Modeling the emergence of a typological anomaly: Vowel nasalization in French

Author(s): Kristen Kennedy Terry and Eric Russell Webb

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KRISTEN KENNEDY TERRY and ERIC RUSSELL WEBB
University of California, Davis

1 Introduction

The present work has as its primary goal the advancement of a theory of sound change incorporating token frequency and language use in a gradual learning algorithm (adapted from Boersma and Hayes 2001). To this end, we reexamine changes occurring in tautosyllabic vowel-nasal consonant sequences in the history of French, providing a sociolinguistic understanding of the 'salience' of nasalized vowels and demonstrating the emergence of typological anomalies through the expression of speaker preferences in language use.

2 Nasalization in the History of French

The evolution of nasal vowel phonemes in French constitutes a well-known and well-studied example of regressive assimilation and consonant elision. Summarily, this is the process by which an oral vowel acquires the feature [+nasal] from a following nasal coda consonant, and subsequently undergoes elision (Sampson 1999), which we abbreviate as VN > ṼN > Ṽ (where V indicates an oral vowel, Ṽ a nasal vowel, and N a nasal consonant).

To give a brief historical overview, textual evidence indicates that during the Old French period (ca. 900-1300) oral vowels followed by nasal consonants were regressively nasalized and nasal consonants were realized (VN > ṼN). The Middle French period (ca. 1300-1600) presents a period of variability in the quality of the vowel and the realization of the nasal consonant (VN > Ṽ(N)). In Standard Modern French (SMF, ca. 1600-present) coda nasal consonants are no longer realized in positions diachronically corresponding to syllabic codas: ṼN > Ṽ. For the purposes of this paper, SMF refers to varieties such as those used by the national and international media and that are typically the object of second language acquisition.

Four unconditioned nasalized vowels are attested in SMF: [ɛ̃, ɑ̃, ɔ̃, œ̃] (at present, the contrast between [ɛ̃] and [œ̃] is neutralized for most speakers). In Table (1) below, we provide some sample data from the relevant time periods.

(1) Sample data from the history of French (Sampson 1999)

		ca. 13th C	ca. 14th-16th C	ca. 17th - 18th C
(a)	*vend* 'sell-3SG'	[vẽnt vɑ̃nt]	[vɑ̃(n)t]	[vɑ̃]
(b)	*vin* 'wine'	[vĩn vẽ(n)]	[vĩ(n) vẽ(n) vɛ̃(n)]	[vɛ̃]
(c)	*maison* 'house'	[mæj.zõn mɛ.zũ(n)]	[mɛ.zõ(n) mɛ.zũ(n)]	[mɛ.zõ mɛ.zɔ̃]
(d)	*humble* 'humble'	[ỹm.blə]	[ỹ(m).blə œ̃(m).blə]	[œ̃bl]

Examples in Table (1) present the beginning and end points of the attested sound changes, as well as synchronic variability recorded in historical texts. Looking to (b) as an example, it is noted that the high nasal vowel begins lowering as early as the 13th century and the nasal consonant is generally realized. In the middle French period, the high nasal vowel continues to lower and the realization of the nasal consonant becomes variable. Finally, in the 17th century, a mid-nasal vowel emerges as the norm and the nasal consonant is no longer realized by the majority of speakers. Importantly, this is an atypical outcome. Ruhlen (1974) shows that languages with a full spectrum of nasal vowels (high-mid-low) are cross-linguistically prevalent (37 of 55 surveyed), followed by languages with high and low nasal vowels only (8 of 55 surveyed). Languages with only mid and low nasal vowels, as in French, are rare (3 of 55 surveyed).

3 Sound Change as a Speaker-Listener Conspiracy

This section briefly reviews a novel approach to explain the facts of nasalization, i.e. the instantiation of change, in an Optimality Theoretic (OT; Prince and Smolensky 1993) framework. Given space limitations, this discussion is necessarily parsimonious; readers desiring full coverage of these issues are referred to Russell Webb and Kennedy Terry (MS/*in press*).

