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Laryngeal contrast and phonetic voicing

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Chapter 8

Formalist models of laryngeal neutralisation and voicing assimilation¹

In the previous chapters I have pursued a distinctly functionalist approach to laryngeal neutralisation and voicing assimilation phenomena. A key feature of this approach is that it posits two separate mechanisms that operate in separate modalities to account for neutralisation rules and regressive voicing assimilation. Following [Steriade \(1997\)](#), I argued that neutralisation of fortis-lenis distinctions should be attributed to their perceptibility in context. [3](#) represents an attempt to extend Steriade's original proposal, which mainly examines the effects of flanking sounds on the perceptibility and neutralisation of laryngeal contrast in obstruents, to positional neutralisation, and neutralisation asymmetries between stops and fricatives. An articulatory mechanism on the other hand forms the core of my analysis of regressive voicing assimilation. As [Slis \(1985\)](#) and [Ernestus \(2000\)](#) I have argued that RVA is rooted in the coarticulation of voicing targets of obstruents. This coarticulation process may feed neutralisation in a diachronic sense, by diminishing the perceptibility of laryngeal contrast in pre-obstruent contexts and biasing the reanalysis of neutralised obstruents, but it remains a distinct mechanism.

Some phonologists, even those who in principle accept the evidence and arguments of the preceding chapters, may maintain that formalist phonological theory still has a role to play in the analysis of laryngeal neutralisation and voicing assimilation phenomena. In [1.4.1](#) I sketched the position of [Hale & Reiss \(2000a,b\)](#), who see phonology as the study of the set of sound systems that can be encoded by human mental representation rather than as the study

¹An earlier and much condensed version of this chapter can be found in [Jansen \(2001a\)](#).

of the proper subset that speakers and listeners are able to acquire and use in practice. According to this view, formalist models should act as a source of metaconstraints on phonological rules that are (in part) motivated by perceptual, articulatory, or acquisition considerations. It is important to note that such metaconstraints are strictly formal and should therefore hold across rules originating from different modalities, and (ideally) account for recurrent features of those rules that are otherwise inexplicable. A slightly different view of the relation between formalist phonological theory and functionalist accounts of assimilation and neutralisation is suggested by Mascaró & Wetzels (2001) (fn. 20) who speculate that their essentially formalist approach may be complimentary to the functionalist model proposed by Steriade (1997).

The aim of this chapter is not to search for evidence for purely formal metaconstraints on laryngeal neutralisation and voicing assimilation processes: it should be abundantly clear from the preceding chapters that I do not believe that such constraints exist. The aim of this chapter is rather to demonstrate that existing formalist models of laryngeal phonology do not offer any useful predictions regarding the data examined in this study that can act as metaconstraints on a functionalist account or complement it.

This critique focuses on the sets of possible rules that are defined by formalist models rather than on the devices responsible for specifying the environments in which rules apply. The reason for this focus is that contexts for rule application are usually simply stated in terms of syllable structure or higher-order prosodic domains or morpheme boundaries. Many proposals in this vein fail to justify the prosodic structure invoked to account for neutralisation rules on independent grounds (Brockhaus 1995 is an exception) and can therefore hardly be counted as explanations. Moreover, I have already discussed the inadequacies of a syllable-based approach to laryngeal neutralisation in 3.

Models that derive specific and testable predictions about possible rule inventories tend to be implemented in terms of procedural rules or ‘hard’ (inviolable) declarative constraints. Consequently, little (specific) attention will be paid to optimality-theoretic treatments of laryngeal neutralisation and voicing assimilation. It is true that OT models produce ‘factorial typologies’ of phonological rules of the sort extensively discussed by for instance Lombardi (1999), but generally speaking they fail to put limits on what constitutes a possible phonological constraint. In the absence of such limits, any logically conceivable statement about the combination of representational primitives (or the mapping between underlying and surface levels) is a possible constraint, and factorial typologies do not generate any real predictions.²

²Note that this is an observation about specific optimality-theoretic accounts of laryngeal neutralisation and voicing assimilation, not a complaint about the overarching framework itself, which can in principle be combined with any theory of phonological or phonetic representations

The bulk of this chapter is reserved for an assessment of what are probably the two most influential types of model forms, both of which can be classified as monovalent lexical feature models. These models can be classified as formalist to the extent that their representational primitives and rule templates are stipulated or derived within the grammar rather than based on external (functional) considerations. Section 8.2 examines *[tense]-based models*, which encode the fortis-lenis distinction identically across voicing and aspirating languages by designating (voiceless) fortis obstruents as universally unmarked. The principal proponent of this approach is Lombardi (1994, 1995a,b). Its main advantage lies in the prediction that (final) laryngeal neutralisation is equally likely in voicing and aspirating languages. However, it fails to predict manner asymmetries in laryngeal neutralisation, the phonetic conditioning of regressive voicing assimilation, and on a more general level, the phonologically ‘active’ status of unaspirated voiceless fortis obstruents. This section closes with a brief excursus on the OT model proposed in Lombardi (1995c, 1997, 1999), which purports to maintain monovalency whilst solving some of the problems faced by her earlier model, but which is formally equivalent to any traditional account based binary [tense] (or some equivalent).

The second type of model is examined in 8.3. *VOT-based models*, independently proposed by Harris (1994) and Iverson & Salmons (1995, 1999) effectively build lexical representations on the VOTs of fortis and lenis plosives in word-initial position. Whilst this approach yields an adequate account of the assimilatory capacities of actively and passively voiced lenis plosives, it also fails to predict the behaviour of unaspirated fortis obstruents. In addition, under the assumption (made by Iverson & Salmons 1999) that final neutralisation represents fortition, VOT-based models are unable to predict that the process is equally likely in voicing and aspirating languages. As in [tense]-based models, attempts to make the model fit the data tend to undermine its basic premise rather than strengthen its predictions.

Furthermore, the phonetic interpretation of both types of model is beset by problems, in particular because they provide exactly the sort of lexical feature analysis of RVA that is contradicted by the acoustic data reported above. The final section of this chapter investigates how phonetically more fine-grained representations can alleviate these and other problems by improving the fit to the

and rules (cf. Boersma 1998; Polgárdi 1998; Flemming 2001). Optimality Theory is a theory of constraint interaction (like Lexical Phonology is a theory of the phonology-morphosyntax interface), and not a theory of phonological representations, which (within the generative paradigm) is an essential prerequisite for a theory of possible phonological rules. It is therefore natural for OT to inspire work on constraint interaction (typologies) rather than on what constitutes a possible constraint. However, as illustrated in a brief discussion of the OT model defended by Lombardi (1999) in section 8.2 this does not dispense with the need for a theory of possible constraints (or a theory of phonetic interpretation).

(phonetic) data under consideration. However, whereas monovalent lexical feature approaches typically undergenerate rules and (phonetic) inventories, refined autosegmental accounts overgenerate, and their output can only be constrained on grammar-external grounds. Thus, rather than solving the problems posed by laryngeal neutralisation and voicing assimilation they merely underline the shortcomings of the formalist enterprise.

8.1 Binary and unary features

As noted at various points in chapters 1-3 it is common practice to represent the contrast between fortis and lenis obstruents in terms of a single phonological feature, and this practice extends to the models examined in the next two sections. Because only a single feature is involved, the predictive power of these models largely derives from the idea that only a single value of [\pm tense] (or its equivalent) plays a significant role in the phonology and the way this *marked* value is assigned to specific phonetic classes of obstruent. The stipulation that only a single value of [tense] is ‘visible’ or ‘active’ in the phonology reduces the number of possible rules that can affect the feature by half (relative to the number allowed by a binary feature) and the same applies to the number of rules that can refer to it as a context. For example, if values of binary [tense] are visible to the phonology, it is possible to derive 4 ‘grammars’ of regressive assimilation: (1) neither tense nor lax obstruents trigger assimilation; (2) [+tense] but not [-tense] obstruents trigger assimilation; (3) [-tense] but not [+tense] obstruents trigger assimilation; (4) both [+tense] and [-tense] obstruents trigger assimilation. If only [-tense] is phonologically active on the other hand, only grammars (1) and (3) can be derived.

Features with a single phonologically active value are usually called *unary*, *privative*, or *monovalent*. Dependency Phonology (Anderson & Ewen 1987) and Government Phonology (Kaye et al., 1985, 1990) are two frameworks that (almost) exclusively employ monovalent features, but they have also been used in feature-geometric models, and in particular models of laryngeal phonology. A universal notational convention of these models is to omit phonologically inert feature values from representations altogether. Although in principle there is nothing wrong with this convention, it sometimes disguises analyses that rely in part or wholly on binary features as strictly monovalent. The next two sections of this chapter identify several instances in the generative literature where this is the case. The remainder of this section spells out what constitutes a true monovalent analysis and what counts as binarity in disguise.

It is not often spelt out explicitly whether the inert value of a feature is invisible for both autosegmental spreading and delinking operations and for the description of the contexts in which such operations apply, or only for the former.

Yet this choice has critical consequences for the restrictiveness of monovalent models. Consider for example the two rules in figure 8.1. The left-hand side of this figure represents a rule that spreads a monovalent feature [A] to a docking site (not containing [A]) preceding it. This sort of rule, which is perhaps the most common of all in autosegmental models, is equivalent to the more traditional ‘agreement’ rule $[-A] \rightarrow [+A]/_ [+A]$. Both rules are equally asymmetric in that they propagate a single value of the feature [A] backwards in sequences ending in that same value, whilst they leave sequences ending in other values of [A], e.g., $[+A][-A]$ unaffected. The fundamental claim which, in a sense, makes a monovalent feature model is that the mirror images of these rules, i.e., an autosegmental rule spreading $[-A]$ or $[+A] \rightarrow [-A]/_ [-A]$ are not available. This leads to the hard prediction that languages will only exhibit harmony and assimilation processes involving single feature values such as $[+nasal]$ (nasal harmony) or (as in the example above) $[+voice]$ (assimilation to voiced sounds), but not their opposites, $[-nasal]$ (oral harmony) or $[-voice]$ (assimilation to voiceless sounds).

However, if the description of rule contexts is allowed to make reference to unmarked feature values this prediction is lost and monovalent models become all but indistinguishable from otherwise equivalent binary models, even if spreading and delinking rules are still restricted to single feature values. It is therefore surprising that some authors (e.g., [Harris & Lindsey 1995](#)) allow for reference to unmarked feature values in the statement of rule contexts, whilst at the same time expounding the restrictiveness of monovalent models. This illustrated by the rule at the right-hand side in figure 8.1, which delinks the marked value of [A] before a docking site specified as unmarked for A. Note that a rule of precisely this type is proposed by [Harris & Lindsey \(1995\)](#) to represent facts about height harmony in the Pasiego dialect of Spanish. The notational conventions of autosegmental phonology may be deceptive here in obscuring the fact that the context for the delinking rule really is $[-A]$, but the rule at the right-hand side in figure 8.1 is nevertheless fully equivalent to $[+A] \rightarrow [-A]/_ [-A]$, the mirror image or the rule to its left. If reference to unmarked features is allowed in the statement of rule contexts, originally monovalent models are in principle endowed with the same power as binary feature frameworks.

For example, the combination in a single grammar of the two rules in figure 8.1 is equivalent to the inclusion of the symmetric agreement rule $[\alpha A] \rightarrow [-\alpha A]/_ [-\alpha A]$. So rather than proving that monovalent models can handle phenomena that seem to call for a binary feature framework ([Harris & Lindsey 1995](#)), rules of the type represented at the right of figure 8.1 are inconsistent with the main premiss of the approach and relax its constraints on the set of possible phonological rules.³

³[Harris & Lindsey \(1995\)](#) only incorporate the delinking rule in their analysis of Pasiego

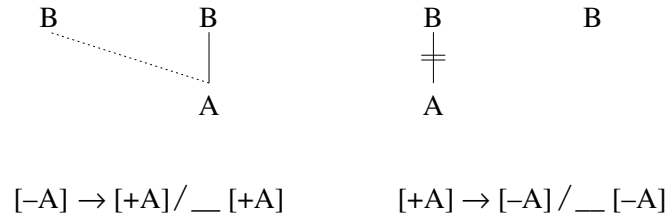


Figure 8.1: Binary rules in monovalent models.

There is one way in which a model that allows access to unmarked feature values in the statement of rule contexts can remain less expressive than full-blown binary models. If the set of autosegmental rule templates is restricted to spreading and delinking, neutralisation triggered by prosodic structure or a context defined in extra-phonological (e.g., morphosyntactic) terms can only produce unmarked feature values. In other words, a model of this kind is able to encode $[A] \rightarrow [-A] / _ _ \#$ but not $[-A] \rightarrow [A] / _ _ \#$. For example, if [+voice] (as a feature representing lenis obstruents) is marked as opposed to unmarked [-voice] (fortis) the former can be delinked to derive the latter, but if insertion of [+voice] is not allowed the reverse mapping is impossible. It follows that word-final [voice] neutralisation is always fortition (and devoicing). By contrast, fully binary feature frameworks allow both mappings and therefore predict that final ‘lenition’ and voicing are equally possible as final fortition. This distinction may seem too fine to be ever important, but it is clearly relevant to the performance of the model pursued by Iverson & Salmons (1995, 1999) (cf. 8.3).

8.2 [tense]-based models

In the early work of Lombardi (1994, 1995a,b) the representation of [tense] oppositions is conceived as part of a comprehensive approach to laryngeal contrast in obstruents and sonorants.⁴ Lombardi defines 3 privative features, i.e., [voice], [asp(iration)], and [gl(ottalised)], which are suspended from a LAR(yngeal) articulator node in a feature-geometric representation. Phonetically, [asp] is interpreted as aspiration noise, whilst [gl] represents the increased glottal constriction found in for example ejectives ([gl]) and implosives ([gl, voice]). On the interpretation of the [voice] feature, see below. Provided that [asp] and [gl] cannot combine under the same LAR node (in the same way that vocalic [+high] and

Spanish, but they do not offer any principled grounds on which the cooccurrence of the rules in figure 8.1 in a single grammar can be ruled out.

⁴Lombardi (1994, 1995a,b) are all based on the author’s PhD dissertation, Lombardi (1991).

[+low] are traditionally said to be incompatible for ‘articulatory’ reasons) the maximal number of laryngeal distinctions (per language) that can be encoded by this feature inventory is 6, which corresponds to the attested maximal number of laryngeal contrasts in obstruent inventories (Ladefoged & Maddieson, 1996). This maximally 6 term contrast includes the fully inert (i.e., [-voice, -asp, -gl]) category, which is represented as lacking a LAR node altogether.

