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English voicing in dimensional theory ☆

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Abstract

Assuming a framework of privative features, this paper interprets two apparently disparate phenomena in English phonology as structurally related: the lexically specific voicing of fricatives in plural nouns like *wives* or *thieves* and the prosodically governed "flapping" of medial /t/ (and /d/) in North American varieties – which we claim is itself not a rule per se, but rather a consequence of the laryngeal weakening of fortis /t/ in interaction with speech-rate determined segmental abbreviation. Taking as our point of departure the Dimensional Theory of laryngeal representation developed by Avery and Idsardi [Avery, Peter, Idsardi, William, 2001. Laryngeal dimensions, completion and enhancement. In: Alan Hall, T., (Ed.), Distinctive Feature Theory. de Gruyter, Berlin, pp. 41–70], along with their assumption that English marks voiceless obstruents but not voiced ones [Iverson, Gregory K., Salmons, Joseph C., 1995. Aspiration and laryngeal representation in Germanic. Phonology 12, 369–396], we find that an unexpected connection between fricative voicing and coronal flapping emerges from the interplay of familiar phonemic and phonetic factors in the phonological system.

Keywords: Laryngeal phonology; Flapping; Coronal lenition; Fricative voicing

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0. Introduction

Assuming a framework of privative features, the present paper interprets two apparently disparate phenomena in English phonology as structurally related: the lexically specific voicing of fricatives in plural nouns like *wives* or *thieves* (also in other derived contexts like *thievery*)[1] and the prosodically governed "flapping" of medial /t/ (and /d/) in North American varieties. Representational systems employing privative or singulary specification (Lombardi 1991/1994; Iverson and Salmons, 1995; Avery, 1996) characterize laryngeal contrasts with various combinations of just three features—[voice], [spread], [constricted]; this tightly circumscribed approach to laryngeal distinctions leads to satisfying explanations for a number of phenomena in the phonology of English, as will be reviewed below. Taking as our point of departure the Dimensional Theory of laryngeal representation developed by Avery and Idsardi (2001), however, along with their assumption that English marks voiceless obstruents but not voiced ones (Iverson and Salmons, 1995), we find that an unexpected connection between fricative voicing and coronal flapping emerges from the interplay of familiar phonemic and phonetic factors in the phonological system. In Section 1 we reprise some of the motivation for moving from a binary to a unary system of representation, and for distinguishing English-type "aspiration" languages from French-type "voice" languages. In Section 2 we review the descriptive consequences of these moves, sketching out the Dimensional Theory of laryngeal representation as it relates to the phonology of English. The redundant character of voicing in both sonorants and obstruents in English is then described in Section 3, while Section 4 presents a demonstration that North American flapping is itself not a rule per se, but rather a consequence of the laryngeal weakening of fortis /t/ (which indeed is a rule) in interaction with speech-rate determined segmental abbreviation.

1. Variation in laryngeal representation

The conventional description of the simple two-way laryngeal contrast found in many of the world's languages pits a series of voiceless stops, marked [−voice], against a series of voiced stops, marked [+voice]. This particular binary opposition has formed something of a Procrustean bed into which languages have been forced phonologically even when their phonetic properties are noticeably different. Thus, it has long been appreciated that the voice onset time (VOT) values of Romance and Slavic languages, on the one hand, and most Germanic languages, on the other, are quite different (Lisker and Abramson, 1964): the voiced stops of French are thoroughly voiced, with early VOT, but the "voiced" stops of English are often not voiced at all at the beginning of the word and in other voicing-unfriendly environments, with comparatively late VOT, causing many phoneticians to consider the English-type to be "lenis" rather than truly voiced. Similarly, the voiceless stops of French are produced with relatively early VOT (at or just after their release), whereas the VOT of the English voiceless stop series is considerably delayed, well into a following vowel or sonorant consonant, with the result that French voiceless stops are reg-

[1] These words are all idiosyncratic, but *wife* is quite stable in showing voicing in the morphological category of plural. In *fifteen*, there appears to be assimilation via fortition from the following /t/, and in *thievery* there is lenition in another medial environment (note lenition also in *thieves*). As will become clear from the analyses below, we express fortition as strengthening via the addition of feature structure, lenition as weakening via the removal of it.

ularly "unaspirated" whereas those of English are rather heavily "aspirated" (Iverson and Salmons, 1995; Flemming, 1995). Using the binary feature [±voice] to encode this contrast at the phonemic level thus engenders certain statements of allophonic distribution in order to ensure that the articulation of English stops turns out to be different from that of French stops. With the feature [±spread] (previously, [±aspiration]) serving as the transmitter of aspiration and its absence, and [±constricted] conveying glottalized vs. plain laryngeal mode, the scheme outlined in (1) is the binary standard for marking the English vs. French-type differences.

(1) Conventional description of "voice" contrasts with binary [±voice], [±spread], [±constricted]

English, German			French, Spanish	
/t/ [-voice] ↓		/d/ [+voice] ↓ [-spread] [-constr]	/t/ [-voice] ↓ [-spread] [-constr]	/d/ [+voice] ↓ [-spread] [-constr]
[+spread] / [-spread]	(foot-initial) (elsewhere)	[-voice] (initial…)		
[+constr] / [-constr]	(syllable-final) (elsewhere)			
[t^h], [t], [$t^ʔ$]		[d̥~t], [d]	[t]	[d]

Thus, voiceless and voiced stops are distinguished as basically [−voice] vs. [+voice] in both types of languages. In French, where aspiration plays no role even as a surface embellishment, the negative value for [spread] needs to be supplied to the voiced as well as the voiceless series, whereas in English, where aspiration is observed among phonemically voiceless stops, the positive value for [spread] must be provided to the voiceless series in foot-initial environments (Kiparsky, 1979; Iverson and Salmons, 1995), elsewhere the negative value. The negative value for [spread] must be imparted to the voiced series in the English or German type of language, too, of course, but these obstruents also acquire the negative value for [voice] in prosodically prominent (phrase- and often word-) initial environments as well as following other voiceless sounds. Finally, the negative value of the third laryngeal feature, [constricted], needs to be supplied to all of the stops in both types of languages, except the positive value accrues, at least optionally, to (glottalized) voiceless syllable-final stops in English, as in *cup* [$k^hʌp^ʔ$].

Under privative feature representation (alternatively, "unary" or "simplex" feature representation), conversely, negatively valued features are missing from phonemic or underlying structure: only the presence of feature properties can be indicated, not their absence. This results in considerable descriptive simplification, because features with negative values are not represented at all. Thus, both voiced ([voice]) and voiceless ([ ]) stops are unaspirated in French, but this goes without saying under privativity since the feature [spread] simply is not being supplied. Similarly, [constricted] is not supplied, either, except in glottalization environments, so no specific statement is needed to

account for the glottally unconstricted character of stops in either French or English. As the English type of phonemically voiceless stop is aspirated in foot-initial environments, however, a statement is needed to provide the [spread] property there, whereas the phonetic voicelessness of "voiced" stops in certain environments requires removal of [voice] from phrase- (or word-) initial and post-voiceless instances of the voiced series. But overall, as illustrated in (2), the privative description is symbolically more parsimonious than the binary counterpart given in (1).