A number of analyses incorporating phonetic phenomena explain the existence of synchronic variation. The most notable of these incorporate notions of articulatory complexity into constraints targeting relative effort minimization, see e.g. Flemming (2002), Boersma (1998), and Kirchner (1998). In this analysis, we distinguish articulation from perception in a formal grammatical stratum,

capturing the instantiation of productive variation and setting the stage for perceptual influences. For the case at hand, we hypothesize a constraint promoting the anticipatory opening of the velum in V-C sequences, e.g. *VN]σ (the velum should be lowered during the production of a vowel prior to a nasal segment, i.e. no oral vowels preceding tautosyllabic nasals in the output), and a constraint promoting non-tense nasal vowels in the output, which we abbreviate *TENSEV_{nas} (Ahn 2001; Bell-Berti and Krakow 1990; Cohn 1990; Delvaux 1999; Delvaux et al. 2002; Homer 1998; see also Houlihan and Iverson 1979).

The interaction of productive constraints is depicted in Table (2). For a given input /en/ and with the constraints thus ranked, the grammar predicts that [ɛ̃n] will be selected, i.e. that speakers will produce a nasal vowel in certain contexts, even for inputs containing non-nasal vowels. Importantly, the production grammar is blind to the effects of this output on subsequent perception.

(2) Sample Productive evaluation of input /en/

en	*VN]σ	MAX(C)	*TENSEV_{nas}	IDENTV
en	*!		*	
ɛn	*!			*
ẽn			*!	*
☞ ɛ̃n				*
ẽ		*!	*	*
ɛ̃		*!		*

Clearly, production cannot be the only source of language change or phonological patterns, as speakers of many languages produce nasal vowels in similar phonotactic environments without such variant production leading to the emergence of contrastive nasalization. To explain how a variant productive output may be selected as underlying by listeners (i.e. as a corresponding perceptual output), we rely on approaches grounded in the reception and processing of speech as the source of change (see e.g. Gess 2003; Jun 1995a; 1995b; Russell Webb and Bradley 2009). This is especially important as it concerns the effect of positional prominence (Beckman 1998; Steriade 2001; Wright 2001, 2004).

Previous attempts to explain the unusual outcome of nasalization in French have relied on distinction (Padgett 1997; see also Flemming 2002; Lindblom 1986) or on constraints targeted to specific segments, notably high vowels (Ahn 2001). We argue that constraints should be motivated by theory-external facts, preferably those related to the production, reception, and psychological

processing of speech. As noted above, the case for a constraint militating against high nasal vowels is not well-supported. If languages with only mid and low nasal vowels represent the exception rather than the rule (viz. Ruhlen 1974), then it is difficult to see how or why a high nasal vowel should be more marked in a particular language than a non-high nasal vowel in the same language based on articulatory considerations alone (see e.g. Delvaux et al. 2002).

Nasal vowels present unique and complex acoustic profiles, among these relatively more or less distinct spectral peaks and valleys corresponding to vocoid frequencies, nasal formants, and antiformants (see Beddor 1993; Chen 1997; Maeda 1993; Wright 1986). The tendency to conflate closely related spectral peaks among listeners, also known as the Center of Gravity effect (COG), is known to operate on vowel formants that are separated by less than 3.5 Bark (Beddor 1993:180-182; Beddor and Hawkins 1990; Padgett 1997:73). We propose that unique perceptual factors come into play in the perception of nasalized vowels and that these factors can be formalized as constraints operating in a unique evaluative matrix.

Knowledge concerning parsing of auditory stimuli is expressed as PARSE(F), promoting the faithful parsing of input spectral prominences in the output. For the discussion here, we assign a violation for every unfaithful mapping of auditory properties to abstract feature value, assuming the values [±high] and [±low], where F1 of 300-400Hz maps to [+high], F1 above 700Hz to [+low], and F1 of 400-600Hz to [-high, -low]. Knowledge pertaining to the categorization of indeterminate auditory information is embodied in *CATEGF1(FN), "do not categorize a spectral peak F1 as corresponding to an output feature if F1 is proximate to FN." Assuming that F1-FN proximity is defined as within 3.5 Bark, or approximately 200Hz, *CATEGF1(FN) penalizes the parsing of F1 for all but low vowels. A third constraint captures the perceptual COG which provides that for all inputs with overlapping or closely adjacent spectral peaks, the output should parse the average of these. Thus, in the case of an input F1 of 300Hz accompanied by FN (400-500Hz), the output should be interpreted as corresponding to the specification of a mid vowel. Output candidates which do not present a value corresponding to the weighted average of F1 and FN violate COG.