It is this last structure that is consistently used by Lombardi and others following a similar approach to represent fortis obstruents (defined as in the introduction to 2) regardless of their phonetic interpretation as plain voiceless or voiceless unaspirated. As shown in figure 8.2, lenis obstruents possess a LAR node with a [voice] feature suspended from it, again irrespective of their VOT/voicing. No distinction is drawn between the representation of laryngeal contrast in plosives and fricatives. Consequently, the structures in figure 8.2 classify the obstruents of aspirating and voicing languages in exactly the same way as the descriptive feature [tense] as I have used it in this study.

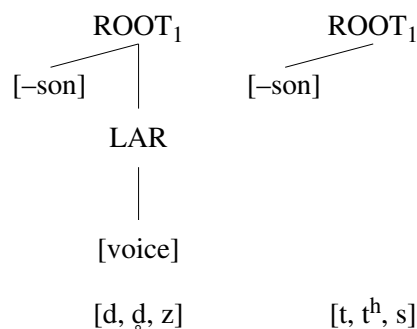


Figure 8.2: Representation of laryngeal contrast in [tense]-based models

Although Lombardi has in some ways erected the most elaborate [tense]-based framework available, the philosophy, if not the technical devices, of her approach are shared by a number of other accounts of the laryngeal phonology and phonetics of languages with a fortis-lenis opposition in their obstruent systems. Among the more notable of these studies are Mester & Íto (1989), Cho (1990a/1999,b), and to a slightly lesser degree by Mascaró (1987/1995). Broadly speaking, the merit of these and other [tense] based models lies in their ability to account for properties and behaviour shared by fortis obstruents and by lenis obstruents across the voicing-aspirating distinction, including some aspects of laryngeal neutralisation and the realisation of fricatives. However, because they are built on [tense] rather than voicing distinctions, their weaknesses reside in their inability to relate the occurrence of voicing assimilation to the voicing

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(targets) of the triggers. To the extent that they subscribe to the Laryngeal Constraint, they also fail to offer an account of the Germanic past tense paradigm and progressive devoicing.

8.2.1 Phonetic interpretation of fortis and lenis obstruents

Since the models discussed in this section capture [tense] rather than phonetic voicing distinctions, they offer a transparent representation of the phonetic properties that pattern with [\pm tense] in both aspirating and voicing languages. For instance, the unmarked structure in figure 8.2 maps consistently into raised F_0 , raised F_1 , shorter duration of preceding vowels, relatively long and high amplitude release bursts, and other cues that correlate with [+tense] across languages (cf. 2). Similarly, the representational format in figure 8.2 captures the fact that both in voicing and aspirating languages the fortis-lenis distinction in fricatives is realised as voiceless vs. voiced. To the extent that voicing and aspirating languages employ voicing (distinctions) in similar fashions in word or morpheme-final environments, [tense]-based models again offer a transparent account of phonetic interpretation.

On the other hand, as already hinted above, the interpretation of [tense] in terms of VOT and voicing does not follow naturally from the structures in figure 8.2. The interpretations of [voice] and the unmarked class have to be stipulated separately for aspirating and voicing languages as zero to short lag vs. long lag, and prevoiced vs. zero to short lag respectively. An additional difficulty in the description of aspirating languages is that the mapping between phonological structure and phonetic voicing is not consistent across manners of articulation, since [voice] has to be interpreted as zero to short lag VOT for (word-initial) lenis plosives but as voicing for lenis fricatives, whilst the unmarked structure represents a long lag VOT for [+tense] plosives but plain voicelessness for fricatives. It is true that Kingston & Diehl (1994, 1995) provide evidence that zero to short lag and prevoiced plosives are *perceptually* similar, but this evidence falls short of rescuing [tense]-based models, as there seems little doubt that they are systematically different in the *production* of speech by monolingual speakers of voicing and aspirating languages. More importantly, bilingual speakers who have both a voicing and an aspirating language also seem to be able to distinguish actively and passively voiced lenis plosives (e.g., Magloire & Green 1999).

A problem of a somewhat different order is the voiced realisation of some neutralised obstruents, e.g., those flanked by sonorants in Catalan and Old English (fricatives), and worse, the neutral but nevertheless voiced initial fricatives of (standard) German and a number of eastern dialects of Dutch (cf. German <See>, [ze:]). If such obstruents are represented by the unmarked laryngeal structure in figure 8.2, its phonetic interpretation is rendered ambivalent be-

tween voiced and voiceless, that is, unless some sort of subsequent sonorant-to-obstruent assimilation rule is invoked to account for the voicing (cf. Lombardi 1995b).

8.2.2 Modelling regressive voicing assimilation in [tense]-based models

Whether or not a lack of phonetic transparency in phonological representation counts in itself as a drawback for a model of course depends on one's beliefs about the nature of the relation between phonology and phonetics. According to the extreme formalist position briefly referred to in 1, it matters little if a model of phonetic interpretation for Swedish should have to stipulate that [voice] corresponds to short lag VOT in lenis plosives, whilst a model for Dutch interprets it as prevoicing. This position is ultimately based on the belief that shape of phonological rules stands in an arbitrary relation to the phonetic substance of the features they operate on. But as shown in the previous chapters, regressive voicing assimilation under word sandhi is clearly conditioned by the phonetics of the trigger obstruents, and therefore the fact that lenis obstruents are invariably marked [voice] constitutes a problem for Lombardi's model. An additional and equally serious problem is that under the most strict interpretation of mono-valency, [tense]-based models predict that only lenis obstruents trigger RVA.

Following slightly earlier proposals by Mester & Îto (1989) and Cho (1990a/1999), Lombardi (1994, 1995a,b) analyses regressive voicing assimilation to [-tense] obstruents in terms of two mechanisms, the first of which postulates an intrinsic link between assimilation and final laryngeal neutralisation. RVA to [+tense] sounds does not really exist in this account, at least not in the intuitive sense conveyed by older models employing agreement rules for [α voice] or autosegmental feature ([\pm voice]) spreading. Instead it is captured by delinking the LAR node of a lenis obstruent when another obstruent follows: if the following obstruent is a fortis one, the result is a sequence of unmarked sounds (which are interpreted as phonetically voiceless; cf. the left panel of figure 8.3). Thus, the model conceives of assimilation to fortis obstruents as neutralisation, and without having to refer to the inert feature value [-voice], at least technically speaking. It is possible to refer to [(+)voice], and therefore RVA to [-tense] obstruents is modelled in the more intuitive way as the backward spreading of a LAR node dominating a [voice] feature (figure 8.3: right panel). In a cluster consisting of two lenis obstruents both operations apply: delinking first derives an unmarked form before [voice] spreading restores the original marked value.⁵

⁵The account proposed by Mascaró (1987/1995), although similar in many other respects, differs from the approach discussed in this paragraph, in allowing spreading of [-voice] as well as [+voice].

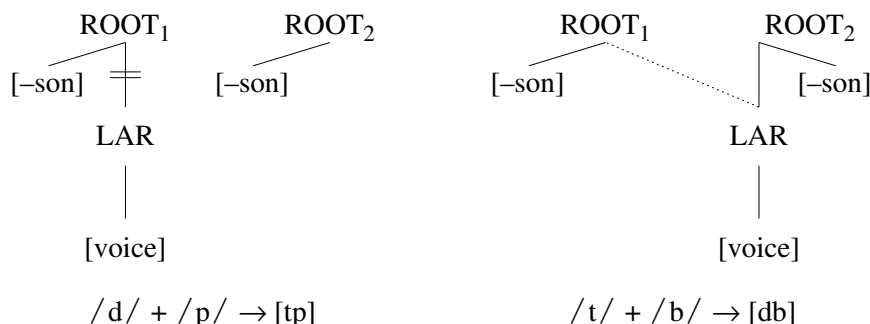


Figure 8.3: Regressive voicing assimilation according to Lombardi (1994, 1995a). Left-hand panel: ‘assimilation’ to fortis obstruents by delinking; right: RVA to lenis obstruents by (delinking and) spreading.

Languages with across-the-board final neutralisation such as Dutch and German are represented in this account with the Laryngeal Constraint switched on, which results in delinking of all word-final LAR nodes, and hence derives the first step in the assimilation process independently for all obstruent clusters straddling a word boundary. This leaves a two way taxonomy of regressive voicing assimilation in these languages: if [voice] spreading is switched on there is RVA of the trivially [tense]-symmetric form that is usually described for Dutch and Polish (although the results of experiment 3 indicate that this description is inaccurate); if it is switched off, assimilation does not occur in any intuitive sense, although clusters ending in a fortis obstruent of course end up as homogeneous sequences of unmarked obstruents.

Lombardi (1994, 1995a), Cho (1990a/1999) as well as Siptár & Törkenczy (2000) agree in the idea that in languages such as Yiddish and Hungarian, which have [tense]-symmetric RVA but not across-the-board final neutralisation, the same two operations illustrated in figure 8.3, delinking and [voice] (i.e., LAR) spreading, are responsible for RVA, although they differ on the technical point of how the delinking of [voice] from lenis plosives and fricatives is restricted to (certain) preobstruent contexts. This means that realisations such as [a:cto:l] in (27c) are derived by delinking [voice] from the palatal plosive. Note that delinking and subsequent [voice] spreading apply to the initial obstruent in [-tense][[-tense] sequences too if the delinking mechanism is not allowed to refer to the unmarked status of fortis obstruents such as the alveolar plosive in /a:ʃ/+ /to:l/.

Because preobstruent delinking and [voice] spread constitute two independent parameters, which are switched on or off with independent possibilities

and/or have independent UG default settings, a four way typology of regressive voicing assimilation is derived for the languages in question. RVA is predicted to be either [tense]-symmetric (preobstruent delinking and [voice] spreading are both active), or asymmetrically triggered by [-tense] (only [voice] spreading is active), or not to occur at all (both mechanisms are switched off). In the fourth type of language where only preobstruent delinking is active, a single series of voiceless obstruents emerges before both fortis and lenis plosives and fricatives. In other words, underlying /d/ + /p/ is predicted to surface as [tp] (or [tp^h] in an aspirating language) whilst /d/ + /b/ as well as /t + b/ should be realised as [tb] ([t^hb]) rather than [db] ([db]). Mascaró & Wetzels (2001) point out that languages exhibiting this fourth pattern do not seem to have been documented, although I argued in 2 that there may be several independent explanations for this (apparent) typological gap. Of course the latter type of language (as well as the voice-only spreading type) may be ruled out if the model somehow states that delinking and spreading always apply in tandem, but since there is no way of deriving this state of affairs this could hardly be said to be an improvement.

(27) [tense]-symmetric RVA in Hungarian and Yiddish (cf. 6.1 and Katz (1987))

a. Hungarian [+tense][-tense] clusters

/ku:t/ + /bɔn/ [ku:dbɔn] in (a) well
 /fu:c/ + /bɔn/ [fu:ɟbɔn] in (a) whistle

b. Yiddish [+tense][-tense] clusters

/bak/ + /bejn/ [bagbejn] cheekbone
 /bux/ + /gəʃeft/ [buɣgəʃeft] bookstore

c. Hungarian [-tense][+tense] clusters

/rɔb/ + /to:l/ [rɔptɔ:l] from (a) pri-soner
 /a:ɟ/ + /to:l/ [a:ctɔ:l] from (a) bed

d. Yiddish [-tense][+tense] clusters

/klug/ + /kind/ [kluk:ind/ clever child
 /briv/ + /trɛgər/ [briftɛgər] mailman

Meanwhile, the four-way typology for languages without across-the-board laryngeal neutralisation excludes a pattern that has been attested. Asymmetric RVA to [+tense] obstruents is predicted not to occur, because preobstruent delinking is insensitive to the laryngeal class of the trigger. Yet this is the pattern displayed to some degree by the English plosives examined in chapter 5, and as Mascaró & Wetzels (2001) note (perhaps to a greater extent) by Yorkshire English, and Ya:thê.

The latter issue is part of the much more serious difficulty identified at the outset of this section (but completely overlooked by Mascaró and Wetzels), namely that [tense]-based models are not able to capture the relation between the voicing of obstruents and their capacity for triggering regressive voicing assimilation. This problem extends to all [tense]-based models, irrespective of the valency of the [voice] feature, and therefore including Mascaró (1987/1995) and the OT analyses of Grijzenhout & Krämer (1998) and Lombardi (1999). For example, in Lombardi's and Cho's models, the lenis plosives of voicing as well as aspirating languages have a LAR node carrying a [voice] available for spreading, but there is no way of predicting that [voice] spreading should be activated for all and only the first group of languages. Instead the value of the [voice] parameter has to be stipulated in the model for every individual voicing language ('on' for Dutch, Yiddish, Hungarian) and every single aspirating language ('off' for English, German, Swedish). Similarly, [tense]-based models are unable to predict voicing-based manner asymmetries of the type established for English by experiment 1. Again, the fact that English /z/ but not /d/ triggers RVA can only be stipulated in the model, because both segments are specified as in figure 8.2.

Moreover, the observation that fortis obstruents have to capacity to trigger RVA as well as lenis obstruents is incongruent with the basic hypothesis of monovalent models that only marked feature values should be phonologically active. In the case at hand this entails that only lenis ([+voice]) obstruents should trigger regressive voicing assimilation. Although the use of pre-obstruent [voice] delinking to represent RVA to fortis obstruents avoids reference to inert [-voice] (as at the right-hand side in figure 8.1) by capitalising on the fact that [voice] is only marked on obstruents, it still equips the grammar of Hungarian, Yiddish and similar languages with the formal equivalent of $[\alpha\text{voice}] \rightarrow [-\alpha\text{voice}]/_[-\alpha\text{voice}]$, as of course it has to. Given the asymmetry hypothesis underlying monovalent feature models this is a patch to cover an inaccurate prediction rather than a real solution.

