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A GESTURAL ANALYSIS OF FRENCH LENITION

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ABSTRACT

Previous accounts of lenition in Late Latin and Gallo-Roman have relied upon synchronic frameworks based on categorical phonological features. In this paper, I argue that Browman and Goldstein's gestural model provides a more explanatory account of lenition by modeling the involved sound changes in terms of principled gestural modifications characteristic of casual speech: reduction in gestural magnitude, and gestural overlap.

0. Introduction

From a diachronic perspective, lenition is defined as the following series of sound changes: degemination, voicing of single intervocalic obstruents, spirantization of single intervocalic voiced stops, and eventually, weakening of voiced fricatives into glides or complete deletion of the fricatives (Bichakjian 1972, 1977). Previous theoretical accounts of lenition have called upon phonological frameworks developed for synchronic purposes, such as Underspecification Theory. More recently, Jacobs (1996) proposes a constraint-based account in order to overcome certain problematical aspects associated with these rule-based analyses.

McMahon and Foulkes (1995:2) make a crucial observation concerning the use of phonological theories to account for diachronic phenomena: "The analysis of sound change has not often been seen as a priority for the designers of phonological theories, whether these have focused on representation or on derivation. Phonologies have generally been applied to historical developments only as an afterthought, and then have typically been found wanting." This is an accurate claim with respect to previous accounts of French lenition. For their dependence upon categorical phonological features, these accounts fail to acknowledge the quantitative, articulatory factors that motivate lenition as a sound change[1].

In this paper, I re-examine the lenition process of Late Latin and Gallo-Roman within the framework of Articulatory Phonology (Browman and Goldstein 1986, 1989, 1990, 1992). It will be shown that a gestural analysis can provide a more explanatory account of lenition by modeling the sound change in terms of principled gestural modifications characteristic of casual speech. I will argue that such an analysis can also account for the stage of lenition that previous analyses have not addressed, namely the deletion of voiced fricatives in certain contexts. The gestural framework, therefore, permits a comprehensive explanation of consonantal weakening in the historical phonology of French.

This paper is organized as follows: In section 1, I present data illustrating the various stages of lenition. In section 2, previous phonological accounts are discussed. I then present a brief description of the gestural framework in section 3, showing how it can be used to explain sound change. Section 4 is devoted to a gestural analysis of the stages of French lenition. In section 5, I summarize and provide some concluding remarks.

1. Lenition of intervocalic stops in Late Latin and Gallo-Roman

The principal focus of this paper is lenition of the intervocalic stops /ptk/ and /bdg/ from Late Latin (ca. 2nd century) through the end of the Gallo-Roman period (mid-9th century). In the initial stages of the lenition process, spirantization and voicing, intervocalic stops were affected regardless of vocalic context. However, the evolution of resulting voiced fricatives exhibits place effects: "Gallo-Roman γ and β were both strongly influenced by the point of articulation of the vowels in their vicinity, especially those following them: both consonants tended to open further and disappear before homophonous vowels, γ before *velar* vowels, β before *labial* vowels" (Pope 1952:138).

The data in (1-3) show the lenition process as it affected intervocalic bilabial stops /p/ and /b/ (Pope 1952 and Joly 1995 constitute the principal sources for the data and chronological information presented here):

(1)	nuba	> [nuβa] > [nuwa]	> nue	'cloud'
	tabonem	> [taβone] > [tawone]	> taon	'horsefly'
(2)	debere	> [deβere] > [devere]	> devoir	'to have to, to owe'
	librum	> [liβrum] > [livrum]	> livre	'book'
	caballum	> [kaβallu] > [kavallu]	> cheval	'horse'
(3)	tropare	> [trobare] > [troβare] > [trovare]	> trouver	'to find'
	saponem	> [sabone] > [saβone] > [savone]	> savon	'soap'
	sapere	> [sabere] > [saβere] > [savere]	> savoir	'to know'
(4)	abbate		> abbé	'abbot'
	koppa		> coupe	'cup'

As shown in (1-2), /b/ initially underwent early spirantization in the Late Latin period. Subsequent development of the resulting voiced fricative depended on the vocalic context. When in contact with rounded back vowels, as in (1), the voiced fricative further weakened to labiovelar [w] and was eventually deleted in the second century. When in contact with front vowels, as in (2), the fricative was strengthened in the late third century to the labiodental [v], which remains in Modern French. The data in (3) demonstrate that during the fourth and fifth centuries, Latin /p/ underwent voicing, spirantization, and strengthening to [v] regardless of the vocalic context. Finally, the data in (4) show that both voiced and voiceless bilabial geminates simplified in Early Old French (ca. mid-ninth century) without subsequent modification.