Examples of perceptual evaluation are provided in Tables (3) and (4) for which presumed F1 and F2 are indicated in parentheses. The perceptual grammar formalized in Tables (3) and (4) succeeds in capturing a number of important generalizations, namely the concurrent effects of nasalization on the parsing and categorization of lower formant frequencies.

(3) Perceptual evaluation of input [ĩ](F1 = 300, F2 = 2500Hz)

[ĩN]	COG	*CATEG F1(FN)	PARSE(F)
ĩN	*!	*	
☞ ɛ̃N		*	*
ɑ̃N	*!		*
ỹN		*	**!

(4) Perceptual evaluation of input [ɛ̃](F1 = 500, F2 = 1300Hz)

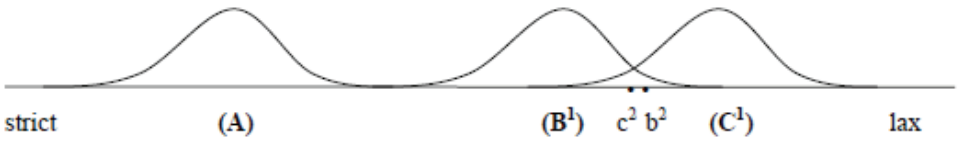
[ɛ̃N]	COG	*CATEG F1(FN)	PARSE(F)
ɛ̃N		*!	
ĩN	*!	*	*
☞ ɑ̃N			*
œ̃N			**!

4 The Gradual Learning Algorithm (GLA)

4.1 Variable Constraint Ranking and Synchronic Variation

We demonstrate above how misperception of vowel nasalization might lead to novel output. Here, we propose to model the emergence of such novel output through an adaption of the Gradual Learning Algorithm (GLA) proposed by Boersma and Hayes (2001). In the GLA, shown in Figure (5) below, constraints are conceived as ranges of values represented by probability distributions (e.g. Gaussian) from which a value (the *selection point*) is chosen during the speech event (the *evaluation time*). The selection point most often associated with the constraint (based on probability of occurrence) is known as the *ranking value* and occupies the center of the range for the constraint. While the ranking value represents the most common realization for the phonological variable governed by the constraint, any selection point within the normal distribution curve is possible.

(5) Variable Constraint Ranking According to the GLA

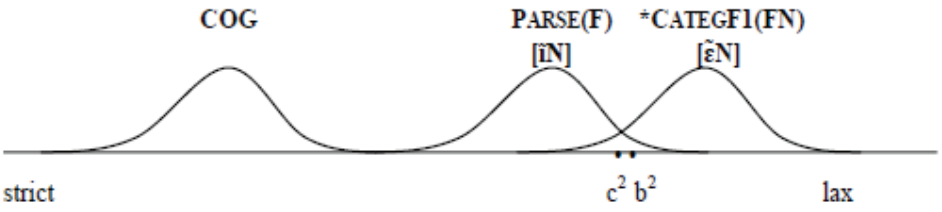


Categorical result:	A >> B, C	(any *selection point* within A)
Common result:	B >> C	(*ranking values* B^1 and C^1 chosen)
Rare result:	C >> B	(*selection points* b^2 and c^2 chosen)

Constraint ranking may be categorical if constraints lie very far apart on the linear scale (constraint A). On the other hand, constraints lying close together on the linear scale may partially overlap, such as B and C. In most cases, constraint B outranks constraint C, but the overlap area allows for synchronic variation in the grammar and for an atypical constraint ranking to occur every so often (e.g. C >> B), thereby planting the seeds of sound change.

The GLA models synchronic variation in the linguistic environment by incorporating the frequency of surface values occurring in free variation into a constraint ranking which is not categorical, but based on the probability of occurrence of surface forms. By recording every occurrence of a particular value (e.g. each selection point chosen at each evaluation time) and subsequently making minor adjustments to the ranking values of constraints, "the algorithm will produce a grammar that mimics the relative frequency of free variants (Boersma and Hayes 2001:53)." For the case at hand, we propose using the GLA and the same constraints as those presented in OT tableaux (3) and (4) to postulate a variable constraint ranking for an adult French speaker in the 13th century (Figure (6)).

