrogram (bottom).

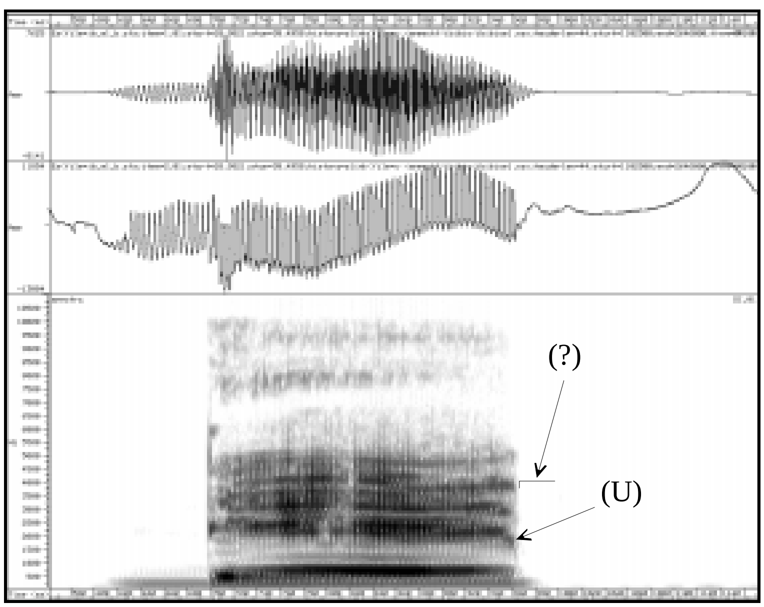

Figure 8. Ibibio *déép* ‘scratch’ (utterance-final): speech (top), Lx (middle), broad-band spectrogram (bottom).

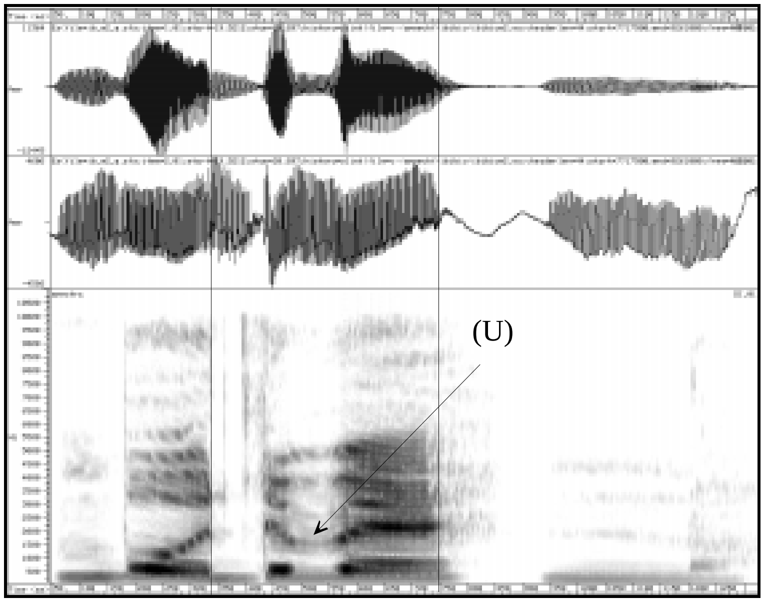

Figure 9. Ibibio *dɪ́βé* 'hide oneself' (between cursor points): speech (top), Lx (middle), broad-band spectrogram (bottom).