Stressed vowel assimilation to palatal consonants in early Romance

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This study is an investigation of the phonetic causes of stressed mid and low vowel raising and diphthongization before single palatal consonants and [jC] sequences in the Early Romance languages, as for example [a] raising in Spanish *leche* derived from Latin ['lakte] 'milk'. The initial hypothesis put to test is that the chances that vowel assimilation applies should increase with the prominence of the anticipatory consonant-to-vowel effects in tongue dorsum raising and fronting and in the second formant(F2) frequency. In accordance with this prediction, vowel assimilatory processes were found to operate most often before [j] + dentoalveolar sequences and single palatals involving maximal dorsal contact in the case of [a] (and to some extent for [ɛ ɔ] as well), and before single palatals rather than before consonant sequences with [j] in the case of [o]. Moreover, assimilation was more prone to affect [ɛ a ɔ o] than the mid high front vowel [e]. The phonetic account of vowel raising and diphthongization reported in the present study complements other explanatory proposals based on chronological and etymological factors. It also supports the notion that the categorization of segmental coarticulatory effects as assimilatory increase with coarticulation size, and that the diachronic vowel changes in question occurred at a time when palatal consonants were in the process of gaining stability.

Keywords: vowel raising, vowel diphthongization, Romance languages, dorsopalatal contact, second formant frequency

1. Introduction

An open area of linguistic research is the investigation of the articulatory and acoustic causes of sound change. A promising strategy in this respect involves paying attention to phonetic detail in order to come up with convincing explanations about the phonetic factors which contribute to sound change inception. Within this research framework, the present study deals with those articulatory

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and acoustic factors which have contributed to the assimilation of stressed [e ɛ a ɔ o] to a following palatal consonant in Early Romance varieties spoken from before the first written documents until about the 13th century.[1] An illustrative example of the assimilatory action in question is the raising of [a] to a mid front vowel before [j] followed by [t] in words derived from Latin ['fakto] FACTU 'to do, past part.' and ['lakte] LACTE 'milk', where [j], whether still present or not, may be traced back to a lenited realization of the syllable-final velar stop or has originated as an on-glide from the blended realization [c]: Spanish *hecho*, *leche*, Catalan *fet*, *llet*, Portuguese *feito*, *leite* ([e]), French *fait*, *lait* ([ɛ]). According to the second proposal, the two stops of the cluster [kt] blended into the alveolopalatal oral stop [c] which could then yield [jt], i.e., [c] > [jc] > [jt]. See later in this section for the meaning of the term "articulatory blending".

In most Romance languages including the ones reviewed here, the vowels subject to change were generated from Latin as follows: mid high [e] and [o] through merging of Latin [eː] (Ē) and [ɪ] (Ĭ), and [oː] (Ō) and [ʊ] (Ŭ), respectively; mid low [ɛ] and [ɔ] from Latin [e] (Ĕ) and [o] (Ŏ); low [a] from Latin [a(ː)] (Ā, Ă). Regressive assimilation of [e ɛ a ɔ o] was triggered by the immediately following single palatals [ʎ ɲ c ɟ j ʃ] and also by consonant sequences with [j] such as [jt jɾ js jz] and also by [bj] which may refer to other sequences with a labial consonant such as [mj vj jb] throughout the paper. Stressed vowel raising triggered by [j] in other consonant sequences will not be subject to investigation (Sp. *vidrio* VĬTREU, *propio* PRŎPRIU). Moreover, the study deals with contextual single consonants and consonant sequences following immediately the target vowel, which is why the descendants for NERVIU and FORTIA are excluded from analysis (see Section 2.6.1.2).