Lenition of Latin intervocalic coronal stops /t/ and /d/ follows a pattern similar to that of bilabials. A crucial difference, however, is that the voiced fricative resulting from spirantization was ultimately deleted regardless of vocalic context. The development of coronal stops is given in (5-7):

(5)	videre	> [veδeire]	> voir	'to see'
	nuda	> [nuδa]	> nue	'naked'
(6)	vitam	> [vida] > [viδa]	> vie	'life'
	gratum	> [gradu] > [graδu]	> gré	'will'
(7)	guttam		> goutte	'drop'

The examples in (5) show that Latin /d/ underwent spirantization in the seventh century and eventual deletion in Early Old French (ca. late ninth century) regardless of vocalic context. The data in (6) show that Latin /t/ became voiced and then underwent spirantization and deletion around the same period as Latin /d/, again regardless of the adjacent vowels. Finally, the example in (7) shows that geminate /tt/ in Latin simplified (ca. mid-ninth century) without subsequent modification.

The final pattern under consideration is that of intervocalic velar stops /k/ and /g/. As with the bilabial pattern shown in (1-3), the subsequent development of voiced velar fricatives exhibits place effects with respect to vocalic context. The development of velar stops is given in (8-10):

(8)	a.	augustum	> [aγostu]	> août	'August'
		ruga	> [ruγa]	> rue	'street'
	b.	negare	> [neγare] > [neyare]	> nier	'to deny'
		plaga	> [plaγa] > [playa]	> plaie	'wound'
(9)	a.	sekurum	> [seguru] > [seγuru]	> sûr	'sure'
		lokare	> [logare] > [loγare]	> louer	'to rent'
	b.	plikat	> [plegat] > [pleγat] > [pleyat]	> ploie	'(it) bends'
(10)		sikkum		> sec	'dry'

The data in (8) show that after spirantization of the voiced velar stop in Late Latin, development of the resulting voiced fricative depended on the vocalic context. The velar fricative was deleted in contact with a back vowel, as in (8a), during the sixth and seventh centuries. Between a front vowel and /a/, the velar fricative became palatalized in the seventh century, as shown in (8b). The data in (9) show that Latin /k/ initially underwent voicing and spirantization (ca. seventh century). The resulting velar fricative was deleted in contact with a back vowel, as in (9a). Between a front vowel and /a/, the velar fricative became palatalized, as in (9b). Finally, the example in (10) illustrates the degemination of /kk/ (ca. mid-ninth century). Note that the data in (8-10) do not include instances where the velar stop preceded the front vowels /e/ and /i/. In this environment, /g/ underwent immediate palatalization, without initial weakening to a voiced fricative.

To summarize the patterns discussed above, we have seen that the initial stages of lenition operated categorically upon single intervocalic oral stops to yield voiced fricatives. Whereas the voiced bilabial and velar fricatives [β] and [γ] evolved early on as a function of the place of articulation of adjacent vowels, the resulting voiced coronal fricative [ð] was deleted much later regardless of vocalic context. In the following section, I will briefly examine previous phonological accounts of lenition. As we will see, these analyses provide no motivated explanation for the sound changes, nor do they address the role of adjacent vowels in the subsequent development of voiced fricatives produced by spirantization.

2. Previous accounts of lenition

McMahon, Foulkes and Tollfree (1994:282) discuss the inadequacies of certain frameworks when applied to consonantal weakening. Most phonological systems formalize lenition as a change in the specification of a feature indicating degree of stricture. For example, /p/ > [ϕ] might have the following representation in Jakobson's system:

(11) p > ϕ

$$\begin{bmatrix} +\text{cons} \\ +\text{diff} \\ +\text{grave} \\ -\text{cont} \end{bmatrix} \quad \begin{bmatrix} +\text{cons} \\ +\text{diff} \\ +\text{grave} \\ +\text{cont} \end{bmatrix}$$