(2) Conventional description of "voice" contrasts with privative [voice], [spread], [constricted]

English, German			French, Spanish	
/t/		/d/	/t/	/d/
[ ]		[voice]	[ ]	[voice]
↓		↓		
[spread]	(foot-initial)	∅ (initial…)		
[constr]	(syllable-final)			
[t^h], [t], [$t^?$]		[d̥~t], [d]	[t]	[d]

Given that three laryngeal features are at play phonetically, however (whether binary [±voice], [±spread], [±constricted] or privative [voice], [spread], [constricted]), it is possible to suppose that the relevant underlying property is not voicing or its absence in all cases, but rather one of the features of glottal width, specifically, the aspiration feature [spread]. This is particularly appealing in an analysis of the English type of language, whose contrast has often been described as a fortis/lenis distinction rather than one of voicing, because the positing of phonemic [spread] rather than [voice] for English, and of [voice] rather than [spread] for French, has the advantage of encoding systematic differences in articulation between the two language types into the representation itself rather than attributing them to mere surface variation. The conventional, Procrustean conformity which posits phonemic [voice] for both types of languages takes their differences in basic articulation to be due to the effect of acquired rules (or alternate constraint rankings), which it might be expected some speakers under-learn or simply fail to apply—yet this never seems to happen among first-language learners, e.g., native speakers of English employing English-like lenis voiced stops but mistakenly producing French-like unaspirated voiceless stops, or, vice versa, native speakers of French employing French-like fully voiced stops but mistakenly producing English-like heavily aspirated stops. In the phonetically informed approach to phonemically distinguishing the two types of languages, conversely, which Patrick Honeybone has instructively termed "Laryngeal Realism," the French system remains as before, marked for voicing, but the English type is recast with glottal spread being the contrastive property that is present to begin with, as portrayed in (3). In manifestations where aspiration is not in evidence, such as in s-clusters, it is still the case that the glottis is spread, but the aspiration is consumed, as it were, by the composite duration of the segments in the cluster (see below, also Iverson and Salmons, 1995). Under this alternative, then, voicing for the English type of language is fully derivative or contextual, accruing automatically to lenis obstruents in voicing-friendly (usually post-sonorant or post-voiced) environments.

(3) Phonetically informed description with binary [±voice], [±spread], [±constricted][2]

English, German			French, Spanish	
/t^h/		/d̥/	/t/	/d/
[+spread]		[-spread]	[-voice]	[+voice]
↓		↓		
[-voice]		[+voice] (post-voiced) / [-voice] (elsewhere)	↓	↓
[+constr]	(syllable-final)		[-spread]	[-spread]
/ [-constr]	(elsewhere)	[-constr]	[-constr]	[-constr]
[t^h], [t^ʔ], [t]		[d̥~t], [d]	[t]	[d]

Translation of the binary system of (3) into its more restrictive privative equivalent, shown in (4), maintains the basic distinction between English as a fortis/lenis language and French as a voiceless/voiced language, but with considerably less machinery since, as in (2), negatively valued features simply are not there. This is the mode of representation we adopt here and elsewhere, with but a single privative feature—albeit a different one—marking the two types of two-way laryngeal contrast.

(4) Phonetically informed description with privative [voice], [spread], [constricted]

English, German			French, Spanish	
/t^h/		/d̥/	/t/	/d/
[spread]		[ ]	[ ]	[voice]
↓		↓		
[constr]	(syllable-final)	[voice] (post-voiced)		
[t^h], [t], [t^ʔ]		[d̥~t], [d]	[t]	[d]

In the next section, we review some of the phonological consequences that emerge from this way of distinguishing the English from French-type languages. Our illustrations are all of obstruent stops, but fricatives would be expected to follow a parallel system of laryngeal organization. Even in languages in which [spread] plays no contrastive role, however, as in French or Spanish, voiceless fricatives have to be articulated with an open glottis in order to maintain sufficient transglottal airflow to cause turbulence at the oral constriction. That is, phonetically, voiceless fricatives are produced with [spread] irrespective of whether phonologically voiced fricatives in the language are laryngeally empty (English, German) or marked by [voice] (French, Spanish); this phenomenon has been dubbed "Vaux's Law"

[2] As Patrick Honeybone points out to us, the relevant phonological content of English or German /d̥/ is the same as that of French or Spanish /t/, i.e., laryngeally empty, hence the fortis–lenis distinction in the former type of language could just as well be symbolized as /t^h/ vs. /t/ instead of as /t^h/ vs. /d̥/. We nonetheless employ the /d̥/ notation here in order to call attention to the lenis, phonologically voiceless character of the English and German traditional "voiced" series, which, if symbolized instead by /t/, might be confused with the fortis "voiceless" series in view of the orthographic practice of rendering the lenis stops as *b*, *d*, *g*, the fortis as *p*, *t*, *k*. But the observation is correct that we intend Germanic /d̥/ to be phonologically equivalent to Romance /t/, the phonetic differences between them then due to varying strategies or rules of implementation.

(cf. Vaux, 1998), and is explored in detail with implications for the phonology of Korean by Ahn and Iverson (2001, 2004) and for the history of Germanic by Iverson and Salmons (2003b). It is also possible for the phonological representation of laryngeal content to differ between stops and fricatives in the same language, as argued by Iverson and Salmons (2003a) to be the case in modern Dutch, whose fricatives (with phonological [spread]) reflect Germanic ancestry but whose stops (with phonological [voice], or [slack]) reveal the contact influence of Romance. As we move toward a description of voicing and related lenition phenomena in modern English, however, these variations do not come into play.

2. Phonological organization

It appears that all known laryngeal systems can be represented via combinations of the three privative features [voice], [spread], and [constricted]. For a system with no laryngeal contrasts (one series is always unmarked), as in Hawaiian, there are no laryngeal feature specifications, whereas languages with a two-way contrast require specification of just one of the three. In Germanic languages (save Dutch and Yiddish), the distinction is expressed in terms of the feature [spread] standing in opposition to laryngeally unmarked ([ ]) segments, whereas for Slavic and Romance and many other two-way systems, the marked feature is [voice]. The features [spread] and [voice] are also involved in many three-way contrastive systems, distinguishing, for example, the voiceless, voiced, and aspirated phonemes of Thai; a simultaneous combination of [voice] with [spread] serves additionally to characterize the ''voiced aspirate'' series in more complex four-way systems such as in Hindi. Moreover, systems may make use of timing tier contrasts which come to have superficial laryngeal expression as well, as in the phonetically glottally tense geminate series of Korean (Ahn and Iverson, 2001, 2004). But there are also two-way systems in which [constricted], rather than either [voice] or [spread], is the specified laryngeal feature, as in the Mayan language K'ekchi. In fact, it is predicted in this system of representation that some languages should organize a two-way laryngeal contrast along the lines exemplified by K'ekchi (with [constricted] marking ejectives), others along the lines displayed by Spanish (with [voice] marking voiced obstruents), but still others along the lines of Germanic, with [spread] marking the class of fortis obstruents. A selection of the possibilities is given in (5), where it should be noted that each system includes one laryngeally unmarked phonemic type (the first column), that two-way systems variously employ one of the three available features, three way systems employ two, and more complex combinations are also possible to produce four and even five-way systems (cf. Iverson and Salmons, 1995).