In sum, it seems that quite apart from their ability to represent the phonetic manifestation of regressive voicing assimilation, [tense]-based models fail to predict the phonetic conditioning of RVA and (as a result) fail to predict too, that the process can pattern asymmetrically with respect to [tense] and manner of articulation where there are mismatches between [tense] and phonetic voicing. Since the models reviewed in this section invariably employ a fortition analysis of final neutralisation as well as a lexical feature account of RVA they are also unable to represent the symmetric nature of the latter process in Dutch that was established by experiment 3. Representation of the voicing of Dutch final obstruents before fortis obstruents (and /h/, [ʔ]), sonorants and lenis plosives requires a 3 point scale rather than the two way contrast available in lexical feature ac-

counts. However, assumptions about the structure preserving ('lexical') nature of final neutralisation and RVA are deep-seated, even in some of the experimental literature, and it is therefore unsurprising that they have gone unquestioned in accounts that pay little heed to phonetic data more generally speaking.⁶

8.2.3 Laryngeal neutralisation

One of the stronger points of [tense]-based frameworks, is their modelling of laryngeal neutralisation. If the fortis-lenis distinction is encoded without regard for its phonetic interpretation, as in figure 8.2, it follows that laryngeal neutralisation (i.e., delinking) also applies without regard to phonetic interpretation. LAR delinking is a single parameter that has the same probability of being switched on or off and/or the same UG default settings, irrespective of the phonetic type of the contrast involved. In 3 I tried to demonstrate that there is little evidence for the claim that the occurrence of laryngeal neutralisation depends on the phonetic interpretation of [tense]: it occurs in aspirating as well as in voicing languages, both within (German, Dutch, Frisian) and outside (e.g., in various Slavonic and Turkic languages) the Germanic group. The predictions of a tense-based account are therefore in accordance with the data.

However, as noted before, neither Lombardi's work, nor Cho (1990a/1999,b), nor Mascaró (1987/1995), draw any distinction between plosives and fricatives in the representation of laryngeal contrast. This implies

⁶This section glosses over a number of additional problems with the model developed in Lombardi (1994, 1995a,b). Several of these problems involve unorthodox claims about assimilation, neutralisation, and syllabification that are not always defended in a satisfactory manner. One issue that deserves some attention here are the hints throughout Lombardi's work that regressive assimilation in languages such as Yiddish and Hungarian is somehow a *lexical* process and/or restricted to word internal contexts (cf. Mascaró & Wetzels (2001)). For example, the constraint that Lombardi (1994, 1995a) employs to block across-the-board final neutralisation in the languages in question (*Final Exceptionality*), takes scope over all word-final obstruents and therefore also blocks RVA at word boundaries, at least assimilation to [+tense] obstruents. Furthermore, whilst Lombardi (1996) retracts the stronger position taken up by the earlier work by stating that [-voice] may be phonologically active *postlexically*, [tense]-symmetric RVA is not used as an argument for this revised model. Thirdly, whilst claiming that the analysis does not extend to the postlexical level, Lombardi (1999) discusses Yiddish RVA data taken from Katz (1987), whose description of the phenomenon indicates that it applies across as well as within (morphologically complex) words.

As Mascaró & Wetzels (2001) observe, Lombardi never offers any argument for the (post)lexical or word internal status of RVA in Yiddish, Hungarian, or any similar language, although the relevant diagnostics (e.g., the presence of lexical exceptions, cyclic effects) are fairly straightforward. Furthermore, there may be hints in the descriptive literature that regressive voicing assimilation is 'optional' across word boundaries or otherwise less pervasive than word internally, but I am not aware of any claims that the process is restricted to word internal contexts. Moreover, the data from experiment 2 unambiguously supports the claims in, e.g., Kenesei et al. (1998) and Siptár & Törkenczy (2000) that Hungarian RVA applies between words (as well as word internally).

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that laryngeal neutralisation affects both classes of obstruent in similar degrees. This may be true for word-final neutralisation in, e.g., the Germanic and Slavonic languages, but in 3 I showed that it does not apply to (lexical) neutralisation in other contexts, nor does it hold universally for final neutralisation phenomena. For example, in the Germanic languages laryngeal contrast is generally less stable in (sibilant) fricatives than in plosives, even if the contrast is not suspended across the board.

8.2.4 Postobstruent devoicing and the Germanic past tense paradigm

I argued in 4 that progressive devoicing of lenis obstruents across word boundaries and the progressive assimilation of the past tense suffix in a number of Germanic languages are two distinct processes. Nevertheless, I will discuss these phenomena together here, because they are treated on a par by most formalist models, witness papers such as Lombardi (1997) on the ‘special’ status of progressive voicing assimilation.

One pertinent observation about the ‘Germanic’ past tense paradigm (data from 4 repeated here as examples 28 and 29) is that its occurrence is not conditioned by the voicing-aspirating distinction: the regular past tense suffix patterns in essentially the same way in aspirating languages such as English and Swedish, and voicing languages like Dutch. Perhaps the most convincing illustration of the lack of a correlation between the use of VOT in initial plosives and the behaviour of the regular past tense morpheme is that there is no dialectal variation in past tense marking coinciding with variation in VOT use: for example, Scottish English, a voicing dialect, has the same past tense allomorphy as the aspirating dialects of English.

- (28) Dutch past tense paradigm
- | | | |
|----------------|-----------|----------------------|
| /zak/ + /də/ | [zaktə] | came down, descended |
| /vas/ + /də/ | [vastə] | washed |
| /dæb/ + /də/ | [dʌbdə] | doubted, wavered |
| /xra:z/ + /də/ | [xra:zdə] | grazed |
| /krœl/ + /də/ | [krʌldə] | curled |

- (29) English past tense paradigm
- | | | |
|--------------|---------|--------|
| /lɒp/ + /d/ | [lɒpt] | lopped |
| /lɒk/ + /d/ | [lɒkt] | locked |
| /lɒb/ + /d/ | [lɒbd] | lobbed |
| /lɒg/ + /d/ | [lɒgd] | logged |
| /lo:n/ + /d/ | [loʊnd] | loaned |

In the light of the discussion of laryngeal neutralisation above, the insensitivity of regular past tense allomorphy to the use of VOT categories might seem to

constitute an argument for [tense]-based privative representations of the fortis-lenis contrast. After all, such models are able to capture the class of obstruents that cause the (initial) obstruent of the past tense suffix to devoice in a crosslinguistically uniform way: both the /k/ of Dutch /zak/ (cf. /zak/ + /ən/, *to come down, descend*) and the /k/ of English /lɒk/ belong to the unmarked category in figure 8.2.

However, the fact that they are unmarked also mean that they have no feature available that can spread onto the underlying /d/s of the English and Dutch past tense suffixes, or otherwise force feature agreement. The laryngeal feature configuration of the plosive clusters in Dutch /zak/ + /də/ and English /lɒk/ + /d/ is illustrated in figure 8.4. This is of course the same configuration that emerges where a word-initial lenis obstruent is preceded by a fortis one (cf. figure 8.3), as (at least under a fortition analysis of final neutralisation) in Dutch /ri:t/ + /zɑŋəɾ/, *sedge warbler (acrocephalus schoenobaenus)*, which is typically realised with a fully voiceless alveolar fricative, [rit̚zɑŋəɾ] (or [rit̚sɑŋəɾ] according to conventional transcriptions). Recall from 4.3 that Dutch postobstruent fricative devoicing is generally considered to be within the scope of generative models, and therefore presents the same problem to [tense]-based privative frameworks as the Germanic past tense rule.

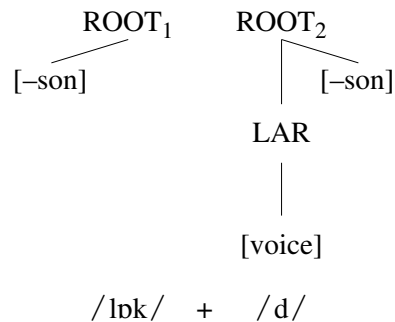


Figure 8.4: Laryngeal feature configuration for fortis + lenis obstruent clusters in privative tense-based models

Because there is no LAR node that can spread from ROOT₁ to ROOT₂ in figure 8.4, such frameworks have to resort to devices that somehow removes the license for the LAR node or the [voice] feature of ROOT₂ to account for the behaviour of the past tense rule and postobstruent devoicing. However, given that the processes in question occur outside ‘typical’ (i.e., constituent-final, preobstruent) laryngeal neutralisation contexts, such devices are difficult to formulate in a principled or general fashion within purely phonological (rather than mor-

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phology or phonetics driven) models. This difficulty is illustrated well by the various wellformedness principles that Lombardi has employed or proposed to handle instances of delinking outside the scope of the Laryngeal Constraint, two of which appear in example (30).⁷

The first principle harks back to typological observations, primarily about morphologically simplex words, made by Harms (1973) and Greenberg (1978) but is implemented in various ways as a formal constraint by Mester & Îto (1989), by Cho (1990a/1999) and by Lombardi (1994, 1995a, 1997, 1999), to deal with the English regular past tense and regular plural rules. The constraint in (30a) forces the final [voice] feature (and presumably its dominating LAR node) in sequences such as /lɒk/ + /d/ to delink, at least under the (questionable) assumption that they are parsed into a single syllable. As a formal device, Harms' generalisation raises two serious objections, both of which hold within the methodological confines of a generative approach as well as on more general grounds. First and foremost, the filter in (30a) is a statement of fact rather than anything else. The way it is formulated implies that the reverse (voiceless obstruents must be closer than voiced to the syllable nucleus) is equally possible (and likely) as a formal grammatical constraint, whether it is attested by typological evidence or not.

The second objection is that using (30a) to derive the allomorphy of the English regular past tense and plural morphemes fails to draw any connection with the similar patterning of the regular past tense in Dutch or Swedish, or more generally with other instances in which affixes adapt to the phonological properties of their hosts, as for instance in the formation of the Dutch diminutive. Harms' generalisation is insufficient to account for the behaviour the regular past tense morpheme of Dutch or Swedish because its underlying /d/ is parsed into a separate syllable (or onset rhyme sequence) with the following vowel under every (re)syllabification algorithm available in the literature. As a result very similar (looking) patterns of allomorphy have to be accounted for in terms of completely disjunct formal mechanisms, which implies that they somehow possess different properties. However, evidence to this effect is not supplied by any of the accounts cited at the beginning of this paragraph.⁸

⁷The wellformedness condition in (30b) is slightly rephrased from the version in Lombardi (1994), but is formally equivalent.

⁸The idea that /lɒk/ + /d/ is parsed into a single syllable is questionable on the grounds that it requires a word-based definition of the English syllable that fails to capture root-level phonotactic constraints (e.g., Harris 1994). Note furthermore that Borowsky (2000) presents a morphology-driven analysis of the Dutch past tense and English regular plural rules that draws on *Correspondence Theory* (McCarthy & Prince, 1995; Benua, 1995). This account nominally maintains privative [voice] but as the OT model of Lombardi (1995c, 1997, 1999) effectively allows reference to both [+voice] and [-voice], and therefore merely highlights the problematic nature of the Germanic past tense paradigm for privative models. See further below.

- (30) Constraints on laryngeal structure in postobstruent contexts
- a. *Harms' Generalisation* (see Harms 1973; Mester & Îto 1989; Cho 1990a/1999; Lombardi 1994, 1999): Voiced obstruents must be closer than voiceless to the syllable nucleus
 - b. *Postobstruent Fricative Devoicing* (cf. Lombardi 1994, 1997): [voice] cannot be licensed in the following configuration:

$$[-\text{son}] \left[\begin{array}{c} -\text{son} \\ +\text{cont} \\ - \end{array} \right]$$

Lombardi (1997, 1999) asserts that progressive assimilation to [-voice] is relatively rare and only occurs under special circumstances. The special circumstances notwithstanding, this constitutes an admission that the laryngeal specification of fortis obstruents can be phonologically active, and thereby undermines a basic premiss of Lombardi's framework. The prose definition of Harms' Generalisation may suggest otherwise, but it is a mechanism along the lines of the delinking rule in figure 8.1: it delinks marked [voice] after an obstruent that bears the unmarked value for the same feature. Consequently, the constraint is equivalent to the traditional agreement rule [+voice] → [-voice]/[-voice]_, or an autosegmental rule spreading [-voice], which (given that [+voice] spreading is also allowed in [tense]-based frameworks) is precisely the sort of rule monovalent feature models purport to be ruling out.

A final problem within the specific context of Lombardi's model that affects both the rules in (30a) and (30b), is that they refer to [voice] rather than to the dominating LAR node, as the other rules and filters in the model. Despite the suggestion in Lombardi (1995b) that all rules of laryngeal phonology refer to LAR instead of to the specific features it dominates, this is tantamount to the admission that there are [voice]-specific rules, and thereby underlines the failure of privative [tense]-based accounts to yield any solid predictions about the behaviour of the Germanic past tense paradigm and progressive devoicing.

8.2.5 Excursus: Lombardi's (1999) OT model and privativity in Optimality Theory

Up to this point I have described Lombardi's work as consistently adopting a [tense]-based and privative approach to laryngeal contrast and voicing assimilation. However, as far as the latter phenomenon is concerned, the OT implementations of Lombardi (1995c, 1997, 1999) represent a break with earlier work, in that voicing assimilation is effectively captured in terms of a binary [voice] feature. The same applies to the analyses of the Dutch past tense and English regular plural rules in Borowsky (2000), which are also nominally based on mono-

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valent [voice]. I will briefly discuss the relevant properties of Lombardi (1999), the latest published version of the OT-based model, because it emphasises the problematic nature of the mechanisms employed to capture [tense]-symmetric RVA, progressive devoicing, and the Germanic past tense paradigm in monovalent models. In my opinion they also underline the shift of attention in much optimality-driven work away from constraining rule inventories and towards the modelling of rule interaction.

- (31) Constraints relating to (symmetric) RVA in Lombardi (1999)
- a. *IdentOnset(Laryngeal)* (Lombardi 1999:270): Consonants in the position stated in the Laryngeal Constraint (cf. figure 3.1 in section 3.1) should be faithful to underlying laryngeal specification
 - b. *Ident(Laryngeal)* (Lombardi 1999:270): Consonants should be faithful to underlying laryngeal specification
 - c. *AGREE* (Lombardi 1999:272): Obstruent clusters should agree in voicing

Lombardi (1999) employs the wellformedness conditions in (31) to model regressive voicing assimilation. The first (abbreviated *IDOnsLar*) is a *positional faithfulness* constraint of the type first proposed by J. Beckman (1997). Both this constraint and the second (abbreviated *IDLar*) belong to the *Identity(Feature)* family (McCarthy & Prince, 1995), but the former is relativised to apply only in a certain context. Consequently, *IDOnsLar* is violated by any output obstruent that (a) precedes a tautosyllabic sonorant and (b) has a laryngeal specification that is in any way different from its correspondent in the input. Thus, given an underlying form /bæd/ this constraint is violated by surface /pæd/ but not by [bæ̥t]. *IDLar* on the other hand is violated by any obstruent in the output that meets condition (b), which means it penalises both /pæd/ and [bæ̥t] as surface forms of /bæd/. Technically speaking, *AGREE* is also an *Identity* constraint, but one demanding identical laryngeal structure in adjacent segments in the same output string, much like the B(ase)-R(eduplicant) faithfulness of McCarthy & Prince (1995), instead of between sounds in different output strings or between correspondent segments in input and output strings.