The problem with the formalism in (11) is that weakening is equated with a simple change in logically equivalent features. An account based on binary features may adequately describe the process, but it achieves very little in the way of actual explanation. Government Phonology offers an account of lenition not in terms of binary features, but rather as elemental decomposition, or reduction in segmental complexity. Harris (1990) analyzes the series of weakenings from /t/ > /s/ > /h/ > Ø in terms of the progressive decomposition of elements, as shown in (12):

```
(12)  x  →  x  →  x  →  (x)
      |     |     |
      R°    R°    |
      |     |     |
      h°    h°    h°
      |
      ?°

      t  →  s  →  h  →  Ø
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Harris (1992) characterizes word-final, preconsonantal and intervocalic contexts as "prime lenition sites" in which less segmental material can be tolerated. As McMahon et al. (1994:283) point out, however, it is unclear how we decide which element to delink in a particular prime lenition site, and how many are to be delinked. Thus, the problem of explanatory adequacy remains, and some external, phonetic account may be needed to explain why the sound change happened in the first place.

Jacobs and Wetzels (1988) propose an account of lenition based on Steriade's (1987) principles of underspecification. They represent the initial step of spirantization as the R(edundancy)-rule (13b), which replaces the R-rule (13a) within the context in which lenition occurred.

(13a) [0cont] → [-cont] / $\begin{bmatrix} \_\_\_ \\ -\text{son} \\ +\text{voice} \end{bmatrix}$ Elsewhere

Since spirantization is likely to have been optional for some time, Jacobs and Wetzels (1988) propose a feature-spreading rule involving the assimilation of the feature [+cont] from the vowel to the adjacent stop, with the additional assumption that different systems of underlying feature representation can occur in different contexts. However, Jacobs (1996) doubts that vowels need to be specified for [cont] and [voice] and questions the validity of requiring different underlying systems of feature values to be learned for different contexts. To overcome these problems, Jacobs (1996) proposes an optimality-based account involving constraints banning association of the features [cont] and [voice] in the context where lenition occurred. This account formalizes spirantization as a re-ranking of the constraints in (14a) to those in (14b):

(14a) PARSE(voice) > PARSE(cont) > *LE/[+voice,-cont] > *LE/[-voice]

(14b) PARSE(voice) > *LE/[+voice,-cont] > PARSE(cont) > *LE/[-voice]

The re-ranking of constraints in (14b) has the effect of forcing the underlying feature [-cont] to remain unparsed in the lenition context (LE). Given the additional assumption that unfilled 'cont' and unfilled 'voice' are interpreted as + in this context, the optimal candidate will be a voiced fricative. Subsequent stages of lenition are also captured in terms of constraint re-ranking. However, Jacob's analysis does not address the final stage of lenition, in which voiced fricatives were deleted in certain contexts.

Although the optimality-based analysis may not be thwarted by the same problems as its rule-based predecessor, both lack explanatory adequacy. For their use of discrete phonological features, these accounts still do not capture the motivation underlying lenition as a sound change. In other words, the re-ranking of anti-association constraints in (14) is really no different than the change in logically equivalent stricture features shown in (11). In short, a phonology that explains sound change in these terms fails to give an accurate account of real articulatory events and could be accused of modifying representations in arbitrary ways. In the following section, I will argue that the framework of Articulatory Phonology is capable of accounting for lenition in a non-arbitrary manner.

3. Articulatory Phonology: a gestural approach to sound change

Articulatory Phonology (Browman and Goldstein 1986, 1989, 1990, 1992) dispenses with the assumption of traditional phonological models that the physical movements of speech derive from an abstract level of discrete, linearly arranged units. Instead, lexical items are represented in terms of scores of overlapping gestures that have inherent duration. Gestures are "autonomous structures that can generate articulatory trajectories in space and time without any additional interpretation" (Browman and Goldstein 1986:223). Within the gestural model, the articulator sets—tongue body (TB), tongue tip (TT), lips, (LIPS), glottis (GLO) and velum (VEL)—constitute semi-independent articulatory systems whose movements combine with each other to characterize speech. In this view, there is no interface between phonology and phonetics, since "gestures are basic units of contrast among lexical items as well as units of articulatory action" (Browman and Goldstein 1992:156).