(5) Laryngeal contrasts employing privative [voice], [spread], [constricted]

	/p ~ b̥/	/b/	/pʰ/	/p′/	/bʰ/
Hawaiian	[ ]				
K'ekchi	[ ]			[constr]	
French	[ ]	[voice]			
English	[ ]		[spread]		
Thai	[ ]	[voice]	[spread]		
Hindi	[ ]	[voice]	[spread]		[spread] & [voice]

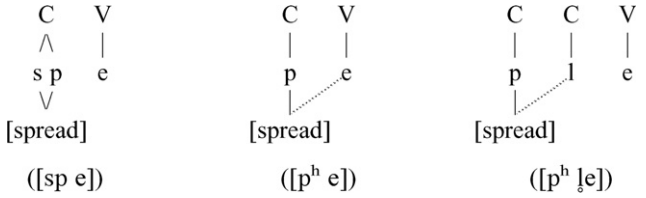
Iverson and Salmons (1995) show that the assumption for English of the scheme of representation in (4) produces insightful accounts of both contemporary phenomena (the pattern of aspiration distributions and sonorant consonant devoicing) and historical change (the failure of post-obstruent stops to shift under Grimm's Law; regarding Verner's Law, see Iverson and Salmons, 2003b). Following Kim (1970), one of the central arguments is that the absence of aspiration in s+stop clusters, as well as the exemption of these stops from the effects of Grimm's Law, is due not to the inapplicability of an aspiration rule, but to the cluster's containing just a single instance of a constantly timed [spread] gesture. As the peak of glottal opening occurs during the mid-point rather than at the end of clusters like /sp/, the vocal folds will have already come together by the time of the release of the stop, hence the absence of aspiration in /p/ following /s/. Quotations from the phonetics literature supporting this understanding of the [spread] gesture in clusters are given in (6) and (7).

(6) ... the glottal movement for /p/ of /sp/ will start during /s/... if the glottis is instructed to open to the same degree and for the same period for /p/ of /sp/ as it would for initial /p/, the glottis will begin to close by the time the closure for /p/ is made, and consequently, by the time /p/ is released, the glottis will have become so narrow that the voicing for the following vowel will immediately start, and thus we have an unaspirated /p/ after /s/ (Kim, 1970, p. 80).

(7) Peak glottal opening in clusters of a fricative followed by a stop does not occur at the same time relative to the oral articulations as it would for either a fricative or a stop occurring alone. The most typical point is close to the boundary between the two oral articulations, a temporal compromise between the early peak of the fricative and the late peak of the stop (Kingston, 1990, p. 427).

Elsewhere, particularly when the stop is word-initial, aspiration does emerge, but this is a consequence of its inherent marking for [spread], not the effect of allophonic aspiration rules, as the systems in (1) or (2) would require. Under the system in (4), in clusters the [spread] feature is shared between two segments organized under the same timing unit and reaches its greatest articulatory manifestation mid-way between them, whereas in singletons the peak of glottal opening is achieved at the point at which the stop is released and thus leaches into the following sonorant, whether vowel (resulting in vocalic voicelessness perceived as aspiration) or consonant (resulting in voicelessness of the consonant). These varying realizations of the same privative feature, [spread], are portrayed in (8) (based on Iverson and Salmons, 1995, 1999):

(8) Laryngeal sharing: clusters and aspiration (*spay* vs. *pay* vs. *play*)



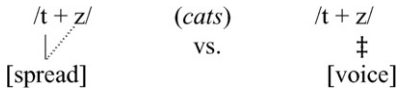
The relative time constancy of the [spread] gesture over syllable-internal clusters like /sp/ and singletons like /p/ corresponds, in our view, to the subordination of both structures under a single timing unit, a "reverse affricate" analysis of English s-clusters which is supported in the phonetics literature particularly by the work of Fujimura (1997), as quoted in (9) and (10) (for elaboration, see Iverson and Salmons, 1999, with support from Steriade, 1994; Weijer, 1996; Wiese, 1996).

(9) The lack of aspiration in English /sp, st, sk/ also reflects the inherent property of the glottal maneuver in the spirantized obstruents as opposed to a sequence (across syllable boundary) of a fricative and a voiceless stop, which is produced with a considerably larger glottal width at the moment of the articulatory release and therefore considerable aspiration (Fujimura, 1997, p. 103).

(10) The elemental gestures [for the words *sting* and *slick*] are both phonetically a frication gesture by the tongue tip, but they have different time functions: the former occurs earlier and remains above the turbulence-generating threshold for less time than the latter ... In contrast, the simple onset fricative [in *sing*] has the same [impulse response function] as in the complex onset of *slick* ... The generation of frication noise by the tongue tip for {fricative} as in *sing* and {spirantized} as in *sting* in English exemplifies a contrast in gesture timing for similar elemental gestures (Fujimura, 1997, pp. 99–100).

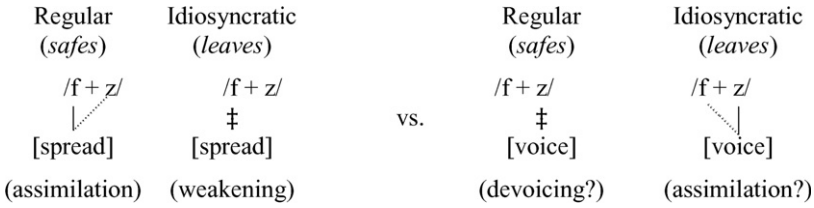
Among the implications of this way of understanding English obstruent phonetics is that assimilatory progressive devoicing in clusters is directly describable in terms of rightward extension of the feature [spread] into a laryngeally unmarked obstruent in cases like the /t + z/ of *cats*. If privative [voice] is assumed rather than [spread], however, the assimilation cannot even be described, as there is no negative value of [voice] available to spread—rather, as illustrated in the comparison in (11), the phenomenon must be characterized as a non-assimilatory delinking of [voice]. This phonological neutralization would take its motivation from the notion of "universal devoicing" (Harms, 1973; Mester and Itô, 1989), a constraint on phonetic implementation to the effect that voicing cannot be maintained within the syllable once it has been turned off. But there are logically many other ways to achieve conformity with a phonetic constraint against intrasyllabic resumption of voicing, including deletion or sonorantization of the offending voiced obstruent, voicing of the voiceless one, or epenthesis of a vowel into the cluster. Instead, the cluster in English experiences (or certainly appears to experience) progressive laryngeal assimilation, description of which is facilitated under the assumption of privative [spread]; under the assumption of privative [voice], conversely, characterization of this prima facie assimilation qua assimilation is just not possible, which then must be expressed alternatively as a stipulated feature delinking in lieu of other logically possible ways to achieve conformity with the phonetic constraint against intrasyllabic resumption of phonological voicing.

(11) Laryngeal assimilation in English: privative [spread] vs. privative [voice]



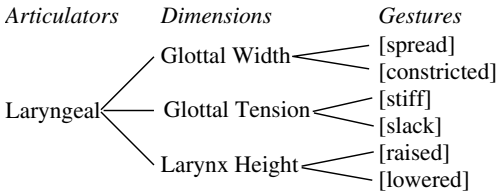
Similar difficulties of analysis arise in the description of regular and idiosyncratic noun plurals in English. As illustrated in (12), the assumption of privative [spread] allows for generalized cluster assimilation in regular plurals (/f+ z / > [fs] in *safes*) as well as for idiosyncratic, lexically triggered lenition in the irregular plurals (/f + z/ > [vz] in *leaves*). The positing of privative [voice], conversely, confounds the description of progressive laryngeal assimilation in English, as already pointed out, while it invites a description of the idiosyncratic plurals as being subject to a general phonological assimilation rather than to a lexically limited delinking of laryngeal content (the relic reflex of a historical lenition).