The tableau in (32) demonstrates how *AGREE* and *IDOns* interact to select the optimal candidates for underlying forms with laryngeally heterogeneous obstruent clusters in languages with [tense]-symmetric RVA, such as Yiddish and Hungarian. The examples here (/fy:c/ + /bɔ̃n/, in (a) *whistle*; /a:ʒ/ + /to:l/, from a *bed*) are from Hungarian, but the top and bottom parts of table (32) correspond directly to constraint tableaux (22) and (23) in Lombardi (1999). The interaction between *AGREE* and *IDOnsLar* derives [tense]-symmetric regressive voicing assimilation in a straightforward way. *AGREE* filters out any surface forms with a heterogeneous cluster, including the perfectly faithful ones

in (b) and (g). IDOnsLar then determines the choice between the candidates showing progressive voicing assimilation (a and h) and those with regressive assimilation (d and e), all of which incur a single violation for IDLar, in favour of the latter two forms: (a) and (h) have an obstruent with a different laryngeal specification in the context defined by the Laryngeal Constraint and therefore violate IDOnsLar as well as IDLar. Thus, the OT account of Lombardi (1999) captures voicing assimilation to both lenis *and* fortis obstruents in terms of the same mechanism: the AGREE constraint, with IDOnsLar determining the direction of assimilation.

- (32) Constraint tableau for [tense]-symmetric RVA according to Lombardi (1999). Examples from (27a) and (27c) above

	/fy:c/ + /bɔn/	AGREE	IDOnsLar	IDLar
(a)	[fy:cpɛn]		*!	*
(b)	[fy:cbɛn]	*!		
(c)	[fy:ɰpɛn]	*!	*	**
(d)	[fy:ɰbɛn] ✓			*
	/a:ɰ/ + /to:l/			
(e)	[a:cto:l] ✓			*
(f)	[a:cdɔ:l]	*!	*	**
(g)	[a:ɰto:l]	*!		
(h)	[a:ɰdo:l]		*!	*

This uncomplicated account of [tense]-symmetric RVA seems surprising in the light of the discussion of this issue above, which attempted to show that the phenomenon is something of an embarrassment for privative [tense]-based models, which are forced to capture RVA to fortis and lenis in terms of two separate mechanisms, i.e., [voice] delinking and [voice] spreading. However, any surprise disappears on closer inspection of the correspondence constraints in (31), which reveals that they equip the model with the full power of binary rather than privative [voice]. First, note that the representations for all the output forms in (32) can be derived from their respective underlying representations by operations on privative [voice]. For example, [fy:ɰpɛn] can be derived from /fy:c/ + /bɔn/ by delinking [voice] from the underlying /b/ and inserting a LAR node carrying voice to the preceding /c/. In other words, it would be correct to say that privativity is maintained in GEN.

But this is not true of H-EVAL, because given the constraint definitions in (31), the algorithm scans and uses the laryngeal specifications of lenis (marked, [+voice]) and fortis (unmarked, [-voice]) in exactly the same way. Take for example the surface forms [fy:cbɛn] (b) and [a:ɰto:l] (g). To establish the performance of the first with respect to AGREE, H-EVAL has to check the laryngeal specification of the labial (marked, i.e., [+voice]) and palatal plosives (un-

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marked, i.e., [-voice]). This information leads to a violation of AGREE, which assigns the unassimilated form (b) suboptimal status. In many ways, this procedure resembles the application of the [voice] spreading rule discussed above to the same input, i.e., /fy:c/ + /bɔn/. The latter also has to check the laryngeal specification of the palatal, which establishes that it is a legitimate target for spreading, and the specification of the labial, which triggers the decision to spread [voice].

Crucially, the OT model processes the performance of the second form, [a:ɟto:l], in much the same way as that of the first. Here the information that [t] is [-voice] (unmarked) whilst [ɟ] is [+voice] (marked) again leads to a fatal violation of AGREE. It is this violation that critically distinguishes it from the optimal form with regressive assimilation (d). But in this instance, the OT model and the earlier framework developed by Lombardi (1994, 1995a,b) behave differently. Whereas in the former the unmarked ([-voice]) specification of the alveolar plosive ‘triggers’ RVA by rendering the candidate without assimilation suboptimal, an autosegmental rule spreading privative [voice] does nothing on encountering the unmarked /t/ in /a:ɟ/ + /to:l/. This means that AGREE is equivalent to a rule spreading *binary* [voice] rather than to its privative counterpart, and it is therefore hardly surprising that the OT model is able to deal with [tense]-symmetric RVA in terms of a single constraint.⁹

So although Lombardi claims that her OT analysis of laryngeal neutralisation and voicing assimilation:

“will get the result that both [assimilation to lenis and assimilation

⁹IDOnsLar and IDLar have the same binary power as AGREE. For example, both the realisation of an underlying lenis (marked) obstruent as fortis (unmarked; a and c in 32) and the realisation of a fortis obstruent as lenis (f and h) lead to violations of the first two constraints. This does not mean that privativity cannot be, or has not been, implemented or simulated in OT. For instance, **Structure*-type constraints (cf. Prince & Smolensky 1993) generally seem to be limited to single values of traditionally binary features, so that **nas(al)* and **voice* (which for present purposes is equivalent to the **Lar* of Lombardi 1995c, 1997, 1999) are possible constraints but not **-nas* and **-voice*. Furthermore, IDOnsLar and IDLar could be redefined as *DEP*-type correspondence constraints (McCarthy & Prince, 1995) that are sensitive to marked but not unmarked structure in output forms. These constraints would still be violated by (f) and (h) in (32), which ‘add’ marked [voice] to the underlying form, but no longer by (a) and (c), which ‘remove’ marked structure, and thus act in a [tense]-asymmetric fashion. AGREE could be redefined along similar lines so as to penalise fortis + lenis (b, f) but not lenis + fortis constraints (c, g). Needless to say, restoring privativity in Lombardi’s model in this way would reintroduce the problems caused by [tense]-symmetric RVA as well.

A different OT-based approach to the sort of asymmetric phenomena that have been accounted for in terms of monovalent features, is to (universally) rank faithfulness constraints for marked feature values above those for unmarked values, as in *Ident(+voice)* >> *Ident(-voice)* or *AGREE(+voice)* >> *AGREE(-voice)*. Depending on how such fixed feature hierarchies are interleaved with other constraints, they supply unary or binary feature power and can therefore describe both symmetric and asymmetric RVA. This approach, which in some ways is closest to the original spirit of OT, is exemplified by the work of Gnanadesikan (1997).

to fortis obstruents] are equally natural, while still allowing us to maintain the result that voice is privative. (Lombardi 1999:280)”

this analysis in fact merely underlines the fundamental problem that [tense]-symmetric RVA poses for truly privative feature accounts.

8.3 VOT-based models

The models of Lombardi (1994, 1995a,b), Cho (1990a/1999,b) and others I discussed in the previous section are both [tense]-based and privative. These are strictly speaking independent properties, but since the hard predictions of these models flow from their privative representation of [tense], I mostly referred to them simply as [tense]-based models. However, most binary feature accounts of the fortis-lenis distinction and voicing assimilation are [tense]-based in that they consistently represent fortis obstruents as [-voice] or [+tense] and lenis obstruents as [+voice] or [-tense], irrespective of their phonetic voicing.

The models reviewed in this section on the other hand, encode the lexical contrast between fortis and lenis obstruents in a way that is transparently (and universally) related to the use of VOT to signal distinctions between word-initial and prestress plosives. Just as Lombardi’s model they employ monovalent features, but they assign the unmarked structure to the series of plosives that has a zero-to-short lag VOT utterance initially. Consequently, laryngeal contrast is represented differently for aspirating and voicing languages, and this leads to the prediction that laryngeal neutralisation and voicing assimilation behave differently in the two types of languages: in this sense VOT-based models are diametrically opposed to [tense]-based accounts.

Perhaps the most comprehensive defense of a privative VOT-based approach to the languages in the Germanic group appears in the work of Iverson & Salmons (1995, 1999), but the idea to encode lexical laryngeal contrast in obstruents in terms of their voicing is present in Kaye et al. (1990) and is fleshed out for English by Harris (1994). Moreover, both of the latter draw on earlier work by Halle & Stevens (1971) to justify their proposals to link the representation of laryngeal contrast in obstruents and F_0 /lexical tone on sonorants. Jessen (1998) also proposes different phonological representations for the fortis-lenis distinction in aspirating and voicing languages but employs binary rather than monovalent features.

Iverson & Salmons (1995, 1999) adopt the articulation-based terminology of recent versions of Feature Geometry (cf. Clements & Hume 1995) whereas the interpretation of the phonological elements used by Harris (1994) is couched in auditory/acoustic terms (see also Harris & Lindsey 1995). Nevertheless, both models recognise the set of VOT classes for utterance-initial stops that was identified by Lisker & Abramson (1964), and both models assign formally identi-

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cal structures to these classes. Figure 8.5 displays the representations of the 3 VOT classes in the notation of Harris (1994): *H(igh tone)* represents the long lag VOT element, *L(ow tone)* the negative VOT element, whilst *h* represents the *noise* element which (roughly) defines the class of obstruents and can for present purposes be treated as equivalent to [-son]. These names for the long lag and negative VOT elements betray the influence of Halle & Stevens (1971) and their attempt to unify the representation of lexical tone and laryngeal contrast in obstruents using the features [±stiff vocal folds] and [±slack vocal folds]. H and L correspond to the features [spread glottis] and [voice] in the work of Iverson & Salmons (1999, 1995).

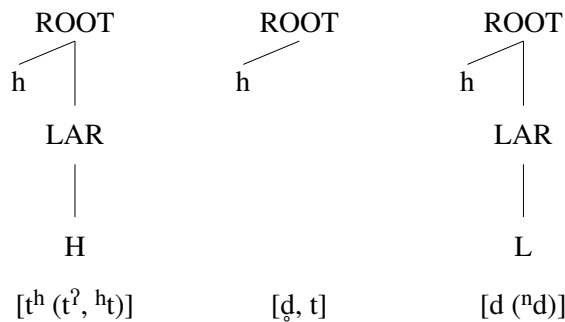


Figure 8.5: Representation of the fortis-lenis contrast according to Harris (1994) and Iverson & Salmons (1995, 1999)

One of the principal advantages of VOT-based models is that they capture the connection between prevoicing in lenis plosives and RVA in a natural way. However, reducing (the representation of) the fortis-lenis contrast to (utterance-)initial VOT distinctions has several serious drawbacks as well. Most of these drawbacks are related to the fact that VOT-based models cannot easily express the various similarities that justify the use of *fortis* and *lenis* as phonetic and phonological classes across voicing and aspirating languages. For example, they are unable to capture the similar behaviour of word-final laryngeal neutralisation and past tense paradigms in voicing and aspirating languages. The unification of passively voiced lax stops and actively devoiced unaspirated tense stops into a single phonological category is another source of problems for VOT-based frameworks. It becomes impossible to predict, for example, that unaspirated fortis stops, but not passively voiced lenis stops are RVA triggers. Finally, the monovalent feature representations of the VOT-based accounts discussed below are unable to capture symmetric RVA in a satisfactory way, much as [tense]-based privative accounts.

8.3.1 Phonetic interpretation of fortis and lenis obstruents

The phonetic interpretation of the structures in figure 8.5 in terms of initial and prestress VOT is obviously unproblematic. However, the broader picture of the phonetic interpretation of the fortis-lenis contrast in VOT-based models is fraught with difficulties, because they posit a single category unifying the tense stops of voicing languages with the lax stops of aspirating languages. Yet it is evident from the work of Kingston & Diehl (1994) and numerous earlier authors that the tense stops of voicing languages and the lax stops of aspirating languages are phonetically distinct in terms of duration, preceding vowel duration, release burst characteristics, low-frequency spectral features. In fact, as argued in sections 2.2.1 and 2.2.2, the two types of stop are most probably distinct even in terms of phonetic voicing. The tense stops of voicing languages behave as if they are actively devoiced whereas the lax stops of aspirating languages are most likely to be passively (de)voiced in context: in a sense, their similar VOTs in utterance-initial and postobstruent environments can be regarded as accidental.¹⁰ As a consequence, VOT-based models have to specify the phonetic interpretation of the unmarked structure on a language-specific basis, whilst the interpretation of marked stops is universally fixed

Moreover, since both Harris (1994) and Iverson & Salmons (1995, 1999) align the laryngeal representation of fricatives with that of stops, there is a many-to-many mapping between the structures in figure 8.5 and [\pm tense] fricatives. The phonological structure and phonetic interpretation of laryngeal contrast in fricative inventories VOT-based frameworks is schematised in figure 8.6. The voiced lenis fricatives of voicing languages are assigned the laryngeal element L, which is consistent with the interpretation of this element as prevoicing (and low F_0) for plosives. However, because both Harris and Iverson and Salmons adopt a manner-symmetric approach to laryngeal contrast in obstruents, the lenis fricatives of aspirating languages are assigned the unmarked structure. Since H, L and the unmarked structure correspond universally to the same 3 VOT categories for (prestressed and word-initial) plosives under VOT-based models, this implies that the lenis fricatives of voicing and aspirating languages belong to 2 separate voicing categories. Yet experiments 1 and 2 fail to support this prediction, and in an ironic twist, the only language that supplies evidence for

¹⁰This observation also undermines the suggestion by Harris & Lindsey (1995) that phonologically unmarked structure is phonetically underspecified in the sense of Keating (1988) or Pierrehumbert & Beckman (1988) (cf. 1.3.5). Note that even if other adherents of Government Phonology do not sign up to this idea as a general principle, they show a strong tendency to interpret the element H in terms of various forms of active devoicing, L as active voicing, and the unmarked structure as passively voiced. Thus, H is sometimes interpreted as the type of stiff voice/laryngealisation associated with Korean ‘tense’ unaspirated stops, or as preaspiration. Likewise, the element L has been used to represent stop (pre)nasalisation. See, e.g., Kaye et al. (1990), Heo (1994), Gussmann (1999), Ploch (1999), and section 8.4 below.

the existence of phonologically inert (passively voiced) lenis fricatives is Dutch, a voicing language which should have L-marked /v, z/ according to the VOT-based approach (see section 4.3).