One of the strengths of the gestural model is its ability to account for casual speech phenomena. Browman and Goldstein (1990) propose that the gestures that characterize a word in careful pronunciation may be altered in magnitude and in their temporal relation to other gestures in faster, casual speech: "we expect gestures to show decreased magnitudes (in both space and time) and to show increasing temporal overlap" (360). Many historical sound changes can be modeled in terms of these two modifications to the gestural scores of lexical items as they occur in casual speech (see Goldstein 1995; Browman and Goldstein 1991; McMahon and Foulkes 1995; McMahon, Foulkes and Tollfree 1994). The remaining sections of this paper are dedicated to showing how French lenition may be accounted for using the tools provided by the gestural model.

4. Articulatory Phonology and intervocalic consonantal weakening

In this section, I will provide a unified account of the various stages of lenition. First, I will address the role of gestural reduction in the stages of lenition affecting consonants regardless of place of articulation, namely spirantization, voicing and degemination. Then, I will examine the role of gestural overlap and blending in those cases that exhibit place effects, specifically the deletion of voiced bilabial and velar fricatives. Because it can provide an accurate description of real articulatory events, Articulatory Phonology is argued to yield a more explanatory account of the sound changes involved in the lenition process.

4.1 Reduction in gestural magnitude: spirantization and voicing

Browman and Goldstein (1990, 1991) argue that many casual and fast speech processes are accommodated

within the gestural framework in terms of reduction in the magnitude of individual gestures. For example, Brown (1977) discusses instances of weakenings in the casual speech of English. Examples involve stop consonants that weaken to corresponding fricatives: *because* pronounced as [pxəz], *must be* pronounced as [mʌsβɪ]. In some types of fast speech, there is a tendency to reduce the movement amplitude of articulators (Lindblom 1983; Munhall, Ostry, and Parush 1985; Kuehn and Moll 1976; Gay 1981). Additionally, reduced magnitude of articulatory gestures may result from speakers paying less attention to the utterance during casual speech (Dressler and Wodak 1982; Barry 1984). The gestural model explains these casual speech phenomena as instances in which magnitude reduction of individual stop gestures yields incomplete acoustic closure.

The notion of gestural magnitude reduction offers a motivated account of intervocalic consonantal weakening processes in Late Latin and Gallo-Roman. Browman and Goldstein (1991:325) themselves give the example of Latin intervocalic /b/, which was lenited to a fricative in modern Romance languages: Latin *habere* 'to have' > Italian *avere*, French *avoir*. The initial stage of spirantization is represented visually by the gestural scores in Figure 1. Initially, Latin /b/ is specified for a LIPS gesture with a [close] constriction degree and a [labial] constriction location, as shown in step (a). Gradual reduction in the magnitude of this gesture occuring in casual speech results in the loss of complete closure, as demonstrated in the intermediary step (b). Over time, listeners become attuned to the reduction in the output magnitude of the gesture and shift the value of the constriction degree parameter. The ultimate result is a recategorization of the gesture as having a [critical] value for constriction degree, as shown in step (c). Spirantization of the coronal and velar voiced stops occurs in a similar manner. The difference is that magnitude reduction and eventual constriction degree shifting affect gestures on different articulatory tiers, involving a TT gesture for /d/ and a TB gesture for /g/.

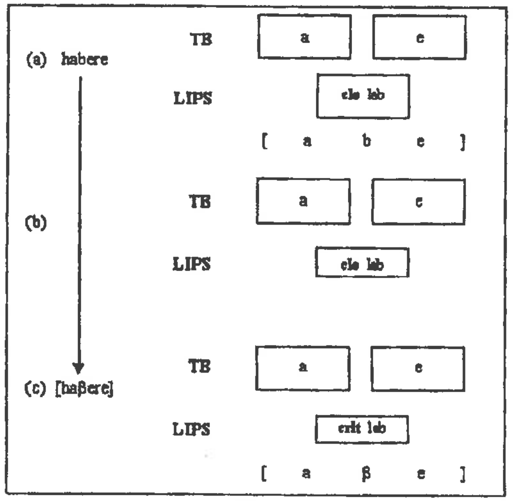

Figure 1
Reduction in magnitude of gesture for Latin /b/, yielding bilabial fricative /β/