(12) Regular and idiosyncratic noun plurals: privative [spread] vs. privative [voice]



The positing of [spread] rather than [voice] as the marked laryngeal feature for English thus leads to a deeper understanding, without rules, of the familiar aspiration distributions and to a more satisfying analysis of the assimilatory devoicing that penetrates into both sonorants and obstruents. The binary alternatives are substantially less constrained, descriptively as well as symbolically, in that they allow reference to both the presence and absence of feature properties even though only presence is phonologically relevant, as we have tried to show. Further along in this line of work, a compelling variation on the privative theme has recently emerged in Avery and Idsardi's (2001) conception of laryngeal phonology. Rather than being defined on just the three privative features [voice], [spread] and [constricted], their proposals distinguish laryngeal contrasts according to the three "dimensions" of Glottal Width, Glottal Tension and Larynx Height. In the Avery and Idsardi system, the dimensions implicate phonetically antagonistic "gestures", which are essentially the same entities as the phonological features of conventional theories. Schematically, the dimensions and gestures relate to each other as in (13), all implemented under the "articulator" Laryngeal.

(13) Geometry of laryngeal representation in dimensional theory



Only one member of an antagonistic gestural pair typically may be used contrastively in a given system, though the other member may be invoked as a phonetic embellishment, or "enhancement", of a contrast. Thus, [spread] and [constricted] form an antagonistic pair

under the dimension of Glottal Width, so usually only one of these is phonologically active, as is the case in English (which contrasts [spread] voiceless aspirated stops with laryngeally unmarked lenis stops). Similarly, [stiff] and [slack] constitute the antagonistic pair which is subordinated under Glottal Tension, hence typically just one of these functions phonologically in a given system (as in French, whose [slack] voiced stops contrast with laryngeally empty voiceless unaspirated ones). The default selection among the dimensions is such that Glottal Width normally implicates [spread], and Glottal Tension typically implicates [slack]. The Larynx Height dimension, which implicates either [raised] (ejectives) or [lowered] (implosives), will not figure further into present discussion. The range of possibilities for characterizing contrasts works out to be similar to that presented up to this point, since under either approach just three privative entities combine in various ways to define a given system. For example, the conventional feature systems listed in (5) translate into dimensional representation as in (14).

(14) The same laryngeal contrasts as in (5) employing the three "dimensions" Glottal Width (GW), Glottal Tension (GT) and Larynx Height (LH) (Avery and Idsardi, 2001)

	/p ~ b̥/	/b/	/pʰ/	/p′/	/bʰ/
Hawaiian	[ ]				
K'ekchi	[ ]			LH	
French	[ ]	GT			
English	[ ]		GW		
Thai	[ ]	GT	GW		
Hindi	[ ]	GT	GW		GT&GW

The anatomical gestures [spread]/[constricted] and [stiff]/[slack], of course, were first presented in the germinal paper on laryngeal features authored by Halle and Stevens (1971). Replacing the cover term [aspirated], the feature [spread] (or [spread glottis]) is associated with the voiceless laryngeal approximant /h/, and with aspiration in stops and other consonants; its contrary gesture, [constricted] (or [constricted glottis]), marks the glottal stop as well as the properties of laryngealization or glottalization. Notably, there is no feature [voice] under this system—instead, voicing in obstruents is implemented via the gesture [slack] (for [slack vocal folds]), exploiting the observation that categorically slackened vocal folds will be set into vibration even when airflow across the glottis has been substantially impeded by a supralaryngeal obstruction. If the Glottal Tension dimension implicates [stiff] (for [stiff vocal folds]), on the other hand, vocal fold vibration is inhibited unless transglottal airflow is quite substantial, as it is in ordinary (voiced) sonorant articulations but not in obstruents; hence, voiceless sonorants are articulated with stiffened vocal folds, as are voiceless obstruents in many systems.

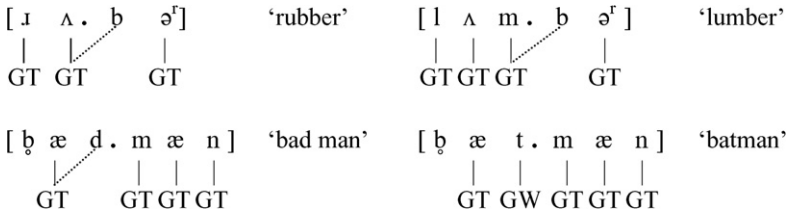
The other member of an antagonistic pair may be (and typically is) used as an enhancement of the contrast encoded by the marked member, but this occurs only at the surface phonetic or post-lexical level. For example, English marks its two-way laryngeal contrast via the Glottal Width dimension with the gesture [spread], which usually produces aspiration, but the contrary gesture [constricted] appears instead in redundantly glottalized

articulation of final unreleased stops, like in the /p/ of *cup* [$k^{h}\Lambda p^{\gamma}$]. In this way, whether construed as a reinforcement or as some form of lenition, antagonistic gestures implicated under the same laryngeal dimension may make their way into phonetic representation even though the phonemic system generally sanctions only one of these. In a similar fashion, even laryngeal dimensions which play no contrastive role in the phonology may be invoked to enhance a contrast phonetically. Thus, in both English and French, voiceless stops are produced with the vibration-inhibiting mode of stiffened vocal folds (Halle and Stevens, 1971) even though the Glottal Tension dimension, which subordinates the gesture [stiff], is otherwise not active among English obstruents; and in French, where it is phonemically active, Glottal Tension instead implicates [slack] as the lexical marker of voicing. These redundancies, or contrast enhancements at the phonetic level, are key to showing how a full range of phonological adjustments can take place without reference to negative values of features, in particular, without reference to [−voice]. Indeed, it has recently been argued (Wetzels and Mascaró, 2001) that [−voice] must be available in the phonology because voicelessness is known to spread from one sound to another in a number of languages. If valid, this conclusion would necessitate positing a binary feature [±voice] in order to allow for the assimilatory extension of [−voice] as well as [+voice], and so vitiate the privativity hypothesis. Iverson and Salmons (2003a), however, show that reference to the negative value of [voice] is not necessary in any of the cases under review, either because they are "aspiration" languages (with Glottal Width available for spreading rather than [−voice]) or they are "voice" (Glottal Tension) languages enhancing phonologically unmarked obstruents with the voice-inhibiting gesture [stiff], which thus is available to interrupt voicing at the phonetic or post-lexical level.

3. Redundant voicing in English

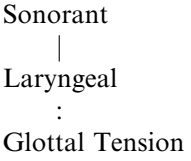
The dimensional view of laryngeal representation integrates easily with phonetic findings to the effect that obstruent voicing in most of the Germanic languages is not controlled actively as it is in Romance or Slavic, where [voice] is the lexically marked privative property (characterized now via the dimension of Glottal Tension). Rather, voicing in a Germanic language like English is implemented only in passing, under phonetic conditions that are favorable to its occurrence: in obstruents, voicing is privileged by the existence of voicing in an immediately preceding segment; in sonorants, voicing is facilitated intrinsically, provided the glottis has not become widened due to association with a neighboring fortis segment (cf. the sonorant devoicing phenomenon in words like *play*). Some exemplifications of such automatic voicing are given in (15).

(15) Extension of Glottal Tension into a laryngeally empty obstruent (intrinsic voicing in sonorants is due to surface Spontaneous Voicing).