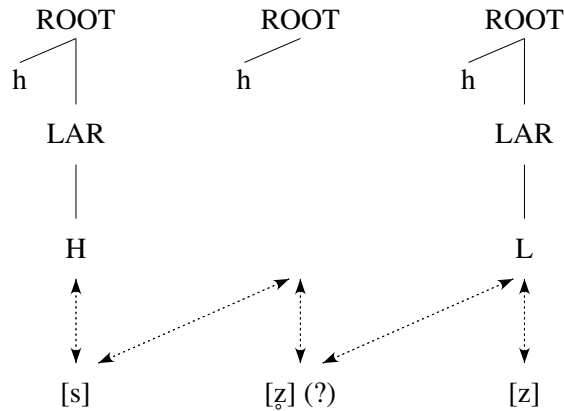


Figure 8.6: Representation of fortis and lenis fricatives in VOT-based models.

The transparency of the relationship between voicing and laryngeal structure in the models of Harris (1994) and Iverson & Salmons is further compromised by the representation of fortis fricatives, again as a result of maintaining manner symmetry in laryngeal representation. Fortis fricatives are marked H in aspirating languages because the corresponding plosives are, whereas they are unmarked in voicing languages. VOT-based models therefore do not only have to fit 4 phonetic stop categories to the Procrustean bed of 3 laryngeal classes, they are also forced to adopt a many-to-many mapping for fricatives: there are 2 possible structures each for voiceless fortis and voiced lenis fricatives, and conversely, the unmarked laryngeal structure can represent at least two categories of fricative.

As before, it might be objected that the relative complexity of phonetic interpretation models is of no concern to the phonologist, and therefore that the intransparencies identified here cannot be held against VOT-based models, but as with [tense]-based models this autonomist position backfires in the analysis of regressive voicing assimilation.

8.3.2 Regressive voicing assimilation in VOT-based models

Regressive voicing assimilation is ostensibly the mainstay of VOT-based models, because they are able to capture the observation that in voicing languages but not in aspirating languages, lenis stops trigger RVA: both Harris (1994) and

Iverson & Salmons (1995, 1999) make this point explicitly. It appears rather ironic in this light that their models perform hardly better in the analysis of RVA than the [tense]-based models of Lombardi (1994, 1995a,b) and others. The behaviour of the sounds encoded by the unmarked structure in figure 8.5 is (again) a major problem, because contrary to the predictions of the approach in voicing languages they trigger regressive voicing assimilation. Furthermore, as all other accounts that subscribe to manner symmetry in laryngeal representation, the VOT-based models reviewed in this section are unable to capture the observation that English /z/ but not /d/ triggers RVA, and as under all privative approaches their account of symmetric RVA leads to some inaccurate predictions.

The single advantage of using the VOT-based structures in figure 8.5 over the [tense]-based representations in figure 8.2 should be easy to appreciate in the context of the present study: prevoiced stops of the type found in Dutch, Yiddish, Hungarian, and similar languages bear (a LAR node dominating) the element L, and can therefore spread their laryngeal specification backwards. Zero to short lag VOT lenis stops of the type found in English, German and the North Germanic languages on the other hand have no such element available for spreading and are consequently predicted not to trigger RVA. Thus, VOT-based models, like the phonetic theory of RVA pursued in this study, capture an important observation about the assimilatory behaviour of lenis stops.

However, whereas the phonetic theory attributes the different assimilatory properties of actively vs. passively voiced /b, d, ʃ, g, ɣ/ and other obstruents to the articulatory gestures involved in their production, VOT-based theories seek an account in terms of the *acoustic results* (in a specific phonetic context) of these gestures. The latter approach is problematic because it predicts that [b̥, d̥, ʃ̥, ɡ̥, ɣ̥] and [p, t, c, k q] should behave alike with respect to regressive voicing assimilation: both categories are represented by the unmarked laryngeal structure and should therefore be phonologically inert. Yet it is evident from the literature and in particular from the experiments reported in the previous two chapters that fortis zero to short lag plosives of Yiddish, Hungarian (cf. the examples in 27), Dutch, and other voicing languages are capable of triggering assimilation whereas their lenis counterparts in e.g. English do not.

Although neither Harris (1994) nor Iverson & Salmons (1995, 1999) discuss this issue, VOT-based models have to resort to L delinking to describe RVA to unmarked [p, t, c, k] just as [tense]-based models have to resort to [voice] delinking to represent this phenomenon. If preobstruent delinking is incorporated as a separate parameter, VOT-based models derive the 4 way taxonomy of assimilation for voicing languages without across-the-board final neutralisation that was described for [tense]-based frameworks above, including the ‘anomalous’ delinking-without-spreading type that derives [tb] for underlying /t/ + /b/ and

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/d/ + /b/. As pointed out in the previous section, preobstruent delinking works around the problem of assimilation to voiceless unaspirated fortis plosives in a technical sense, but it introduces binary power into the model, and consequently weakens the basic hypothesis of monovalent feature models.

Moreover, introducing preobstruent delinking to VOT-based models has an undesirable side-effect in the analysis of H-based (aspirating) languages. Note that laryngeal spreading needs to be available as a parametric option for such languages because it allows for the representation of [tense]-asymmetric assimilation to fortis obstruents as found in Yorkshire English and to some extent for English /t/ in experiment 1 (cf. the right panel of figure 8.7). This form of assimilation cannot be derived for L-based languages for the same reason it cannot be modelled in [tense]-based models (see above), which amounts to the prediction that [tense]-asymmetric RVA to fortis obstruents only occurs in aspirating languages. However, if delinking of preobstruent laryngeal structure is also available for H-based languages (and this can be ruled out only by stipulation if it is employed in L-based systems) a 4 way typology of regressive voicing assimilation is derived for this group which contains two systems with RVA to lenis plosives, i.e., those with H delinking switched on. This is illustrated in the left panel of figure 8.7: if the lexical H of a fortis obstruent is delinked before a lenis one, the result is an ‘assimilated’ lenis + lenis cluster, which (assuming spontaneous voicing for the unmarked category) would be phonetically realised as [db̥] or [d̥b̥], where [̥] represents partial final devoicing of the alveolar stop. The fact that zero to short lag VOT lenis plosives never trigger RVA is one of the key observations behind VOT-based models and it is therefore unfortunate that to maintain this generalisation preobstruent delinking has to be ruled out for H-based languages on entirely arbitrary grounds.

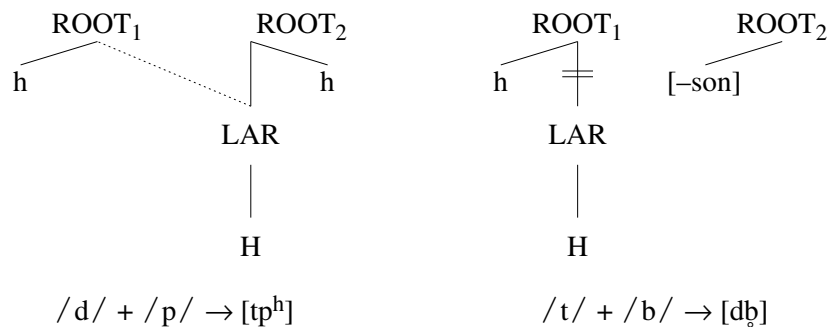


Figure 8.7: RVA in aspirating systems according to VOT-based models. Left: assimilation to fortis obstruents; right: assimilation to lenis obstruents.

Finally, ignoring the complications introduced by preobstruent delinking as a device for representing RVA, VOT-based models reviewed in this section are unable to predict the assimilatory behaviour of fricatives. Both Harris (1994) and Iverson & Salmons (1995, 1999) (tacitly) assume that laryngeal representation is manner-symmetric, and thus [v, z, ʒ, ʁ] are marked L in voicing languages but left unmarked in aspirating languages. This implies that only the lenis fricatives of the former are able to trigger regressive voicing assimilation in a preceding obstruent. Conversely, only the fortis fricatives of aspirating languages have a H element available for spreading, which predicts that voicing assimilation to fortis fricatives occurs only in this group. These suggestions are plainly contradicted by the results of experiments 1 and 2 which show that (aspirating) English [z] and (voicing) Hungarian [s] are both able to trigger RVA.

8.3.3 Laryngeal neutralisation

Iverson & Salmons (1999) maintain a fortition analysis of final neutralisation in German and Dutch, which entails that the phenomenon is represented in different ways for these two languages: for an aspirating language such as German the change of a lenis obstruent into a fortis one involves the insertion of H, whereas for voicing languages such as Frisian and Dutch it involves L delinking (cf. figure 8.8). Under a uniform analysis of neutralisation as delinking such as that of Lombardi (1994, 1995a,b), final neutralisation would manifest itself as H delinking in aspirating languages and hence as lenition rather than fortition and phonetic ‘deaspiration’ instead of ‘devoicing’. Given that the final neutralisation rules of German, Dutch and Frisian are descriptively very similar, invoking two distinct devices to represent these rules raises the suspicion that their principal motivation is to make the fortition analysis work.¹¹

Iverson & Salmons (1999) appear to be aware of this issue and defend their position with the claim that in German the phonetic result of neutralising laryngeal contrast between plosives is an aspirated plosive whereas in Dutch it is a plain voiceless plosive. Since H is interpreted as long lag VOT (produced by means of aspiration) prevocally this would be a sound argument in favour of an insertion analysis if Iverson & Salmons’ description of German final plosives were accurate, but unfortunately it is not. It is true that German plosives have been described as being postaspirated, but in many cases this description seems to refer to the presence of an audible oral release. Note that according to this definition of the term *aspiration*, which extends well beyond the literature on German, the final neutralised obstruents of Dutch are aspirated too. But as shown by Jessen (1998) word-final plosives in German are not normally accompanied by a wide glottal abduction gesture that peaks around the time of oral

¹¹Although Harris (1994) does not propose an analysis of final neutralisation along these lines (see below) I have maintained his notation throughout this section for reasons of clarity.

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release (see also Moulton 1962; Knetschke & Sperlbaum 1987). Apart from the evidence reviewed in 3 that final neutralisation in German is phonetically incomplete, descriptions suggest that the phonetic manifestation of the phenomenon is highly similar in German, Dutch and Frisian. Thus, there seems little phonetic justification for the account of Iverson & Salmons (1995, 1999).

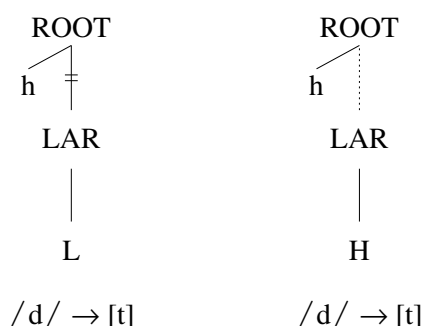


Figure 8.8: Final neutralisation in aspirating and voicing languages, according to a VOT-based model. Left: final neutralisation in voicing languages; right: neutralisation in aspirating languages.

Harris (1994) does not offer an analysis of final laryngeal neutralisation, but his general approach, in which phonetic reduction as well as phonological neutralisation are represented in terms of delinking, is hardly consistent with Iverson and Salmons' account of neutralisation in aspirating languages. Rejecting H insertion leaves only the H delinking, 'deaspiration' route open as a way of capturing final neutralisation in aspirating languages using a VOT-based framework. Although it runs counter to the long tradition of viewing final neutralisation as fortition or *Auslautverhärtung* (sharpening), this solution does not complicate the phonetic interpretation of the model to any greater degree than the H insertion analysis, whilst it eliminates the question (left unanswered by Iverson & Salmons 1999) why H insertion and L delinking should be available but L insertion and H delinking (both resulting in final obstruent 'voicing') not. It is also congruent with the spirit of the VOT-based approach, which acknowledges the observation that phonetic voicelessness is not invariably tied to phonological [+tense].¹²

¹²Jessen (1998) represents German final neutralisation as lenition and deaspiration rather than as fortition using a binary feature [tense]. Brockhaus (1995) is a detailed account of German final laryngeal neutralisation couched in Government Phonology, but it is crucially different from the models discussed in this section and section 8.2 above in that it abandons monovalent representation of the fortis-lenis distinction and a structure preserving analysis of final neutralisation. See section 8.4 below.

A VOT-based delinking account of final neutralisation (cf. figure 8.9) regains an important generalisation captured by [tense]-based frameworks (as well as the cue-driven account of Steriade 1997), namely that final neutralisation is equally likely to occur in aspirating and voicing languages. The presence or absence of final neutralisation is again controlled by a single parameter (LAR delinking in an independently specified set of contexts) with a single probability of being switched on (and/or a single UG default setting) whereas the model of Iverson & Salmons (1999) requires two parameters (delinking and insertion), which can only be assigned identical probabilities of being switched on or identical default settings by brute force stipulation.

Note that a VOT-based delinking analysis is still structure preserving in the sense that the output of laryngeal neutralisation is a feature structure that is present at the underlying level, i.e., the laryngeally unmarked one. As pointed out above the phonetic interpretation of this structure is problematic, and employing it to represent the class of neutralised obstruents hardly improves the situation. For German the unmarked structure represents underlying /b, d, g/ (as well as /v, z/), which are realised as [b̥, d̥, ɡ̥] in word (utterance-)initial and postobstruent environments but as voiced or partially voiced plosives postvocally, where they are also preceded by longer vowels than their fortis counterparts (e.g., Jessen 1998). For Dutch and Frisian on the other hand, the unmarked structure represents underlying /p, t, k, f, s, x/, which trigger vowel shortening postvocally (Slis & Cohen, 1969a) and are generally speaking mostly voiceless across the environments in which these languages maintain laryngeal contrast. Thus, representing laryngeal neutralisation in terms of delinking implies that all else being equal, neutralised obstruents are phonetically identical to the unmarked series outside neutralisation contexts, and since the unmarked series is not implemented uniformly across voicing and aspirating languages, that there are phonetic differences between the neutralised obstruents of aspirating and voicing languages. In other words, the prediction is that the final obstruent of (the citation form of) Dutch /rad/, *wheel* is phonetically similar to the medial obstruent of /rat/ + /ən/, *rats* whereas the final plosive of German /ra:d/, *bicycle*, is phonetically more similar to its medial counterpart in /re:dər/, *bicycles*.