The voicing stage of lenition may be given a similar account. In gestural terms, a voiceless stop gesture, while a voiced stop is a single oral constriction gesture (Goldstein and Browman 1986:340). Cases of intervocalic voicing assimilation involve a reduction in magnitude of the glottal opening-and-closing gesture responsible for voicelessness. A sufficient decrease in the magnitude of the opening effectively eliminates devoicing (Browman and Goldstein 1991:370). The voicing process is represented by the gestural scores in Figure 2.

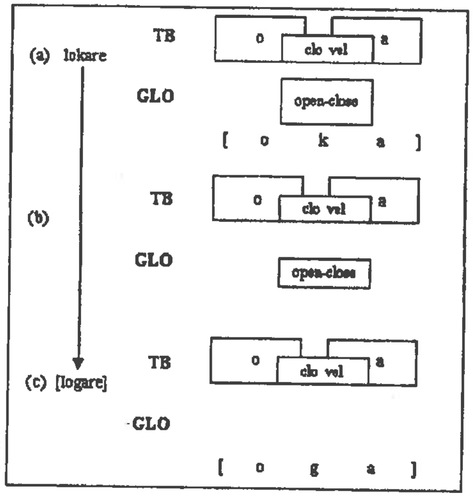

Figure 2
Reduction in magnitude of glottal opening-and-closing gesture for Latin /k/, yielding voiced velar stop /g/

In the initial step (a), the intervocalic voiceless /k/ is specified for two coordinated gestures occurring on separate articulatory tiers: a TB constriction gesture and an GLO gesture. Over time, the glottal gesture reduces in magnitude, as shown in step (b), until the necessary degree of vocal fold separation for devoicing is no longer reached. Listeners eventually reanalyze the lack of devoiced output as reflecting the absence of a GLO opening-and-closing gesture altogether. At this point, the listener sets up a representation in his own lexicon in which the GLO gesture is no longer present, as shown in step (c). The end result of this process is the voiced velar stop /g/, which specifies a single TB constriction gesture. Voicing of the bilabial and coronal voiceless stops involves the same reduction and subsequent erosion of the GLO gesture. Ultimately, the resulting voiced stops undergo spirantization, in which the remaining oral constriction gesture reduces in magnitude and shifts to a [critical] constriction degree value, as discussed above.

4.2 Temporal reduction of gestures: degemination

In order to provide a gestural account for the simplification of intervocalic geminates, we must first define the representation of geminate consonants in terms of articulatory gestures. As pointed out by Steriade (1990:384-5), the issue of segmental quantity distinctions is not discussed explicity in the early proposals of Browman and Goldstein. Autosegmental models proposed in the early 1980s account for quantity distinctions in terms of various types of mappings between autosegmental and timing tiers. These models explicitly reject the alternative of representing long segments as sequences of adjacent, identical elements. However, this alternative appears to be what Browman and Goldstein (1986:235) advocate in their discussion of distinct, overlapping gestures on the same tier.

More recently, Smith (1995:217-9) considers two possible gestural representations of geminates. In a one-gesture representation, the increased duration of the geminate as compared to a single consonant is modeled (1) by reducing the stiffness of the gesture, yielding slower articulator movement, and (2) by having the gesture remain active longer after reaching its target position. While a one-gesture geminate representation appears to correspond to articulatory data as observed in Japanese and Italian speakers, Smith hypothesizes that a two-gesture geminate might better match the representation of certain phonological contrasts and patterns across languages. However, the fact remains that most speakers exhibit significantly slower articulatory movement in forming a geminate closure. If geminates involve two distinct gestures, then at least the first one would have to have a lower stiffness than if it were alone. Smith concludes that a two-gesture model of geminates is a more costly approach because a one-gesture model only requires one change (in the parameter values for stiffness), as opposed to two changes (in parameter values and in the specification for an additional gesture).

If we take the one-gesture model as the representation for Latin geminates, then degemination may be explained in terms of a reduction in the temporal extent of the single gesture. Whereas spirantization and voicing involve a reduction in gestural magnitude (i.e., decreased articulatory movement in the vertical domain), degemination involves a reduction in the activation period for a given articulator in the horizontal (temporal) domain. The end result in both cases is recategorization of the gestural output, at which point the listener restructures his lexicon with parameter values different from those specified for the original gesture.