The Glottal Tension dimension (implicating the gesture [slack]) is redundant in the phonological system of English, an aspiration language whose two-way laryngeal contrast is represented instead via presence vs. absence of the Glottal Width dimension (which in turn implicates the gesture [spread]). As in most languages, moreover, voicing is automatic among sonorants, or "spontaneous" (in the manner described by Chomsky and Halle, 1968; Halle and Stevens, 1971), because glottal vibration ensues automatically with sufficient air-flow across vocal folds that are in an adducted state; this is the case with ordinary sonorants, consonants as well as vowels. Sonorants are therefore articulated as voiced rather than voiceless unless some contrary gesture intervenes, such as spreading apart or tightly constricting the vocal folds so as to inhibit their vibration. Formally, spontaneous voicing can be expressed as in (16), i.e., the introduction into laryngeally unmarked sonorants of the Glottal Tension dimension (which by default implicates the gesture [slack]). Representative redundant occurrences of Glottal Tension due to spontaneous voicing are portrayed among the several sonorant segments in the English words listed in (15).

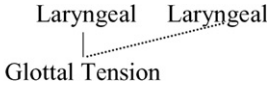
(16) Spontaneous Voicing



With the Glottal Tension dimension phonetically present among sonorants because of spontaneous voicing, the phenomenon of passive voicing in obstruents can be understood as an extension of spontaneous voicing into a neighboring segment that is not already specified for some laryngeal feature. This penetration moves rightward, from a segment imbued with Glottal Tension to a following laryngeally empty segment, which, in English, is any of the lenis or "voiced" obstruents. Accordingly, the laryngeally unspecified /b/ in *rubber* or *lumber* acquires the Glottal Tension property from the spontaneously voiced sonorant immediately preceding it. Similarly, the /d/ in a phonological phrase like *bad man* [b̥æd.mæn] acquires the configuration of Glottal Tension due its positioning after a redundantly voiced segment, viz., the vowel in *bad*. But passive voicing does not occur in the /b/ of *bit* [b̥ɪt] because that segment is not immediately preceded by an occurrence of the Glottal Tension dimension, or in *batboy* [b̥æt.b̥ɔɪ], where the syllable preceding the medial /b/ terminates in a segment marked instead for Glottal Width.

Finally, passive voicing of the /b/ in a word like *tab* [t^{h}æb], where a preceding but no following voiced segment appears, is typically less extensive than in the more favorable inter-voiced instances; a more narrowly accurate transcription then would be [t^{h}æ b̥], with the subscripted right parenthesis (an IPA diacritic used in disordered speech) indicating just partial final voicelessness. Still, post-voiced lenis finals in English are themselves voiced at least to begin with, unlike in Dutch (where they are thoroughly devoiced, Iverson and Salmons, 2003a) or German (where they are made fortis, Iverson, 1997). Though thus variable in its implementation, passive voicing operates generally as expressed in (17).

(17) Passive Voicing:
(variable implementation)



It is this implementation of passive coarticulation of phonetically slackened vocal folds that accounts for obstruent voicing in languages which do not mark voice phonemically via Glottal Tension. In ordinary language, Kohler (1984) characterizes the mechanism simply as in (18).

(18) Vocal fold vibration is regulated passively in Korean, as it is in English, German and Danish, to name but a few other examples. This means that the aerodynamic conditions for voicing are not actively controlled; voicing only continues during a stop closure as long as the articulatory context allows a pressure drop across the glottis (Kohler, 1984, p. 162).

Indeed, obstruent voicing of just this type has been documented in many phonetic studies, as reviewed by Jessen (1998, pp. 57–58). German stops in a voicing-friendly environment, for example, range from largely voiceless to fully voiced, depending on rate and register, and the process is familiar outside of Germanic from the variable and rate-dependent, similarly non-contrastive voicing of medial lax stops in Korean (Iverson, 1983; Ahn, 1998; Jun, 1998). These cross-linguistically attested patterns of partial or even full voicing in post-voiced position differ sharply from the essentially voiceless realization of the same lenis series in initial position, appropriately distinguishing derivatively voiced stops in "aspiration" (Glottal Width) languages from inherently voiced ones in "voice" (Glottal Tension) languages.

4. Coronal Lenition and "flapping" in English

A related form of obstruent voicing, but one with well-known neutralizing consequences, affects the coronal stops in North American English.[3] This "flapping" phenomenon, as Steriade (1999) puts it, is the result of an "[extra-short closure]" property that characterizes medial coronal stops. Based on studies by Zue and Lafferriere (1979), Steriade (1999) reports mean closure durations for English medial taps or flaps of just 26 ms, whereas closure durations in unflapped coronals, as among many British speakers (Docherty, 1992), are often much longer (Steriade reports that /d/ averages 75 ms, /t/ 129 ms).[4] Port (1977) demonstrates that average closure durations also vary with tempo of speech, so that, in slow tempo, /b/ and /p/ average 66.5 ms and 88.3 ms, respectively, but, in fast tempo, these shorten to 56.6 ms and 64.5 ms, respectively. Dividing the tempo dimension even more finely into three categories, Port found the average closure durations among American English medial /b, p, g, k, d, t/ to be distributed as in (19).

[3] Forms of flapping also occur in Hiberno-English and perhaps other varieties, Patrick Honeybone points out to us.

[4] Here and below, as an orthographic convenience paralleling quoted sources, we use the simpler symbol /d/ rather than /d̥/ to represent the English lenis coronal stop.

(19) Mean stop closure duration (in ms) for six phonological stops at three tempos (Port, 1977, p. 14)

	Slow	Neutral	Fast
/b/	69.0	58.0	47.7
/p/	91.6	78.3	58.8
/g/	54.1	43.3	39.0
/k/	68.5	56.9	45.0
/d/	25.3	25.0	20.8
/t/	26.2	21.1	20.5

As the rate of speech increases, unsurprisingly, the duration of closures decreases. There is also a place of articulation effect, such that labial closures under the same tempo condition are longer than velar ones, and a familiar voicing effect, such that closure durations in voiced labials and velars are substantially shorter than in corresponding voiceless stops. But among coronals, there is no such voicing effect, as very brief closure durations are in evidence for both the phonemes /d/ and /t/.[5]

Brevity of closure duration is a recurring if not invariant correlate of voicing, however, so that longer closure periods correlate with voicelessness in stops, shorter ones with voicing. This has to do ultimately with the physiological difficulty of maintaining voicing during the articulation of an obstruent stop: voicing requires transglottal airflow sufficient to induce vibration of the vocal folds, but an oral closure impedes the flow of air. Hence obstruents stops are preferentially voiceless, and voiced ones, by comparison, tend to be produced with shorter closure durations since the airflow necessary to maintain voicing is curtailed by the upstream closure. Interestingly, brief closure durations are associated with voicing even when the stop is phonetically voiceless: both Liskjer (1957) and Port (1977, p. 58) have shown that "... an intervocalic [b] will continue to sound phonologically voiced when all traces of glottal pulsing are removed from the closure interval, as long as the closure duration is kept sufficiently short, and ... if the silent closure is lengthened sufficiently, American listeners will hear a phonologically voiceless stop." In the case of North American medial coronal stops, which are abbreviated much more than labials or velars, the typical perception is that these "flaps" are voiced, whether they really are or not.