Although a great deal of research remains to be done on the phonetics of laryngeally neutralised obstruents, this prediction appears to be inaccurate, as impressionistic phonetic descriptions suggest that the neutralised obstruents of Dutch, Frisian, and German (as well as Polish and other languages outside Germanic) are phonetically highly similar (again ignoring the incomplete neutralisation debate). Such descriptions may be (partially) biased by assumptions about the nature of final neutralisation, but as pointed out in 3 there is experimental evidence from Dutch (Ernestus, 2000) and Taiwanese (Hsu, 1996) that neutralised obstruents are phonetically distinct from both fortis and lenis obstruents (in con-

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texts where an opposition is maintained) and similar crosslinguistically in lacking phonetic targets for $[\pm\text{tense}]$. Nevertheless, since the model of Iverson & Salmons (1999) faces similar problems with regard to phonetic interpretation, a delinking model remains preferable over a VOT-based fortition account.

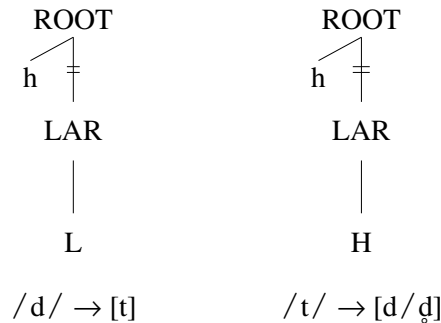


Figure 8.9: Final neutralisation in aspirating and voicing languages, according to a VOT-based delinking model. Left: final neutralisation in voicing languages; right: neutralisation in aspirating languages.

8.3.4 Progressive devoicing and the Germanic past tense paradigm

One of the motivations offered by Harris (1994) for employing the high tone/long lag VOT element to represent the fortis-lenis distinction in English is that it allows the regular past tense and plural paradigms of this language to be captured as H spreading. The underlying representation for the past tense of stems ending in a fortis obstruent such as $/\text{ɒk}/$, *lock*, is depicted in the left-hand panel of figure 8.10. Forward spreading of the H onto the laryngeally unmarked $/\text{d}/$ of the past tense suffix derives the surface form $[\text{ɒkt}]$ with a voiceless final obstruent cluster. Stems ending in a sonorant or lenis obstruent have no laryngeal element available for this spreading operation, and consequently the past tense suffix surfaces in its unmarked, (partially) voiced form. Note that under this account it is essential that despite their difference in word-initial voicing both $[\text{+tense}]$ fricatives and $[\text{+tense}]$ plosives are marked for H, because the English regular past tense and plural paradigms behave symmetrically with respect to obstruent manner of articulation.

However, spreading of H cannot be responsible for the allomorphy of the past tense suffix in (voicing varieties) of Dutch or in Scottish English, because fortis obstruents are unmarked in these varieties of Germanic. The right-hand side of figure 8.10 illustrates the underlying representation for past tense forms of stems ending in a fortis obstruent in voicing languages, which is of course

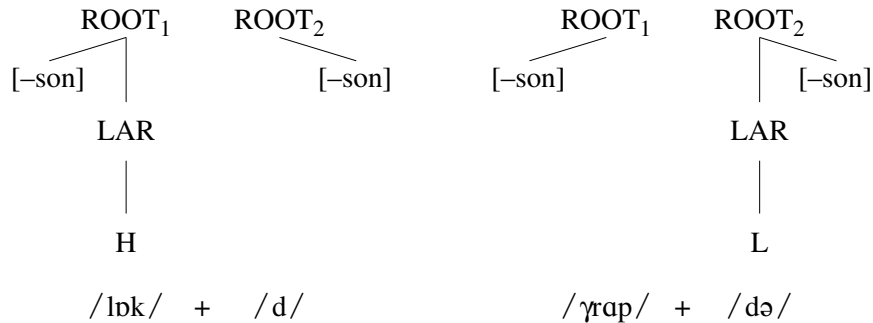


Figure 8.10: Progressive devoicing and the Germanic past tense paradigm in VOT-based models.

identical to the underlying representation assigned to such forms in the [tense]-based frameworks discussed above (cf. figure 8.4). Neither Harris (1994) nor Iverson & Salmons (1995, 1999) discuss this issue at any length, but the only way to arrive at the correct surface forms for stems such as Dutch /ɣrɒp/ (cf. /ɣrɒp/ + /ən/, [ɣrɒpən] *to (make a) joke*) is to delink the L element of the past tense suffix. As reference to the unmarked laryngeal feature value of stem-final [+tense] obstruents is disallowed, this delinking rule would have to apply after all obstruent-final stems. In order to restore the original L of the past tense suffix after lenis obstruent-final stems and derive appropriate surface forms such as Dutch [krɒbdə], *scratched*, with voiced obstruent clusters, an additional rule would have to be posited that spreads L forward from stem-final obstruents. The two-step derivation of past tense forms of stems ending in a lenis obstruent is illustrated in figure 8.11 below.

A VOT-based account of the Germanic past tense paradigm and similar phenomena begs the same sorts of questions as Iverson & Salmons's approach to final neutralisation in German and Dutch. First and foremost, it implies that the past tense rule of (voicing varieties of) Dutch is somehow a very different species from its (aspirating) English and Swedish (and aspirating Dutch) counterparts, whilst there is little data to suggest that this is indeed the case. It is true that the Dutch past tense rule is lacking in phonetic motivation to the extent that it preserves a contrast between stem-final /x/ and /ɣ/ which is neutralised in all other contexts for many speakers. But this 'abstractness' primarily concerns stem-final lenis obstruents: the underlying form /də/ and, crucially, its progressive assimilation after fortis stem-final obstruents are used productively, as testified by past tense forms of relatively recent borrowings from English such as [blo⁰:də], *smoked dope* (cf. /blo⁰:/ + /ən/, *to smoke dope*), and [sɪftə] *surfed*. Moreover, there is no evidence that the regular past tense and plural rules

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of Scottish English behaves in any way differently to its counterpart in aspirating dialects. Consequently, there seems little empirical support for the distinct analyses they (necessarily) receive under VOT-based models.

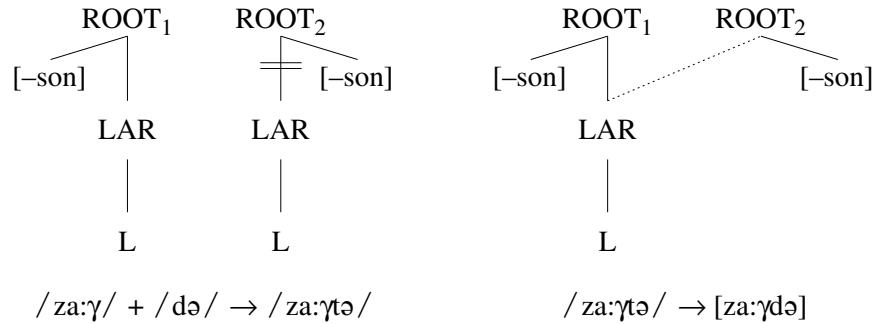


Figure 8.11: Two step derivation of past tense forms of stems ending in a lenis obstruent in voicing languages, according to VOT-based models.

In addition, the analysis of the Germanic past tense paradigm again prompts the more technical question of why L and H are typically subject to different types of rules, whilst it is expected under the general logic of monovalent models that they are subject to the same range of operations. For example, L and H must both be available for backward spreading (to model RVA) but for reasons outlined above only the former can be subject to preobstruent delinking (to capture [tense]-symmetric RVA in voicing languages). In the fortition-based account of Iverson and Salmons, final neutralisation, word final L is delinked whereas H is spread, but the authors fail to explain why word-final L insertion and H delinking are unavailable (or rare). Furthermore, on the one hand, L has to be delinked in postobstruent position to derive the correct allomorphs of the regular past tense suffix in (voicing varieties of) Dutch as well as to capture the devoicing of word-initial lenis fricatives in postobstruent environments. On the other hand, there seems to be little or no data to motivate a parallel rule of postobstruent H delinking, which (among other things) would predict a variety of English in which fortis fricatives are voiced after another obstruent: the pronunciation of <quicksand> as [kwɪkzænd] (with H delinking) in this unlikely dialect would be phonologically parallel to the realisation of Dutch /rit/ + /zɑŋər/, *sedge warbler*, as [ritzɑŋəɪ] (with L delinking).

As I argued in 8.1 above, a serious theory-internal objection to allowing both the spreading of a marked feature value x to a particular context y and delinking of the same marked feature value in the same context, is that it compromises monovalency. By also allowing *insertion* of x in y (i.e., H in word-final contexts)

Iverson & Salmons (1999) equip their model with full binary feature power. Needless to say, any additional constraints to protect monovalency, such as a ban on inserting L word finally in voicing languages or deleting H in aspirating languages have to be stipulated separately in the model.

8.4 Between discrete and continuous representations

In the previous two sections I have attempted to demonstrate that monovalent lexical feature models have little to offer that in any way complements the predictions of the functionalist approach(es) to neutralisation and RVA pursued in chapters 2 through 5, or places useful metaconstraints on these predictions. It is true that both [tense]-based and VOT-models ‘connect’ predictions about domains (neutralisation and assimilation) that are treated as separate according to the functionalist approach, but such predictions are often inaccurate, e.g., the connection between the ability of lax stops and lax fricatives to trigger regressive voicing assimilation.

Three particularly notable problems for the models I reviewed are: (1) the behaviour of the plain voiceless fortis obstruents [p, t, c, k, f, s, ʃ, x] of voicing languages, which are predicted to be phonologically (and phonetically) inert, but which are nevertheless capable of triggering RVA and the allomorphy of the Dutch and Frisian regular past tense suffixes; (2) the phonetic interpretation and assimilatory inertia of the (passively voiced) lenis plosives [b̥, d̥, t̥, k̥] of aspirating languages, which are either classified with the actively (pre)voiced plosives of voicing languages (in [tense]-based models) or with the actively devoiced fortis obstruents of the same group of languages (by VOT-based models), but which are clearly distinct from both; (3) the behaviour of plain voiceless fortis and voiced lenis fricatives, which are predicted to always pattern with the corresponding plosives in the same language, which yields the wrong results for aspirating languages.

It would be unfair to dismiss all (contemporary) generative work on the laryngeal phonology of voicing and aspirating languages on the basis of the two previous sections alone. There are models that take a less parsimonious line on the representation (and phonological visibility) of the fortis-lenis distinction, and therefore appear to make the problems identified here more tractable. However, the goal of this section is to demonstrate that the solutions offered by these models are little more than apparent, since they undermine the basis of the formalist enterprise in phonological theory. First and foremost, the proliferation of structural categories in frameworks with enriched representations leads to an explosion of the number of possible rules that are available on formal grounds. It seems highly unlikely that it is possible to contain this explosion without invoking grammar-external (functional) principles. Moreover, enriched models blur

the distinction between discrete phonological and continuous phonetic levels of representation (or modules), and given that human phonetic knowledge extends to the continuous domain, this prompts the question whether a level of discrete representation might be entirely superfluous.

Rather than discussing a selection of the models offered by the recent literature on an individual basis, I have opted here to combine what I consider to be the key aspects of these models in an outline of a single refined autosegmental framework for laryngeal representation, and examine its performance against the data surveyed in the previous chapters. The principal reasons for pursuing this approach rather than embarking on a model-by-model survey are to keep the size of this section manageable, and to avoid repetition.

8.4.1 A refined autosegmental model

Although this is not necessarily the case for the individual models it is based on, the refined model developed here is a surface underspecification model in the sense of [Pierrehumbert & Beckman \(1988\)](#): if a particular feature is underspecified it is not only inert in the phonology, but also with regard to phonetic interpretation (i.e., it is not interpreted at all). As far as the phonological invisibility of underspecified features is concerned I assume the strong interpretation described in section 8.1, which means that no reference can be made to an underspecified feature in the statement of a rule environment. In addition, I have made the following basic assumptions. Terminal nodes in the subsegmental feature tree have universal phonetic interpretations, which means that even if two segments are phonologically identical their representations contain different terminal features to the extent that they have distinct phonetic targets. Non-terminal (class) nodes are devoid of any phonetic content (cf. [Harris & Lindsey 1995](#)) and merely serve to facilitate the expression of phonological rules. Finally, only two autosegmental operations are available for either type of node: spreading and delinking.

The refined model assigns the structures in figure 8.12 to aspirated and plain voiceless fortis plosives, passively voiced (zero to short lag VOT) and actively (pre)voiced lenis plosives, and voiceless fortis and voiced lenis fricatives. The *X* at the top of each structure represents a single timing slot. Nothing important hinges on whether this slot is interpreted as a slot on the skeletal (*X* or *CV*) tier adopted in many autosegmental models, or in moraic terms. Timing slots dominate *oral aperture nodes* of the type introduced by [Steriade \(1992, 1993\)](#) (see also [Clements & Hume 1995](#)). Aperture nodes are similar to the more familiar root nodes in that they mediate between subsegmental and prosodic (timing) structure, but bear information about the degree of oral aperture involved in the production of a segment. A_0 represents full closure, A_f the critical constriction during the friction phase of a fricative, and A_{Max} a degree of aperture that ap-

propriate for a vowel or glide, i.e., for laminar airflow. In the account of Steriade (1992, 1993), released plosives are represented as contour segments consisting of a closure (A_0) node and a release node, i.e., A_f for affricates and A_{Max} for stops (including nasal stops) with a plain release. Fricatives, approximants and vowels on the other hand, consist of single A_f and A_{Max} nodes respectively.¹³

Aperture nodes serve as anchors for the LAR node and the remaining elements of subsegmental structure, which, as elsewhere in this chapter, is omitted from segmental representations. By tying together information about the laryngeal phonology and phonetics of segments, the LAR node fulfills the same role as its namesake in other recent frameworks, including the ones reviewed above. Its presence encodes the availability of a lexical laryngeal contrast and with respect to the languages that form the focus of this study, it therefore has the same purpose as the descriptive feature [tense].