The vowel shifts which will be subject to investigation in the present study include essentially raising processes: mid high vowels shifted to high vowels ([e] > [i]; [o] > [u]), low [a] to a mid front vowel, and mid low vowels to mid high vowels ([ɛ] > [e]; [ɔ] > [o]) or else to high vowels through an intermediate rising diphthong ([ɛ] > [jɛ] > [je] > [i]; [ɔ] > [wɔ] > [wo] > [o]) (Section 2.3). Sound change data will be reported for Spanish (Sp.), Catalan (Cat.), Occitan (Occ.), French (Fr.), and Portuguese (Port.) and, to a lesser extent, for Italian and Romansh, which provide less clear cut evidence for the implementation of the vowel raising processes of interest. The data presented in this study belong generally to the most representative dialect of the languages into consideration unless other dialects are mentioned explicitly; thus, the French data are mostly from Central Gallo-Romance and the Spanish data from Castilian Spanish.

1. Due to space reasons, the manuscript does not deal with unstressed vowels, which underwent similar developments as stressed ones.

In contrast with more traditional descriptive accounts, the present study does not treat palatal consonants as a whole but focuses on the role that their individual articulatory and acoustic characteristics play on vowel assimilatory phenomena. Thus, for example, to the extent that a more anterior closure and less dorsopalatal contact for [ʎ] than for [ɲ c ɟ j] accounts for the presence of a lower second formant (F2) frequency in the acoustic spectrum of preceding [a], the chances that the low vowel may be heard as mid front ought to be also less in the former consonantal context than in the four latter ones. I believe that this methodological approach should provide more realistic explanations for changes in stressed mid and low vowels triggered by palatal consonants than those proposed earlier in the literature (see Section 1.2).

1.1 Theoretical framework

The general hypothesis put to test in the present study is that vowel raising assimilation to a following palatal consonant is determined by the magnitude of the consonant-to-vowel coarticulatory effects and their perceptual salience. In specific conditions, an enhancement of the partial overlap between the lingual gestures for the vowel and the consonant may yield a categorical change in vowel quality provided that the acoustic output is sufficiently similar to another existing (higher) phoneme in the language (regarding the role of articulatory enhancement in sound change, see Garrett & Johnson 2013). This view is consistent with available evidence for the gradualness of regular sound change in the case of vowel sounds (Labov 1994). Other sound changes may be interpreted in a similar fashion. Thus, for example, when becoming very frequent or systematic, a considerable degree of gestural overlap between the nasal and the following oral stop in the cluster /np/ (e.g., Eng. *seven peas*) may cause the alveolar gesture for /n/ to be heard as /m/ even when the nasal consonant is not articulated with a complete bilabial closure and involves some tongue tip raising.

At the perceptual level, Ohala (1981, 1990, 1993) attributes assimilatory processes of this sort to hypocorrection, i.e to the failure on the part of the listener to compensate for the spectral changes triggered by context. Thus, for example, listeners may believe that a raised realization of a low vowel before a palatal consonant is a realization of the phoneme /ɛ/ rather than a contextually conditioned realization of the low vowel phoneme. Consequently they may select a phonological form which differs from the phonological form in the speaker's grammar through a mechanism which has been labeled "Choice" in Evolutionary Phonology (Blevins 2004). This perception-based account of assimilatory processes has been shown to operate in several cases. Thus, for example, a fronted high back rounded vowel coarticulated with a dentoalveolar or palatal consonant may be categorized as a

front vowel (Harrington, Kleber, & Reubold 2008, Kleber, Harrington, & Reubold 2011). Likewise, it has been suggested that phonemic vowel nasalization and vowel harmony may originate from the failure to compensate for spectral changes induced by anticipatory velar lowering in a vowel + nasal stop consonant sequence and by vowel-to-vowel coarticulatory effects, respectively (Beddor, Harnsberger, & Lindemann 2002, Beddor, Brasher, & Narayan 2007, Beddor 2009). Moreover, crucially for the point being made here, these and other studies reveal that the subjects' failure to compensate for a specific spectral change is determined by the degree of segment-to-segment coarticulation: the larger the coarticulatory effect, the higher the chances that sound change may take place (Grosvald & Corina 2012). The degree of coarticulation in a given segmental sequence also varies from speaker to speaker, and listeners can be more or less innovative to coarticulatory variations that occur in the acoustic signal (Stevens & Harrington 2014).