A number of phoneticians (see Charles-Luce, 1997; de Jong, 1998; Keating, 1984; Kenyon, 1997; Wells, 1982; Zue and Lafferriere, 1979) have observed that some North American speakers indeed do retain voicelessness in flapped /t/, which thus remains distinct from flapped /d/. In consideration of their brevity and for the reason just given, many linguistically naive listeners will perceive these sounds—voiceless [ɾ̥] and voiced [ɾ]—as nonetheless the same, i.e., as voiced, yet it is apparent that "flapping" does not always entail merger in production. In short, flapping involves shortening of closure durations, and listeners typically perceive the results of stop closure truncation among coronals, where the abbreviation

[5] This experimental finding is the same as the impressionistic perception results reported in a survey of professional linguists recently conducted on the Internet by Trask (2001): "The most salient phonetic feature of the tap is not ... its voicing—which need not even be present—but rather its shortness." And the fact that voicing often, but not always, accompanies flap or tap articulations (we do not distinguish these here, though 'tap' is the phonetically more accurate term) was also confirmed in the Trask's survey of linguists: "Even in the most casual speech, some speakers report that they consistently use a voiceless tap for /t/ but never for /d/...".

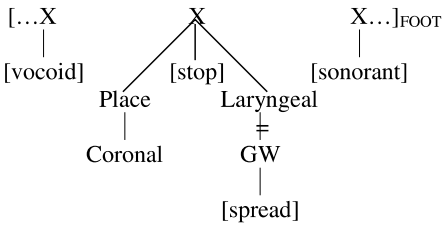
effect is greatest, as resulting in the same segment; but some speakers may continue to produce (and presumably perceive) the phonetic reflexes of /t/ and /d/ as still distinct, as [ɾ̥] vs. [ɾ].

There is more work to be done in producing a full description of medial stop shortening and its "flapping" effects on coronals in North American English, of course: questions arise in particular as to how extensive the phenomenon is in other varieties of English (indeed, in other languages), what the prosodic conditions are which facilitate the shortening (syllable, foot and word structure limitations), whether it is perceived by some but not all speakers, etc. The sum of phonetic research to this point nonetheless clearly indicates that medial stop shortening is a variable, tempo-dependent characteristic of speech which, in the North American variety of English, results in especially short closure durations for coronals. It is this magnified abbreviation of coronals during phonetic implementation which we refer to as "flapping" per se—not a rule of the grammar in any traditional sense (and therefore not formalized here), rather an acquired aspect of the basis of articulation for this and, perhaps to a lesser extent, other varieties of English. The key distinguisher of North American English in this connection then is thus not so much the flapping phenomenon itself, but instead the phonological merger that typically takes place between hyper-abbreviated /t/ and /d/.

For speakers who do merge these two stops, and thus neutralize the phonemic contrast between them, we assume as with other neutralizations that there is an actual rule at play, learned as a favored option in the North American surface manifestation of medial coronals. Though this could be formulated in terms of tableaux and constraints rather than a rule (albeit without contributing remarkable insights), the mechanism for the neutralization under present assumptions is one of laryngeal weakening, a lenition which effects the removal of phonemic Glottal Width from the phonetic representation of medial /t/. With this adjustment, which we call Coronal Lenition, lenited /t/ is indistinguishable from phonemically lenis /d/ in English, and this in turn undergoes passive voicing as described in (17). Our interpretation that coronal stop neutralization is weakening (with parallels in Kiparsky, 1979) thus results in merger between foot-internal instances of /t/ and /d/, and is formalized in (20). The reason that this weakening results in voicing, to reiterate, is that the laryngeally lenited product of the process is subject to passive voicing, just as are other medial lenis obstruents in English.

(20) Coronal Lenition: foot-internal laryngeal weakening of a medial fortis coronal stop

(/t/ → [d̥] / […[vocoid] ___ [sonorant] …]$_{FOOT}$)



To be clear, then, we reserve the term "flapping" for the exaggerated shortening of medial closure durations which affects (but does itself not neutralize) coronal stops during phonetic implementation. Coronal Lenition, on the other hand, is a phonological

neutralization merging /t/ and /d/ under conditions that are sensitive, as is widely appreciated, to stylistic as well as prosodic properties. In particular, Coronal Lenition is not categorical or obligatory in very careful speech, and the stress (metrical prominence or intensity) associated with the syllable containing the following sonorant should not be greater than that associated with the preceding vocoid.[6] The restriction of Coronal Lenition to a foot-internal context (Kiparsky, 1979) is intended to convey this latter limitation, as a foot boundary will be present at the beginning of a stressed syllable but not of an unstressed one. Hence lenition will occur in *pretty* or *satyr*, with a stressed vowel preceding the lenitable /t/, but not in *pretend* or *perturb*, with stress following the /t/. It is also possible for /r/ but not other sonorant consonants to precede the lenited coronal, as reviewed in detail by Vaux (2003); thus, /t/ weakens in *party* (whether in rhotic or non-rhotic varieties of North American English) as it does in *potty*, but it generally does not weaken after the lateral liquid /l/, as in *filter* [filtə^{r}],[7] nor after a nasal, as in *Sumter* [sʌmtə^{r}] or *winter* [wɪntə^{r}]. Taking the feature expression "[vocoid]" (Clements and Hume, 1995) to include the class of vowels, glides and the vocalic /r/ of American English, rule (20) is thus formulated to sanction lenition in just the observed cases.

The coronal lenition process is sometimes construed to affect /t/ also following a homorganic nasal, but Vaux (2003) shows that a preceding /n/ typically triggers deletion rather than voicing of /t/, as in the American casual pronunciation of *winter* [wɪr̃ə^{r}], which, for many speakers, is homophonous with *winner*. Words like these then are produced either with a flapped nasal (or nasalized flap) and no vestige of the coronal stop, or they retain the /t/ in voiceless unaspirated form, as in [wɪntə^{r}]. We follow Vaux in attributing post-nasal /t/-loss to a rule separate from the lenition process in (20), noting, moreover, that underlying /d/ in this same context does not elide, as in *wind̲y* [wɪndɪ] (except perhaps in very casual speech). Thus, while *winter* and *winner* can be homophonous when /t/ is deleted, *winter* does not rhyme with *cinder* or *hinder* even when /t/ is retained, which shows that post-nasal /t/ in general is not subject to Coronal Lenition.

In derived contexts involving the decade suffix *–ty*, however, post-nasal /t/ can weaken directly to [d], as in *seventy* [sɛvənti] or *ninety* [naɪndi] (of course, it can also remain /t/, i.e., [sɛvənti] and [naɪnti]—with unaspirated [t]—are possible in especially careful speech). Rather than attribute this lexically limited voicing to the general lenition process in (20), however, we consider it to be a special property of the affix *–ty*, whose /t/, by a separate optional stipulation, loses its Glottal Width dimension when preceded by a stem-final nasal.[8] In casual speech, this idiosyncratic weakening may be disregarded, triggering then the more general post-nasal /t/-loss described in the previous paragraph so as to result in

[6] An anonymous reviewer points out that this prosodic restriction governs only word-internal lenition, whereas at the phrasal level (which has not been not part of present discussion), the relative stress limitation does not hold (e.g., *t* is lenited even in *Gèt ín!*, etc.).

[7] The same reviewer astutely observes that flapping is possible after /l/ in some words, viz., in *faculty*, *penalty*. In the pronunciation of the present author who is a native speaker of American English (Iverson), the overall duration of *t* in these words is indeed very short, i.e., the *t* is flapped, but it is not lenited or voiced (aside from perhaps the most casual speech style). The canonical pronunciation is thus that of a voiceless unaspirated [ɾ̥], consistent with the limitation on (20) that Coronal Lenition occurs after vocoids but not after the lateral /l/. For reasons described just above, however, the brevity of a phonetically voiceless flap (which is especially short in unstressed surroundings) can lead to its perception as voiced.