The gestural scores shown in Figure 3 illustrate the degemination process as it affected Latin /tt/ . As shown in step (a), the Latin geminate /tt/ is specified for a single TT gesture that controls the tongue tip for a longer extent of time than for a singleton consonant. Temporal reduction of this gesture over time, as shown in step (b), ultimately leads to acoustic outputs that listeners recategorize as the result of a gesture specified for a shorter activation period. The final step (c) demonstrates the recategorization of this reduced output in terms of gestural parameters appropriate for singleton consonants.

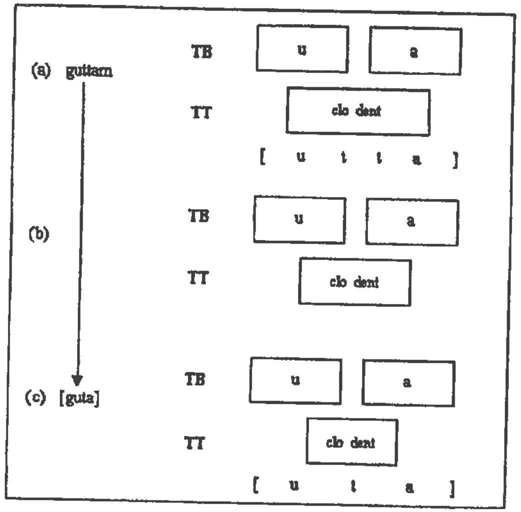

Figure 3
Reduction in temporal extent of gesture for Latin geminate /tt/, yielding single stop /t/

4.3 Gestural overlap and blending: development of voiced fricatives

The remaining stage of lenition to consider is that in which voiced fricatives underwent further modification as a function of phonetic context. As we have seen, the voiced bilabial fricative further weakened to [w] and was eventually deleted in the presence of the rounded back vowels [o] and [u]. Two crucial notions are needed to account for this change in gestural terms, namely (1) that vocalic and consonantal gestures overlap, and (2) that overlapping gestures that use the same tract variable are blended. The gestural model captures the fact that "in an utterance containing bilabial consonants and rounded vowels, during the bilabial consonant the lips will be affected by both the consonant and the vowel, given consonant-vowel overlap" (Browman 1994:339). Figure 4 illustrates the possible scenarios for overlap of vocalic and consonantal gestures controlling Lip Aperture (LA). The estimated gestural score for "Poe" shows the overlap of controlled lip gestures for the consonant and the vowel. This contrasts with "pa," with lip control only for the consonant; "toe" with lip control only for the vowel; and "ta," which has no lip control at all. In the case of simultaneous lip gestures, as in "Poe," lip opening will be a blend of the consonant and vowel target values. The gestural model predicts that in intervocalic contexts, as in [bobob], "the resultant lip opening during the intervocalic bilabial is larger (wider) in the context of a rounded vowel (when the small consonantal LA is blended with the larger vocalic LA) than in the context of an unrounded vowel (when the only control of the LA is the small consonantal LA)" (Browman 1994:340).

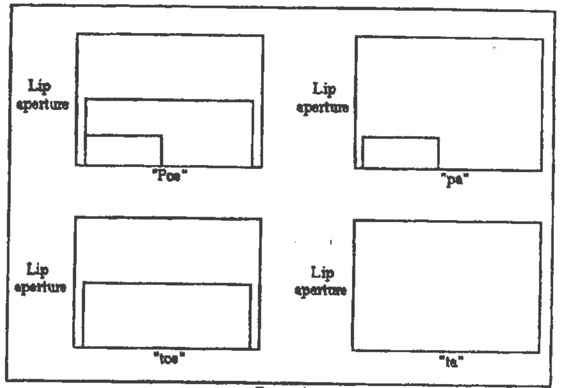

Figure 4
Partial schematic gestural scores for different labial aperture scenarios, with boxes indicating estimated extent of gestural control

The combined notions of consonant-vowel overlap and gestural blending offer an explanatory account for the role of adjacent rounded vowels in conditioning the deletion of the voiced bilabial fricative. Figure 5 shows the gestural scores representing the deletion process. Initially, the voiced bilabial fricative specifies a LIPS gesture that overlaps with the greater LIPS gesture of the rounded vowel, as shown in step (a). Blending of the two overlapping gestures results in a wider lip aperture during the constriction period of the bilabial fricative. It may be that this increase in lip aperture further promotes the magnitude reduction already taking place during the spirantization stage, eventually yielding an even smaller gesture for the fricative constriction, as shown in step (b). The acoustic output at this stage would be interpreted as the labiovelar [w], since the reduced bilabial constriction coincides with a velar constriction provided by the overlapping back vowel. Over time, speakers take the wider lip aperture as being controlled by the greater vocalic gesture, resulting in the eventual erosion of the smaller consonantal gesture. The ultimate result involves recategorization of the output as reflecting the lack of a consonantal LIPS gesture altogether, as shown in the final step (c).

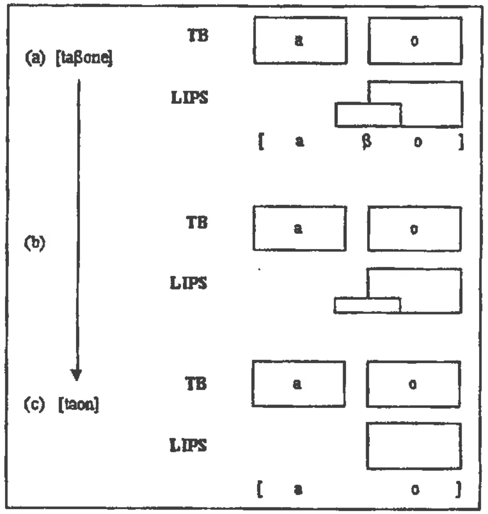

Figure 5
Overlapping LIPS gestures for [o] and [β], resulting in eventual deletion of gesture for [β]

The notions of overlap and blending also account for the deletion of the voiced velar fricative. The gestural scores in Figure 6 illustrate example scenarios for overlap in intervocalic contexts between rounded back vowels and voiced fricatives. In each case, there is both a LIPS and a TB gesture for the vowel. LIPS controls lip rounding, and TB specifies the constriction location and degree appropriate for back vowels. This explains why [o] and [u] condition the deletion of both the voiced bilabial and velar fricatives. Since both vowels contain gestures on two separate tiers, blending may affect overlapping consonantal gestures on either tier, ultimately leading to the complete erosion of the smaller consonantal gesture[2].