LAR dominates two features: [voice] and [L/H]. The former is a ternary feature intended to capture active obstruent voicing ([+voice]) and devoicing ([-voice]), and passive voicing ([0voice]: i.e., lack of a voicing target). Because [0voice] is assumed to be phonologically as well as phonetically inactive it is graphically represented as absent, according to standard practice in monovalent autosegmental models. L encodes the phonetic features shared by lenis obstruents across the voicing-aspirating divide such as shorter closure duration and F_0 lowering, whereas H represents the phonetic features shared by fortis obstruents. L and H may be seen as two marked values of two binary features, each with one active value, or a single ternary feature, with a third '0' value representing the absence of targets for the phonetic features in question. In addition, both [voice] and [L/H] could be conceived as nonterminal nodes dominating the separate articulatory ([spread glottis], [stiff vocal folds], etc.) or acoustic features involved in their production, much as the *dimensions* of Avery & Idsardi (2001). They also bear some resemblance to the *Intermediate Perceptual Properties* (IPPs) of Kingston & Diehl (1994, 1995). Note that the split representation of phonetic voicing and the other phonetic properties involved in the signalling of the fortis-lenis distinction has precedents in early generative work on Dutch RVA such as Hubers & Kooij (1973) and Brink (1975), as well as the 'syncretic' representation of lenis fricatives in German as [+voice, -tense] proposed by Jessen (1996, 1998).

Both long lag VOT and plain voiceless fortis obstruents are represented in the refined model as containing the feature H and as actively devoiced ([-voice]). The difference in VOT between these two phonetic categories is encoded in terms of the docking site for the LAR node: the release (A_{Max}) for the former,

¹³Since the structures in figure 8.12 are intended to facilitate discussion of certain proposals in the literature rather than as a fully-fledged framework for laryngeal representation, I have ignored a number of issues that would have been relevant otherwise, such as the representation of (contrastively) voiced aspirates, aspirated fricatives, or voiceless sonorants.

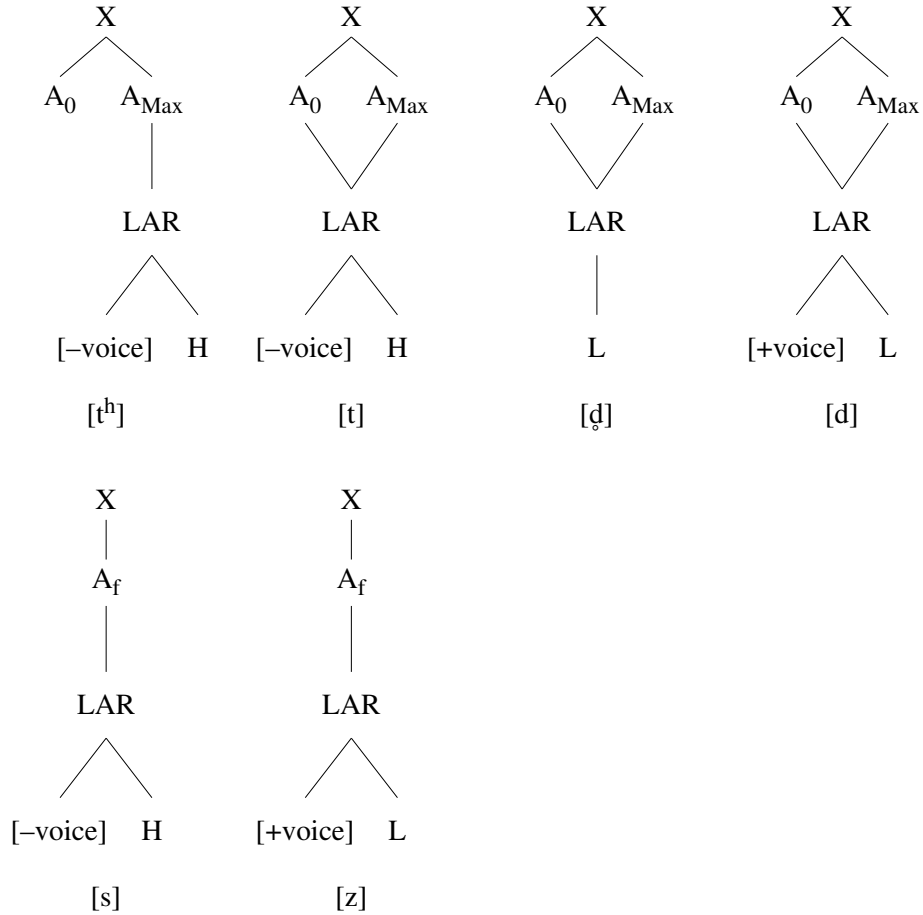


Figure 8.12: Refined autosegmental representations for plosives and fricatives. Place and manner features omitted.

and both A₀ and A_{Max} for the latter. This encoding is more or less iconic in terms of the timing of the glottal abduction gestures involved in the production of long lag and zero to short lag VOT in fortis plosives, and parallels the representation of postnasalised vs. nasal and glottalised vs. postglottalised stops in the work of Steriade (1992, 1993) (see also Keating 1990a). Furthermore, it is reminiscent of the encoding of the glottalised and aspirated plosives of Korean in Heo (1994) and Ploch (1999). According to these accounts, both glottalised and aspirated obstruents contain the element H, which is ‘fused’ into a single phonological expression with the other relevant elements in the former, and ‘extraposed’ as a separate phonological expression in the latter instance.

The structures for lenis plosives similarly capture the phonetic similarities

and differences between the passively voiced (zero to short lag VOT) and actively (pre)voiced classes: both contain the feature L, which maps into, e.g., relatively long preceding vowels and relatively low F_0 on a following vowel, but only the latter includes the active voicing ([+voice]) feature. In the fricative structures, LAR can only be associated with the single aperture node A_f , which captures the observation that there appear to be only 2 distinctive voicing targets for fricatives across (most of) the languages examined in this study.¹⁴ Both fortis and lenis fricatives are assigned an active value for [voice] as well as for [L/H], whilst voiced sonorants are assumed to be phonologically and phonetically fully inert (underspecified) in terms of laryngeal structure. The representation of fricatives in the refined model therefore entails abandoning the assumption that laryngeal representation is symmetric with respect to obstruent manner of articulation, which is central to many lexical feature models.

It is important to note that, as a surface underspecification model, the framework for laryngeal representation presented here is intended to be phonetically transparent only with respect to the phonetic *targets* associated with [\pm tense], and the coarticulation of those targets. It is not designed to derive the effects of hypoarticulation or supralaryngeal articulatory settings on the manifestation of the fortis-lenis distinction in the speech signal: such effects are assumed to arise in the course of phonetic implementation and as byproducts of the mechanics and aerodynamics of the vocal tract respectively. Thus, the deaspiration of fortis plosives in poststress prevocalic positions in aspirating languages is not represented as the association of the LAR node of aspirated stops to A_0 , but is attributed to local articulatory reduction, which affects all articulatory gestures in a gradient fashion. Similarly, word-initial lenis stops in aspirating languages are represented as lacking an active value for [voice], in spite of the fact that these stops may be (partially) voiced, especially after sonorants, since this voicing is most likely passive (cf. chapters 4, 5).

Conversely, where there are grounds to assume that positional variation in the realisation of [\pm tense] reflects genuinely different targets, this variation has to be incorporated in the model, even if the phonetic differences involved are not lexically contrastive. Since there is good phonetic evidence for treating the unaspirated realisation of final fortis plosives in many aspirating languages as stemming from a distinct positional target, this phenomenon provides the clearest case for inclusion in the model. The fortis plosives of English and similar aspirating languages are therefore represented by the leftmost structure in figure 8.12 if they occur before a sonorant within the same word, but with a doubly linked LAR node word finally. In addition, a [-voice, H] LAR node with a single association to A_0 can serve to represent preaspirated or preglottalised fortis stops (Steriade, 1992, 1993).

¹⁴On the representation of lenis fricatives in Dutch, see below.

8.4.2 Advantages of the refined model

One of the advantages of the model sketched in figure 8.12 is that it allows for a crosslinguistically uniform and phonetically falsifiable analysis of laryngeal neutralisation. Since both fortis and lenis obstruents in aspirating as well as voicing languages are marked with a LAR node, a single operation of LAR delinking suffices to eliminate the contrast between the two lexical classes. As in [tense]-based frameworks and VOT-based delinking models, LAR delinking can be stated as a single (UG) parameter and consequently the refined model predicts correctly that (final) neutralisation does not depend on the phonetic manifestation of a laryngeal contrast. It is different from the models discussed in the previous two sections but similar to the analyses of Gussman (1992), Brockhaus (1995), Steriade (1997), and Ernestus (2000) in that laryngeal neutralisation is neither fortition nor lenition but a symmetric operation that affects both fortis and lenis obstruents to produce a separate, fully inert, laryngeal category. Under the assumption that phonologically unmarked always equals phonetically underspecified, this account predicts that laryngeal neutralisation results in obstruents that are phonetically distinct from both their lenis and fortis counterparts in acquiring their voicing, duration and other ‘laryngeal’ properties from the phonetic context (and their own remaining phonological features). 3 discussed how phonetic evidence from Dutch, Taiwanese, and English /s/ + stop clusters is consistent with this prediction.¹⁵

Furthermore, since the refined model outlined in figure 8.12 encodes active obstruent (de)voicing in a transparent fashion, it is able to capture the set of obstruents that trigger regressive voicing assimilation in terms of a simple [\pm voice] spreading-cum-delinking rule. The two classes of fortis plosives, fortis as well as lenis fricatives, and prevoiced lenis plosives all have a [voice] feature with an active value available for this spreading operation, which is illustrated in figure 8.13, and so the model correctly predicts that these obstruents are able to trigger voicing assimilation in a preceding obstruent. Passively voiced lenis plosives are unable to trigger RVA because they are assigned the inert value for [voice]. Consequently, it appears that the [voice] spreading rule does not have to be parametrised, as for example in Lombardi’s model: if it is universally switched on the assimilatory behaviour of fortis and lenis obstruents follow from

¹⁵Gussman (1992) retains the notion that final laryngeal neutralisation ultimately results in fortition/devoicing by using a ‘fill in’ rule late in the derivation that specifies all underspecified obstruents as [-voice]. Brockhaus (1995) on the other hand maintains the traditional idea that laryngeal neutralisation in German is something that *happens to lenis obstruents only*, but nevertheless treats the output of the process as laryngeally unmarked and therefore distinct from lexically fortis obstruents, which are marked H in her model. Data showing that German final laryngeal neutralisation is incomplete provides the main argument for this ‘hybrid’ position, which is independently suggested by Charles-Luce (1985).

the representations in figure 8.12.¹⁶

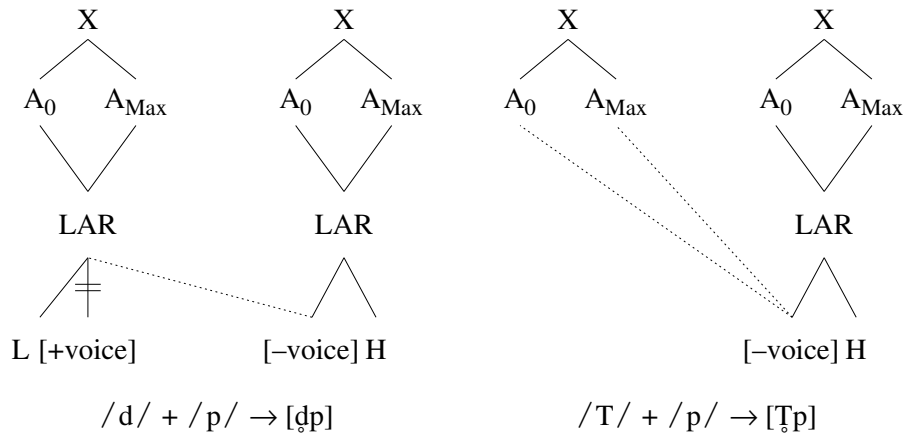


Figure 8.13: Regressive voicing assimilation in the refined autosegmental model. Left-hand side: non-neutralising RVA in languages that maintain a fortis-lenis distinction in word-final contexts. Right: RVA in languages with final laryngeal neutralisation.

Modelling RVA in terms of [voice] delinking and spreading has two additional advantages over the models described in the previous sections of this chapter, and over lexical feature analyses more in general. First, it accounts for the non-neutralising nature of the process as it was established for English and Hungarian in chapters 5 and 6, because it operates on a ‘sublexical’ feature. For example, if [-voice] spreads from an underlying /p/ to a preceding /d/ with concomitant [+voice] delinking in the latter, the alveolar obstruent still retains its lexical [L] specification and thus remains distinct from underlying /t/ (cf. the left-hand side of figure 8.13). In IPA notation this corresponds to, e.g., /d/ + /p/ → [ɖp] rather than the /d/ + /p/ → [tp] which is implied by lexical feature analyses. Second, in conjunction with an analysis of final neutralisation in terms of LAR delinking, sublexical [voice] spreading captures the [tense]-symmetric RVA effect reported for Dutch in 7. Because neutralised obstruents are [0voice], spreading of [-voice] from a following fortis plosive is no longer vacuous or inapplicable (as it is in lexical feature models), and neutralised are predicted to show a 3 way voicing distinction before lenis plosives ([+voice] through spread-

¹⁶To the extent that underlying voicing distinctions are maintained in obstruents targeted by RVA the delinking part in the left-hand panel of figure 8.13 could be omitted. The output of the spreading rule would then be a segment display contour or doubly articulated behaviour with respect to [voice]. See Hayes (1992) for an approach in roughly these terms to incomplete neutralisation in English coronal place assimilation.

ing), sonorants (inert [0voice]) and fortis obstruents ([-voice]: cf. figure 8.13)¹⁷

The refined model is also able to handle (most versions of) the Germanic past tense paradigm and similar rules of allomorphy as well as traditional binary feature accounts, at least under the assumption that these processes involve complete neutralisation. Spreading the LAR node of stem-final fortis obstruents forward and delinking the underlying LAR node from the initial /d/ of the past tense suffix derives the right pattern for both aspirating and voicing languages, since fortis obstruents have a node available for spreading in both types of language. Note that the spreading rule can but does not have to be defined as targeting stem-final fortis obstruents only: given that stem-final lenis obstruents have the same laryngeal specification as the initial /d/ of the suffix, and given that voiced sonorants are inert in terms of laryngeal structure, the output is the same if all available stem-final LAR nodes are spread rightward. The analysis is illustrated in figure 8.14 for Dutch /ɣrap/ + /də/, [χraptə], *joked*, and /krab/ + /də/, [krabdə], *scratched*.