[8] This is a morpholexically restricted laryngeal weakening then, similar in form to that which affects irregular noun plurals as presented in (26) below.

[sɛvə̃ri] and [naɪr̃i]. Finally, the word *twenty* [twɛ̃ri] is unusual in that it regularly has a flapped nasal in place of the /nt/ sequence (*[twɛndi] is out), which suggests that, in correspondence with the bound character of the formative *twen-*, the derivative 20 is listed lexically in parallel to words formed out of a single morphological unit, like *winter*.

With respect to the sonorant which follows a /t/ under consideration for Coronal Lenition per (20), the [vocoid] restriction that is imposed on the preceding sonorant does not obtain: hence, either a central or a lateral liquid will trigger lenition of a preceding /t/, as seen in words like *water* [wɔrə^{r}] and *little* [lɪdl̩], the latter showing "lateral plosion" from the lenited /t/ (= [d]) into the [l]. A following heterorganic nasal, similarly, is no impediment to lenition, as reflected in the pronunciation of *bottom* [barm̩], for example. But a following homorganic nasal does inhibit laryngeal weakening, as in *kitten* [kɪt^{ʔ} n̩] or *button* [bʌt^{ʔ} n̩]; apparently the coda glottalization which affects prenasal /t/ (which is perhaps ambisyllabic) fortifies it against the ravages of lenition. Hence, only the phonetically [spread] form of /t/ lenites, as per (20), not the [constricted] variant found in syllable-final position.[9] With these elucidations in place, the range of cases where Coronal Lenition does and does not take place is listed in (21), where presumed foot structure is indicated by brackets.

(21)

Lenition	No Lenition
[pre<u>t</u>ty]	[pre[<u>t</u>end]]
[po<u>t</u>ty]	[per[<u>t</u>urb]]
[sa<u>t</u>yr]	[sa][<u>t</u>ire]
[po[ta<u>t</u>o]]	[po[<u>t</u>ato]]
[a<u>t</u> all]	[a<u>t</u> [once]]
[par<u>t</u>y]	[fil<u>t</u>er]
[migh<u>t</u>y]	[win<u>t</u>er]
[li<u>tt</u>le]	[ki<u>tt</u>en]
[bo<u>tt</u>om]	[bu<u>tt</u>on]

There is also the complication of the celebrated "Withgott effect" (due to observations first made by Withgott (1982) and reintroduced by Steriade, 1999), which is that weakening takes place in words derived from bases in which /t/ has been lenited, but not in words derived from bases in which /t/ remains fortis, as compared in (22), though there is some speaker variation on this matter. We follow Vaux (2003) again in ascribing this difference to the psychological (if not phonetic) presence of a residual secondary stress in words like *militaristic* rather than to paradigmatic consideration of the fact that lenition/flapping does not occur in the bases from which they derive. In a related vein, it also seems reasonable to suppose that an internal stress foot blocks lenition of medial /t/ in the word *Mediterranean* ([[*Medi*[*terranean*]], cf. [[*sub*[*terranean*]]).

(22)

Lenition	No Lenition (most speakers?)
capi<u>t</u>alistic (cf. cápi<u>t</u>al)	mili<u>t</u>aristic (cf. míli<u>t</u>àry)
fa<u>t</u>alistic (cf. fá<u>t</u>al)	rela<u>t</u>ivistic (cf. réla<u>t</u>ìve)

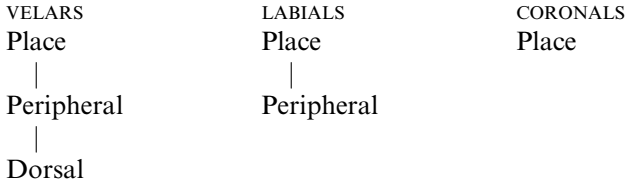
[9] Varieties of English which do not glottalize /t/ in these words presumably are precisely those which retain a vowel in the second syllable ([bʌtʌn]) and which do not exhibit Coronal Lenition in any case.

Phonologically, Coronal Lenition as presented in (20) is a variable, speaker-dependent post-lexical neutralization process merging the fortis stop /t/ with its lenis counterpart /d/. This neutralization has phonemic consequences for English speakers, of course, and is the aspect of the overall "flapping" phenomenon to which we attribute psychological salience. But whether lenition of fortis /t/ takes place or not, coronal stops are still subject to the rate-dependent truncation which results in the very short average closure durations reported for medial /t/ and /d/ in (19). This is how these stops generally, whether merged or distinct, are phonetically implemented in North American English—i.e., as flaps—and such abbreviation forms part of the "base of articulation" for this variety of the language. Presumably, the shortening of medial closure durations is a quality of speech that is acquired in the learning of specifically North American English, but movement toward this variable norm is characteristic of other varieties as well.[10] The temporal weakening of medial coronal stops appears to be physiologically motivated, moreover, perhaps even determined, by the dynamics of consonant–vowel coarticulation. de Jong (1998) summarizes this finding as in (23).

(23) Assuming the flapped stops are part of an unstressed syllable, along with the following unstressed vowel, they should exhibit greater coarticulatory overlap (co-production) with the neighboring vowels. Since neighboring vowels demand a lower jaw and (usually) a lower and more retracted tongue body, this increased overlap would tend to lower the jaw and lower and retract the tongue body, which in turn would weaken and retract the coronal closure (de Jong, 1998, p. 286).

In phonological terms, we follow a familiar line of recent research branding the coronal place of articulation as least "marked," representationally emptiest among the three organizing oral place sites subsumed under the notion of "Peripherality" (Rice, 1994; cf. also Ahn, 1994; Iverson and Lee, 1995; Davis et al., 1999). The idea here is that, for labials and velars, a node Peripheral is subordinate to Place in the feature geometry. Coronals are then unspecified for all Place properties, labials are marked just for Peripheral, and velars contain Peripheral along with the subordinate articulator Dorsal, as shown in (24).

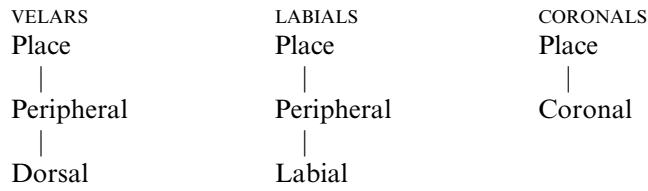
(24) Place representation (phonological, lexical)



[10] For example, Docherty (1992) reports shorter closure durations in medial coronal stops than in labials and velars in British English. We do not take the abbreviated surface quality of closure durations to be part of the phonology per se, however (though Coronal Lenition in North American English clearly is); rather, we consider shortening to be an aspect of phonetic implementation which, when exaggerated among coronals as in American English, is likely facilitated by the fact that flaps serve no other function there, whereas a flap is a possible manifestation of medial /r/ in other varieties of the language.

At the post-lexical or phonetic level, even unmarked structural properties of speech sounds are accessible, yet here, too, coronals remain representationally less complex than either labials or velars. As shown in (25), the coronal place of articulation is in this sense still less structured, or emptier, than the other two, thus mirroring phonologically the lenition (structure reduction) that derives from the forces of coarticulation described in (23).