We have seen that gestural overlap and blending can explain the deletion of voiced bilabial and velar fricatives. Two phenomena remain to be accounted for at this point, namely (1) the development of voiced bilabial and velar fricatives in contact with the vowels [e], [i] and [a], and (2) the categorical deletion of [ð] regardless of vocalic context. First, the failure of [β] to undergo deletion in the absence of a rounded vowel follows from the lack of gestural blending on the LIPS tier. Since unrounded vowels contain no LIPS gesture (cf. "pa" in Figure 4), gestural overlap necessarily involves different articulatory tiers. Lip aperture in this case is unaffected because blending operates only on gestures that occupy the same tier. As a result, the consonantal gesture remains and may undergo subsequent modification,

such as strengthening to labiodental [v] (in the third century for [β] < Latin /b/, in the fifth century for [β] < Latin /p/)[3].

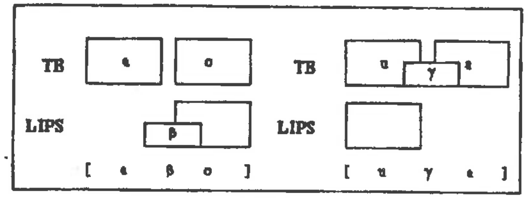

Figure 6
Gestural overlap between rounded back vowel and intervocalic fricatives [β] and [γ]

While a vocalic LIPS gesture is present only for rounded vowels, all vowels necessarily control a TB gesture. Since a vocalic TB gesture is present for any vowel, an overlapping consonantal TB gesture for [γ] will always undergo blending. Overlap involving two TB gestures will have an effect on the values of the smaller consonantal TB gesture in both the vertical and horizontal domains, depending on the constriction values specified for each gesture. Given that [γ] involves a [vel] constriction location and a [crit] constriction degree, gestural overlap with either [o] or [u] will affect only the value for constriction degree, yielding a wider velar aperture. Since the overlapping gestures are both [vel], there is no change in constriction location. On the other hand, overlap of [γ] with [e], [i] or [a] will affect constriction location because the [pal] value of the vocalic gesture blends with the [vel] value of [γ]. The end result over time is the eventual recategorization of the original TB gesture for [γ] with new values for constriction degree and location in the case of front vowels, or the complete erosion of the gesture in the case of back vowels (both of which occurred in the sixth and seventh centuries).

The final case to consider is that of the voiced dental fricative. The categorical deletion of [ð] regardless of vocalic context did not occur until Early Old French (ca. late ninth century), where as the deletion of the voiced bilabial and velar fricatives took place much earlier. We have seen that in the case of [β] and [γ], the crucial determining factor for deletion was overlap (and subsequent blending) with a vocalic gesture occupying the same articulatory tier. In the case of [ð], which contains a TT gesture controlling the tongue tip, same-tier overlap cannot occur with a vowel because only TB and LIPS are possible vocalic gestures. With respect to consonantal TB and TT gestures overlapping with vocalic gestures, only velar consonants involve same-tier overlap and blending (as discussed above). "[T]his blending is usually described as fronting of the velar consonant in the context of the following front vowels. In contrast, alveolar stops can be produced concurrently with a vowel without changing the place of articulation of the stop" (Browman and Goldstein 1990:363). The categorical failure of consonantal TT gestures to blend with any vocalic gesture on the same tier means that the only possibility for eventual deletion of [ð] is through a continued reduction of the gestural magnitude originally begun during the spirantization stage. Thus, [β] and [γ] were deleted earlier due to added effect of overlap and blending with same-tier vocalic gestures. [ð] was not deleted until much later because there was never an overlapping vocalic gesture to "push it along" towards the path of eventual complete erosion[4].

Figure 7 summarizes the development of voiced fricatives as a function of overlapping vocalic gestures.

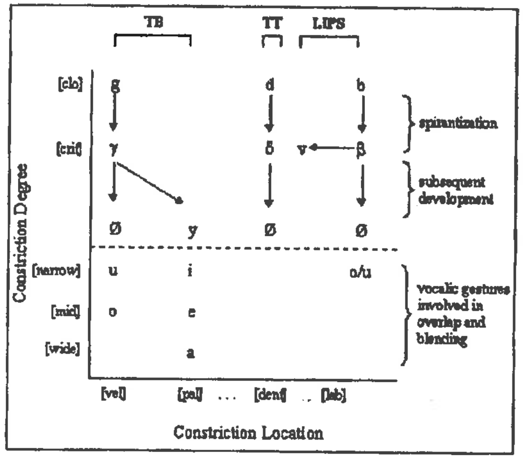

Figure 7