(6) Initial Constraint Ranking at (t_0) – 13th Century Speaker



Categorical result: **COG >> PARSE(F) , *CATEGF1(FN)**
(any selection point within COG)

Common result: **PARSE(F) >> *CATEGF1(FN)**
(when ranking values [ĩN] and [ɛ̃N] chosen)

Rare result: ***CATEGF1(FN) >> PARSE(F)**
(any selection points within overlap area - represented by c^2 and b^2)

Given a high nasal vowel input, the constraint ranking in Figure (6) predicts the realization of a high nasal vowel output in the majority of cases. However, the overlap area between these constraints allows for the reverse ranking to occasionally hold: for a mid vowel output to be occasionally realized.

4.2 Using the GLA to Model Acquisition and Transmission

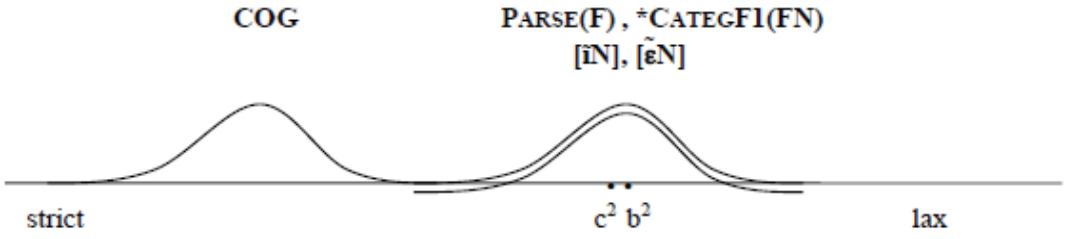
The GLA models the language acquisition process by means of a series of adjustments to constraint ranking values based on the probability of occurrence of adult surface forms until the target grammar is generated. Over the long term, when exposed to a full range of representative surface forms, the GLA will adjust constraint ranking values and "will ultimately achieve the right grammar" (Boersma and Hayes 2001:52).

Multiple iterations of the GLA may be conceived of as the establishment of a constraint ranking by each new generation of speakers within a speech community. By adjusting constraint ranking values to mimic the relative frequency of free variants in the environment, the GLA 'records' the linguistic preferences of each generation of speakers and transmits these to the next generation during the language acquisition process.

For example, if the frequency of occurrence of a particular surface form increases from one generation to the next (e.g. from t_0 to t_1) the probabilistic constraint ranking established by the GLA at t_1 will be slightly different from that established at t_0. That is to say, the constraint ranking of each new generation of speakers will be set to match the frequencies of surface forms extrapolated from their linguistic experience. The output data at t_1 then becomes the input data for the next generation at t_2 and so on.

Using the same constraints as Figure (6), we propose Figure (7) to depict the changing linguistic preferences (as they relate to vowel nasalization) for French speakers between the 13th and 15th centuries. In Figure (7), we see that the probabilities of occurrence or ranking values, for these constraints have shifted over time: for a high nasal vowel input, a mid nasal vowel output has become as frequent as a high nasal vowel output. This change is depicted in the GLA by fully overlapping constraints as shown in Figure (7) below.

(7) Partial Constraint Reranking at t_1: 15th Century Speaker

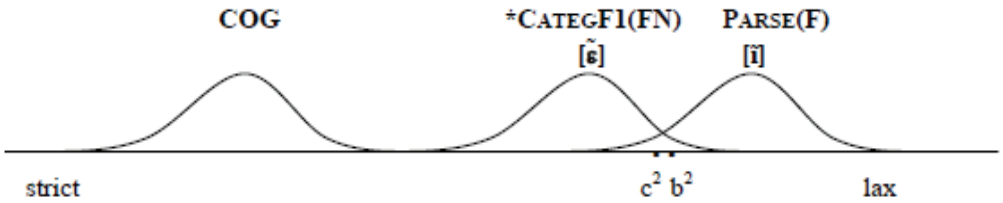


Categorical result: COG >> PARSE(F) , *CATEGF1(FN)
(any selection point within COG)

Common result t_1: PARSE(F) = *CATEGF1(FN)
(ranking values [ĩN] and [ɛ̃N] chosen at equal frequencies)

Finally, Figure (8) represents a further shift in the linguistic preference of French speakers between the 15th and 18th centuries and depicts the near-end state of the sound change in question: the elimination of high nasal vowels in favor of mid-nasal vowels. We emphasize that this sound change occurs due to changing frequencies in the variants selected during the speech event – frequencies which represent the shifting linguistic preferences of each time period. Figure (8) also shows the elision of the nasal consonant which had become the linguistic norm for the majority of speakers at this time; however, we do not show the constraints or variable rankings related to this change.