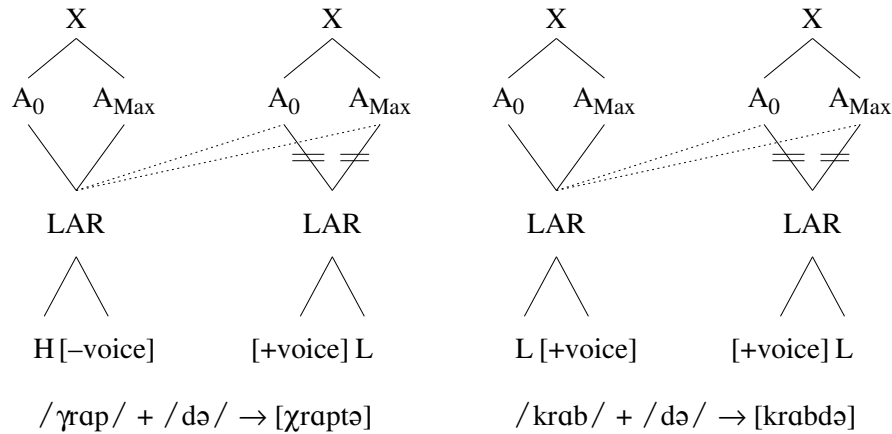


Figure 8.14: The ‘Germanic’ past tense paradigm in the refined autosegmental model. Left-hand side: LAR spreading from stem-final fortis obstruents. Right: (vacuous) spreading from lenis obstruents.

Finally, in chapters 2 and 4 I argued that Dutch postobstruent lenis frica-

¹⁷For the sake of the argument I have assumed that [\pm voice] attaches directly to the aperture nodes in neutralised obstruents. A more detailed version of the refined model would have to include a precise statement of the possible docking sites for [\pm voice], but this is not relevant to the point made here. Also note that the assimilatory behaviour of Dutch word-initial /h/, [ʔ] demands that both segments be specified [-voice]. There do not seem to be compelling arguments against a [-voice] representation of these sounds, given that they can be distinguished in terms of the lower level articulatory features [(+)spread glottis] for /h/ and [(+)constricted glottis] for [ʔ].

tive devoicing is not a form of voicing assimilation in the same sense as the regressive assimilation to lenis and fortis plosives found in the same language. The main argument for this position is that in languages that maintain a fortis-lenis contrast word finally, lenis fricatives are devoiced after both classes of obstruent, even to a smaller degree than in Dutch. Dutch, and as shown in 6, Hungarian prevoiced plosives are also subject to (partial) devoicing following another obstruent, especially in unstressed environments. It seems therefore plausible that the particularly strong devoicing of Dutch lenis fricatives arises through the interaction of normal obstruent aerodynamics with a voicing target that is somehow weaker than that of the corresponding fricatives in English and Hungarian, even though the clinching evidence (A substantial intraspeaker correlation between the degrees of lenis fricative devoicing in utterance-initial and postobstruent environments) is not yet available.

In contrast to lexical feature models, the refined model goes some way in modelling this analysis. Weakly voiced lenis fricatives can be represented analogously to passively voiced lenis plosives as possessing a LAR node that bears active L but inactive [0voice]. As [0voice] cannot be spread, this would mean that Dutch /v, z/ do not have the capacity to trigger RVA in a preceding obstruent, and since [0voice] is phonetically interpreted as the absence of a voicing target, fricative devoicing would follow (passively) from the aerodynamics of obstruent sequences. On the grounds of the same aerodynamics it would be predicted that utterance initially, Dutch lenis fricatives are voiceless, but shorter than their lenis counterparts and followed by a lower F_0 . Between sonorants however, they would be subject to a greater degree of passive voicing than /f, s, x/, which are represented as actively devoiced ([-voice]).

8.4.3 Problems with the refined model

To return to the three especially problematic observations highlighted in the introduction to this section, it seems that a marked improvement can be achieved with the refined model on all three counts. Given the nature of the data it is not surprising that the model's comparative success is largely due to its phonetic realism, and to its symmetric encoding of the fortis-lenis distinction (the latter could be regarded as a corollary of the former). Thus, in contrast to monovalent lexical feature analyses, the refined model represents plain voiceless fortis obstruents as phonologically marked and therefore active rather than inert. Phonetic realism entails that actively voiced lenis stops, passively voiced lenis stops and actively devoiced fortis stops receive different structures, and consequently different assimilatory properties. It also entails abandoning manner symmetry as an a priori principle in laryngeal representation, and this in turn leads to more accurate predictions about the (crosslinguistic) assimilatory behaviour of fricatives.

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However, as it stands, the refined model still leaves a number of empirical issues unresolved, and raises a number of more serious theoretical problems. The different propensities of stops and fricatives for (lexical) laryngeal neutralisation represent one prominent empirical issue. Another is the observation that voicing, but generally not durational correlates of $[\pm\text{tense}]$ are involved in regressive assimilation: the model in 8.12 accounts for the fact that voicing can spread separately, but offers no explanation why L/H cannot spread independently. The former problem could be tackled by exploiting differences between fricatives and plosives at the aperture node level. For instance, the LAR class node could always be linked to both aperture nodes in plosives (this would involve re-encoding of the difference between aspirated and unaspirated fortis plosives). Just as double linking has been used to represent geminate integrity (e.g., Hayes 1986), this ‘double bond’ could then be employed to encode the relative resistance of plosives to laryngeal neutralisation.

As far as the durational correlates of $[\pm\text{tense}]$ are concerned, their failure to spread backwards would follow if they were incorporated into prosodic rather than melodic (sub)segmental structure. I discussed this idea early on in 4.1.2 to illuminate the predictions of a coarticulation-driven account of RVA. It involves representing the durational contrast between fortis and lenis obstruents by assigning the former a larger number of slots on a timing tier (cf. figure 8.15), much as the contrast between singleton and geminate consonants is usually encoded in terms of positions on a *X*, *CV* or moraic tier (see Perlmutter 1995 for a survey and references). Under this analysis, the lack of durational assimilation in obstruent sequences would follow from the general prohibition in autosegmental models against the spreading of prosodic structure (i.e., anything above the root level). At least in principle, it would also allow for the durational trade-off between obstruent duration and preceding vowel duration to be treated as compensatory lengthening, again along the same lines as familiar analyses of fixed quantity syllable rhymes (e.g., Hayes 1989).¹⁸

Note that a serious proposal in this vein would be beset by all sorts of complications, including the awkward specification of the fixed quantities involved (given that many languages allow lexically contrastive length regardless of the laryngeal specification of the following obstruent, e.g., English or allow contrastive length to cross classify with $[\pm\text{tense}]$), e.g., Italian, and the difficulty of making durational contrast dependent on the presence of a LAR node. Moreover, prosodic representation of the durational correlates would still leave the behaviour of F_0 and F_1 cues unaccounted for.

Unfortunately, given a formalist perspective, these complications are part of

¹⁸In the light of the grid-based representation of phrase-final lengthening developed by Selkirk (1984), the use of a phonological timing tier to represent this sort of phonetic detail is less odd than it may seem.

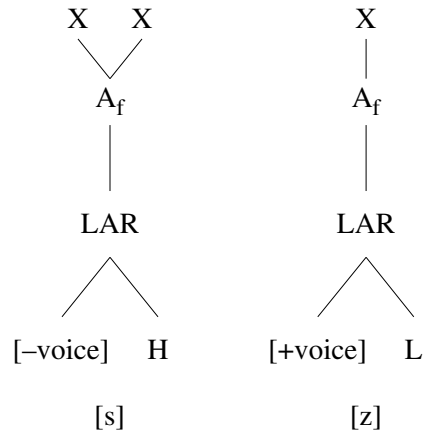


Figure 8.15: Prosodic representation of durational cues to the fortis-lenis distinction.

a much heavier price of overgeneration that comes with the structures in figure 8.15. According to a strictly formalist logic, the inventory of possible phonological rules is derived from the available structural primitives and a small number of principles governing their combination. Consequently, an increase in the number of structural primitives leads to an increase in the number of possible rules, and to the extent that the resulting rules have to be ruled out on arbitrary grounds they attenuate the predictive power of the model in question. It is certainly no accident therefore that those who take the formalist enterprise most seriously (e.g., Jensen 1994; Ploch 1999) generally seek to reduce rather than expand the number of structural primitives. Recall too that one of the arguments used by Lombardi (1994, 1995b) in favour of her three term ([voice], [asp], [gl]) monovalent feature inventory is that it maximally generates a 6 term system, which is exactly the maximum number of contrasts that has been established for a single language.

Because the refined model encodes laryngeal contrast on three tiers (nodes) and allows for two autosegmental rules (delinking and spreading) it generates 6 types of rule with phonetically distinct outputs. For instance, the model predicts a three way taxonomy of final neutralisation, comprising a language with complete neutralisation of phonetic contrast between fortis and lenis obstruents (LAR delinking), a language that erases only voicing distinctions ([voice] delinking) whilst leaving durational, burst-related and F_0/F_1 cues intact, and a type of language in which final laryngeal contrast is solely marked in terms of voicing (L/H delinking).¹⁹ Needless to say, the latter two types have not been

¹⁹None of the combinations of these rules can be distinguished from LAR delinking in terms

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attested. Likewise, the refined model generates a number of unlikely underlying forms and lexical inventories in addition to the ones illustrated in figure 8.12. For example, there is no model-internal reason why lexical laryngeal contrast between obstruents could not be solely based on [voice] or L/H features, or worse, why there should not be a system that cross-classifies these features to derive a wholly unattested 12 term lexical contrast.

It seems difficult if not impossible to rule out this hypothetical lexical inventory or the related rule taxonomies on formal grounds, other than by brute force stipulation. Simply stating, e.g., that LAR only spreads within words whereas [voice] spreads (presumably) both within and across word boundaries, whilst L/H does not spread at all represents the relevant observations fairly accurately but does nothing to predict them. Dispersing the cues related to the L/H feature across other layers of structure does not provide a solution either, but rather compounds the problem. For example, prosodic representation of the durational cues to [\pm tense] implies the possibility of a four-term lexical length contrast without concomitant distinctions in terms of voicing or other correlates of [\pm tense] (i.e., through crossclassification of the durational distinctions between fortis and lenis obstruents with the regular singleton-geminate contrast).

It is possible, on the other hand, to rule out 12 term lexical contrasts involving voicing, F_0/F_1 perturbation and duration on external, functional, grounds. The absence of this type of lexical inventory is plausibly attributed to the small amount of perceptual contrast between the individual terms, and by the same token the cooccurrence of certain values of [voice] and L/H can be seen as auditory and/or articulatory enhancement in the sense of Stevens & Keyser (1989). But the introduction of such external constraints undermines not only the formalism of the model but also the need for discrete phonological representations as part of a modular model of the phonology-phonetics interface. Recall from 1.3.2 that in principle, external mechanisms such as auditory enhancement, articulatory effort reduction (mediated by various forms of feedback), misperception, and phonological (re)analysis by listeners are able to generate, maintain, and change 'implicit' structure in continuous phonetic space. This means that the need for a level of categorical phonological representations hinges on arguments for purely formal constraints on phonological patterns. The previous chapters of this study have built a case for an analysis of voicing assimilation and laryngeal neutralisation phenomena wholly in terms of grammar-external principles. The previous sections of this chapter show that at least the predictions of monovalent lexical feature models do not reveal any tenable metatheory of assimilation and neutralisation. Consequently, the observation that the refined autosegmental model, whilst improving on the predictions of lexical feature frameworks, overgenerates rules and (phonetic) inventories cannot be dismissed as a minor drawback,

of its output.

but undermines the most basic premises of formalist approaches to laryngeal neutralisation and voicing assimilation.

8.5 Conclusions

The aim of this chapter was to demonstrate that current generative models of laryngeal phonology do not provide a theory or metatheory of laryngeal neutralisation and/or voicing assimilation that adds to, or reaches beyond, the predictions of a functionalist approach. This investigation was inspired by the thinking of citethare00a,hare00b and others who see a role for formalist phonology next to, or as a prerequisite to, functionalist models. Its principal method was an assessment of the predictions of two influential generative frameworks of laryngeal phonology: the [tense]-based approach of Lombardi and others, and the VOT-based approach espoused by Harris (1994), Iverson & Salmons (1995, 1999), and in a modified form by Avery & Idsardi (2001).

Both types of model were found to be fundamentally inadequate in a number of respects, even if the phonetic detail of regressive assimilation at word boundaries is ignored. [tense]-based models fail to predict the critical difference in assimilatory capacity between actively voiced and passively voiced lax stops, and derive the grossly incorrect prediction that all fortis obstruents are phonologically inactive. Both types of model fail to predict the phonological and phonetic activity of fortis obstruents in voicing languages, and are unable to handle asymmetries between plosives and fricatives. Neither of the two models has a phonetic interpretation that is transparent across contexts, obstruent types, and/or languages. Worst of all perhaps, the patches that are introduced (or have to be introduced) to deal with some of the more glaring mispredictions effectively involve the use of binary [\pm tense]. This seriously reduces the predictive power of the models in question, which is mostly founded on unary feature marking.

Using only devices that have been proposed in the published literature, I then constructed an alternative autosegmental model of fortis-lenis laryngeal phonology and phonetics that improves on feature-based models by explicitly incorporating ('phonemic') information about lexical contrast and ('subphonemic') information about phonetic detail. The former allows for a uniform statement of (final) neutralisation rules across voicing and aspirating languages (as in [tense]-based lexical feature frameworks) whilst the inclusion of phonetic detail allows for more accurate predictions about the triggers and phonetic manifestation of regressive voicing assimilation, and potentially about fricative-stop asymmetries in laryngeal marking.

However, this refined autosegmental model is untenable on formalist grounds because its proliferation of structural categories results in overgenera-

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tion. Without evidence for purely formal constraints on the laryngeal phonology of fortis-lenis systems it is equally untenable from a functionalist perspective since the external principles that it requires to avoid overgeneration render explicit categorical phonological structure superfluous.

It is impossible to show that purely formal constraints on laryngeal neutralisation and voicing assimilation do not exist; it is also true that I made no attempt in this chapter to unearth any such constraints. But I have demonstrated that current generative models of laryngeal phonology are fundamentally flawed even on their own terms, and bring no insights that complement or enable the explanations provided by a functionalist approach. I believe that this puts the burden of evidence in this matter firmly back on proponents of formalist models.