Summary of gestural overlap and blending effects depending on constriction degree and location values for overlapping consonantal and vocalic gestures

The vertical axis gives ordered constriction degree values, and the horizontal axis gives only the relevant constriction location values. The arrows indicate changes in the original values for consonantal gestures as a result of magnitude reduction during spirantization and blending during subsequent development. The shaded boxes highlight the place effects exhibited by different vocalic gestures that overlap and blend with the consonantal gestures. These shaded boxes show, as argued above, that overlap and blending involved (1) a consonantal TB gesture and *any* vocalic TB gesture, (2) a bilabial LIPS gesture and *only* vocalic gestures specified for lip rounding, and (3) *no* consonantal TT gesture.

5. Conclusion

Previous attempts to account for consonantal weakening in Late Latin and Gallo-Roman have called upon formalisms involving discrete, abstract features. Whether rule- or constraint-based, such featural approaches describe historical developments in arbitrary ways, without actually explaining the underlying motivation of change. Articulatory Phonology, on the other hand, provides a distinct mechanism for capturing sound change. An analysis based on gestures serves to elucidate the manner in which articulatory-based casual speech phenomena motivate particular developments in the consonantal inventory of a language. As I have attempted to show in the case of French, the notions of gestural reduction, overlap and same-tier blending make it possible to give a unified account of the various stages involved in consonantal weakening processes.

Notes

I would like to thank Barbara Bullock for useful comments and discussion with earlier drafts of this paper. All errors remain my own.

[1] Much recent work on the phonology-phonetics interface calls for a distinction between categorical and gradient operations. Keating (1990:452), for example, argues that phonological rules are expected to affect most of a segment in a significant way, whereas phonetic rules can have more gradient effects. According to this view, phonetic implementation converts the discrete featural output of the phonology into gradient values that are realized over time. Timing is therefore extrinsic to the phonological representation. The framework utilized in this paper, however, is the gestural model of Browman and Goldstein (1986, 1989, 1990, 1992), which presents a slightly different view: phonological representation consists of categorically-perceived articulatory gestures that possess intrinsic timing specifications. Gradient modifications of gestures during the act of speaking are often the cause of sound change, as I will discuss later. The important point here is that accounts involving featural modifications alone have little to say about the gradient, articulatory basis underlying diachronic change.

[2] One might argue that since a TB gesture is arguably present in all vowels, its presence in back vowels [o] and [u] cannot be the sole motivation for eventual deletion of [γ] in this context alone. I maintain that deletion of velar fricatives results only when there is overlap between consonantal and vocalic TB gestures that contain the same value for constriction location. (See the subsequent discussion of [γ] and TB gestures.)

[3] It should be noted here that the absence of overlapping LIPS gestures only explains why [β] failed to delete when a rounded vowel was not present. That is, there appears to be no inherent articulatory motivation for the change from [β] to [v] in the presence of a front vowel. Gestural blending of constriction location values presumably would not have occurred, given the absence of a LIPS gesture in non-rounded front vowels. This suggests the influence of some extralinguistic factor operating regardless of phonetic context.

[4] The lack of gestural overlap and consequent blending explains the relatively late deletion of [δ] as the result of prolonged gestural magnitude reduction alone. However, the question remains as to why [δ] deleted at all (cf. the retention of [δ] in Modern Spanish). One possibility underlying this cross-linguistic difference is the strength of syllable stress characterizing the speech of Germanic populations at the time. Strong syllable stress might have induced more extreme elision of unstressed syllables and weakened consonants in French as compared to Spanish.

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