(8) Full Constraint Reranking at t_2: 18th Century Speaker



Categorical result: COG >> *CATEGF1(FN), PARSE(F)
(any selection point within COG)

Common result: *CATEGF1(FN) >> PARSE(F)
(when ranking values [ɛ̃] and [ĩ] chosen)

Rare result: PARSE(F) >> *CATEGF1(FN)
(any selection points within overlap area - represented by c^2 and b^2)

5 Evidence from Sociolinguistics

In the above sections, we show how changes in token frequency and language use may be incorporated into successive grammars; we also show how the process of vowel nasalization in the history of French, including the instantiation and transmission of change, may be modeled using multiple iterations of the GLA. To complement the grammatical analysis, we now turn to evidence from sociolinguistics to provide support for the sound changes modeled in previous sections.

5.1 Social and Stylistic Variation in the History of French

Labov (1966) was one of the first to demonstrate the existence and systematic nature of the social stratification of language variables within a speech community. While social groups differ in the extent to which they realize a particular linguistic variable, all follow a similar pattern of style shifting. Members of all social groups are said to exhibit consensus as to which linguistic variables represent prestige or vernacular forms. In the most casual style of speech, vernacular forms are realized more frequently by the lower social groups and prestige forms by higher social groups. Importantly, however, a range of forms exist in synchronic and stylistic variation at any given time within a language (defined as both as a communal performance and an individual competence).

The task of the historical linguist, then, may be conceived as the inverse of that of the sociolinguist who has identified the linguistic variables of change in progress, but does not yet know their effect on the language system. The historical

linguist, having a specific endpoint in mind, has already identified the effect on the system, but must reconstruct the variables (sociolinguistic and other) which came into play during the period of change.

The role of social factors in the establishment of linguistic norms is apparent in the textual evidence available from the late Middle to the early Modern French periods (ca. 16th - 17th centuries). Much of the evidence of the linguistic variables representing 'vernacular French' of the 17th century has been reconstructed from the metalinguistic commentary in the works of the *remarqueurs* (authors expressly concerned with the subject of grammatical precision and style in French) in addition to other forms of prescriptive grammars (dictionaries, systematic grammars). According to Ayers-Bennett (2004:4), while French grammarians writing in the 16th century acknowledged, but remained tolerant of linguistic variation, the explicit division of linguistic forms into categories such as *populaire, familier, vulgaire,* and *bas* in the 17th century reflects the stigmatization of non-standard forms and the heightened sensitivity to their usage moving from the Middle French to the Modern French periods.