(25) Place representation (phonetic, post-lexical)

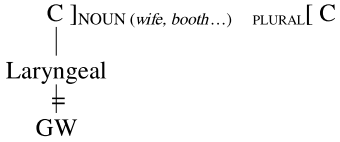


The susceptibility particularly of /t/ to the removal of Glottal Width in a prosodically weak position correlates with the overall emptiness of its basic representation: next to /d/, which is unmarked for both Place and Laryngeal, /t/ is the least specified obstruent in English, marked only for [stop].[11] Removal of Glottal Width from prosodically weak /t/ thus expresses the predilection apparent in North American English for uniform vacuity of obstruents occupying weak positions. Presumably it is difficult to maintain laryngeal structure in the onset of a prosodically non-prominent syllable without the supporting specification of place and manner properties. Inherently weak /t/, in any case, is weakened even further in prosodically weak environments by the removal of its Glottal Width dimension, resulting in merger with lenis /d/ and consequent automatic voicing in these voicing-friendly contexts. The flapping which typically accompanies coronal lenition, albeit rate determined, is an independent variable, moreover, thus it is possible for one to occur without the other. Indeed, the literature reports "flappers" who do not lenite, and in slow speech even laryngeally lenited coronal stops may be produced with the longer closure durations that are characteristic of non-flaps. Nonetheless, there is a strong association between laryngeal lenition (or voicing) and flapping, which we see as a product of the perceptual correlation between stop voicing and very brief obstruent closure durations.

Returning now to the illustration in (12) of irregular noun plurals in English, it can be appreciated that the fricative voicing which occurs in a plural like *wives* is cut from the same cloth as the voicing that normally accrues to the flap in American pronunciations of *water*. Both are a consequence of laryngeal weakening feeding into the implementation of passive voicing. But whereas /t/-voicing emerges from the variable, post-lexical generalization expressed in (20), voicing in irregular plurals is a highly restricted reflex of the historically prior passive voicing of medial fricatives in Old English. This rule today takes the morpholexically limited form expressed in (26), with the voicing in its output segments due, not to laryngeal assimilation in an obstruent cluster, but to the same process as voices lenited medial coronals in American English, viz., passive voicing.

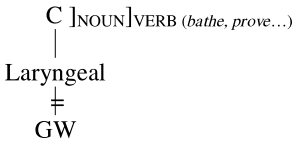
[11] Other coronal obstruents are marked for additional manner or place features, e.g., /s/ and /z/ are [continuant], /θ/ and /ð/ are [continuant, distributed], the affricates /tʃ/ and /dʒ/ are [stop]/[continuant].

(26) Laryngeal weakening in irregular noun plurals (*wives*, *booths*, *leaves*, *houses*, etc.)



The same kind of weakening, amenable to a similar formalization, occurs in several denominal fricative-final verbs: *bathe* < *bath*, *prove* < *proof*, *mouth* < *mouth*, *house* < *house*, etc.

(27) Laryngeal weakening in selected denominal verbs (*bathe*, *prove*, *mouth*, *house*, etc.).



Several idiosyncratic derivatives also show the same weakening—*thievery* < *thief*, *mouser* 'cat good at catching mice' < *mouse*, *greasy* (Southern US) < *grease*—but none, apparently, shows strengthening to the fortis series. It is interesting to note, moreover, that under present assumptions the cases under discussion all run parallel to another component of the grammar in that their base forms experience loss of specified phonological marking (via delinking of Glottal Width) when derived, just as the process of word derivation in general involves loss of specified morpholexical markings (Kiparsky, 1982). For example, the preterite of the otherwise strong (irregular) verb *to fly* is weak (regular) in the derivative baseball sense (*The batter flied* / **flew out in the third inning*), i.e., the base verb loses its [STRONG] designation when derived into the baseball noun *fly* (shortened from *fly-ball*), so that when this *fly* is converted into a verb again (*to fly out* in baseball), the special marking of [STRONG] is no longer present. Similarly, the noun *leaf* loses its special marking that triggers rule (26) when derived into the name of the Canadian baseball team, *Toronto Maple Leafs* / **Leaves*, with regular progressive assimilation rather than idiosyncratic stem-final weakening. In the present analysis, these losses of specified marking in word derivation are paralleled in the phonology by the loss of laryngeal structure that takes place in association with the same morphological process.

5. Summary and conclusion

Under Dimensional Theory, voicing in English is everywhere redundant: spontaneous in sonorants, passive in obstruents. The key understanding is that English is an "aspiration" language, i.e., one which marks fortis obstruents with the laryngeal dimension of Glottal Width, but does not mark lenis obstruents with any laryngeal property. The post-lexical adjustment affecting /t/ and /d/ then emerges as two distinct but often co-occurring phenomena. Coronal Lenition, defined in (20), weakens the fortis stop /t/

in prosodically weak environments so as to merge it with /d/. Flapping per se then is a rate-of-speech dependent abbreviation of stop closure durations which varies according to laryngeal mode: fortis closures are longer, passively voiced lenis closures are shorter. But closure abbreviation also varies by place of articulation, with the effect weakest in labials, stronger in velars, and quite powerful in coronals. Thus, coronal closure durations in weak positions abbreviate the most, and, as it happens, speakers of North American English typically also merge the coronal fortis stop with the lenis one via Coronal Lenition. This neutralization is phonemically significant, but the abbreviation of closure durations is not, except insofar as this may lead to the perceptual identification of passively voiced lenis stops with otherwise voice-resistant fortis stops, which do abbreviate appreciably in closure duration but for many speakers do not lenite laryngeally.

The key to the analysis then is this: /t/ and /d/ in English are phonemically distinguished as marking Glottal Width laryngeally (/t/) vs. having no laryngeal marking at all (/d/). When Coronal Lenition takes place to remove the Glottal Width dimension, /t/ therefore merges with /d/, resulting in the typical American dialect in which *matter* is pronounced the same as *madder*. But for most British and some North American speakers, Coronal Lenition is not part of the phonology, hence these speakers keep the two phonemes distinct by contrasting Glottal Width-marked /t/ (fortis, voiceless) with laryngeally empty /d/ (lenis, voiced). Irrespective of any merger ensuing from Coronal Lenition, however, English speakers (perhaps Americans more than British, though both do this) also engage in ''flapping'' per se, which is the rather sharp reduction in closure durations that has been described here.[12] When closure durations are reduced substantially, as is common among coronals in ordinary registers, speakers may perceive the resulting abbreviated stops (i.e., ''flaps'') as voiced even though the flaps that derive from /t/ are still phonetically voiceless if Coronal Lenition has not taken place. This covers the full range of variation, as schematized in (27). Typical American speakers participate in Coronal Lenition, which is a rule that has psychological salience and results in the merger of /t/ and /d/, but some do not. Yet most (if not all) speakers dramatically reduce the closure durations of medial coronal stops (including nasals), which is the ''flapping'' phenomenon per se—not a rule in the conventional sense, but rather a matter of phonetic implementation.

(27) Variable realizations of English medial /t/ and /d/ via Coronal Lenition and flapping

Neither flapping nor lenition	Flapping without lenition	Lenition without flapping	Both flapping and lenition
[t], [d]	[ɾ̥], [ ]	[d]	[ ]

[12] Of course, if medial /t/ is glottalized (*bottle* = [bat^{ʔ}l]), or reduced to a glottal stop ([baʔl]), as in some British varieties, then flapping is preempted.

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