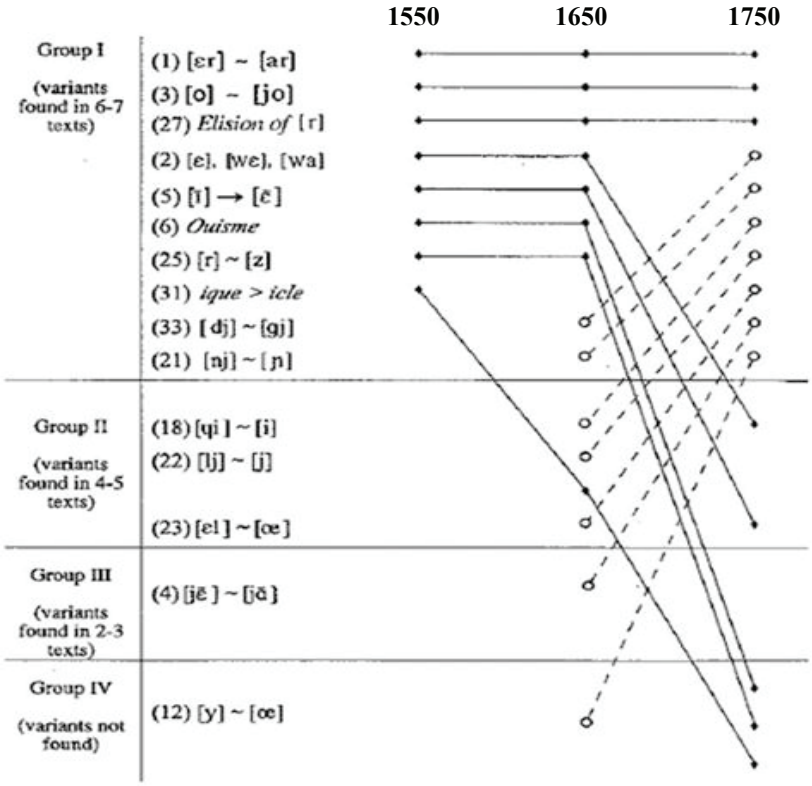
5.2 Salience, Reallocation, Consensus

The concept of salience as developed by Trudgill (1986) and discussed by Lodge (2004) is helpful in identifying the sociolinguistic variables at the origin of high nasal vowel loss in Modern French. Trudgill defines salience, or the level of awareness associated with particular variants, in terms of various factors such as overt stigmatization, linguistic change, phonetic distance, and phonological contrast (1986:11). He proposes that the level of salience of a particular linguistic feature is especially important in contact situations because speakers are more likely to modify the features of which they are most aware.

Labov further explains that when a highly salient feature becomes a symbol of an "overt opposition of social values" and rises above the level of social consciousness, it will likely become a marker or a stereotype (1994:300-1). Once this occurs, one of the two forms may win out and lead to the elimination of the other form over time. At the same time, a feature may remain below the level of social consciousness and become an unconscious socio-stylistic indicator. Following Lodge (2004), lower levels of salience will lead to a process of reallocation from which a new social consensus will evolve.

According to Lodge, one possible measure of a variable's salience is "its capacity to engender metalinguistic comment." In order to measure the salience of a number of linguistic variables in the history of French, Lodge (2004:188) proposes a graphical representation of the most salient features in Parisian French from the 16th to the 18th centuries which is shown in Figure (9).

(9) Changes in Salience 1550-1750 (Lodge 2004:188)



Lodge identifies a number of salient phonological variables (based upon non-standard spelling conventions), calculates the incidence of each variable across a corpus of texts, and plots this graphically in order to create a salience trajectory for each variable. One of these is of critical interest to the current analysis: the lowering of [ĩ] to [ɛ̃] (#5 in Figure (9)) in vernacular Parisian French.

In Figure (9), we see that the alternation between the high and mid nasal vowels remains highly salient until the mid-17th century and then declines steadily through the middle of the 18th century. Following Labov and Lodge, we may deduce that when this alternation lost its social stigmatization and became a socio-stylistic indicator operating below the level of consciousness for 18th century speakers, the process of reallocation towards a new social consensus, the preference of a mid vowel over a high vowel, was initiated. The establishment of this new consensus is what we propose to have modeled, using the GLA, in figures (6) – (8).

6 Discussion and Conclusions

The preceding analysis asserts that an explanation of change must make reference to both internal and external factors, and that formal models should motivate their conceptual units with theory external evidence. The basic units of this analysis echo theories of transmissibility, such as Evolutionary Phonology (Blevins 2004; cf. de Lacy 2006), situating the source of initial variation among speakers and ascribing a critical role to listeners, as well as incorporating the intergenerational involvement of both. The proposal integrates changes to linguistic norms motivated by social factors, namely sociolinguistic preference expressed through token frequency, thereby capturing the influence of these on the grammar. Additionally, and no less importantly, the proposal ascribes a central role to synchronic variation in the instantiation of change and an equally important role to sociolinguistic preference in the transmission of such change through the intergenerational transfer of grammatical knowledge.

Any reader familiar with recent literature will note that many challenges to our approach may be leveled. Those approaching the question from a sociolinguistic perspective may question the need for a grammatical account in the first place, whereas those OT practitioners may be ill at ease with the inclusion of categorical constraints to capture perceptual knowledge and argue against the application of the GLA to diachrony. Still others, regardless of disciplinary background, might argue that the present analysis is highly idealized, involving abstracted linguistic competence encapsulated in grammars constructed against a relatively rigid blueprint. Rather than ignore these issues, we prefer to acknowledge them and the challenge they represent. By advocating the inclusion of knowledge based on social preference and frequency, the present proposal expands the scope of forces which might inform the grammar and reinvigorates the debate as to how formal models can best account for language change.

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Kristen Kennedy Terry
Eric Russell Webb
Department of French and Italian
University of California Davis
One Shields Avenue
Davis, CA 95616

kmtkennedy@ucdavis.edu
erussell@ucdavis.edu