The assimilatory process under analysis in the present investigation took place during a historical period when a new series of palatal consonants which did not exist in Latin gave rise to an entire place of articulation series encompassing different manners of articulation (see Section 2.2). It may be hypothesized that vowel assimilation operated at a time when palatal consonants were in the process of gaining stability in line with, among other possible factors, the presence of several noticeable perceptual cues for the palatal consonants in question, i.e., a high F2 locus frequency and prominent VC and CV acoustic transitions in low and back rounded vowel contexts (see Hume & Mailhot 2013 for similar sound change scenarios). This possibility is in agreement with the prediction of self-organizational models of sound change that diachronic changes are prone to apply when the phonological system is in an unstable state and follow a cumulative path (Blevins & Wedel 2009).

Regarding lexical diffusion, it appears that vowel assimilation to a following palatal consonant in Early Romance proceeded highly systematically across words exhibiting the original contextual conditions (a subset of which will be presented in the Appendix) but did not spread through the entire lexicon nor even through segmental contexts other than those triggering the change. To the extent that frequently used words were also affected it can be hypothesized that the change in question originated in high frequency lexical items since these are most prone to be hypoarticulated (Bybee 2001, though see Garrett 2015 regarding evidence against this hypothesis).

1.2 Previous accounts

Several scholars have attributed the fact that vowel assimilation in Romance occurred before specific palatal consonants rather than before others to chronological

factors. Thus, it has been assumed for Old Spanish that a palatal on-glide must have been present not only in [VjC] sequences such as [ajt] derived from [akt] (see above) but also in VC sequences with the single consonants [ʎ ɲ c ɟ j ʃ], and that vowel assimilation was more prone to take place whenever the glide in question stayed for a long time than when it was absorbed early by the following palatal consonant (see among others Menéndez Pidal 1968: 44–50 and Alarcos Llorach 1965). According to this hypothesis, vowel raising occurred in Spanish [ˈletʃe] LACTE 'milk' presumably through the development [akt] > [ajt] > [ejt] > [ec] > [e tʃ] but not in [ˈpaxa] PALEA 'straw' where the original string [alj] has yielded [ax] presumably through the development [alj] > *[ajʎ] > [aʎ] > [aʒ] > [ax]. Problems with the on-glide hypothesis will be identified in Section 2.2 and some assumptions of the chronological approach will be questioned with production data for the VC sequences subject to change. Along the same lines, there have been more recent attempts to account for why vowel assimilation applied or failed to apply based on the chronologically motivated presence vs. absence of [j] in single palatal consonants and [jC] sequences (Barbato 2013).

It has also been proposed that stressed mid and low vowels failed to undergo certain quality changes before a palatal consonant either because they appeared before an on-glide in a checked syllable (Fouché 1952–1961: 289–290) or since the consonant was particularly long and forceful (La Chaussée 1982: 38). As shown later on, however, vowels may be especially prone to assimilate to following syllable-final [j] in a checked syllable (see data for stressed [a] in Section 2.6.1.2) and there is no apparent reason why articulatory reinforcement should result in less rather than more prominent consonant effects on the preceding vowel. One possibility is that, at the time that the process applied in Early Romance and in parallel to present-day Tuscan Italian, the target vowels were located in a checked syllable since the palatal consonant triggers following the vowel were not simple but geminate segments. In contrast with views held in the literature (Loporcaro 2011), I believe that this possibility is not granted by some available data. According to Loporcaro, gemination follows from the fact that palatal consonants could derive from heterosyllabic consonant sequences (e.g., NN, MN, NG*e,i* > [ɲ] as in some of the etymological sources included in the Appendix) and also from glide hardening in the case of /pj/ (e.g. Occitan and Rhaetoromance *sapcha* SAPIAT), which implies that these and analogous sequences like /lj nj/ were heterosyllabic. However, the fact that palatal consonants may be traced back to a sequence of two heterosyllabic consonants does not mean that the resulting palatal should be long and that all word-medial consonant sequences evolving into a palatal consonant ought to be heterosyllabic. Rather than being associated with syllable affiliation, palatalization ought to be related to the presence of a large contact area at closure location and behind it if the Latin source is a geminate in cases like NN > [ɲ], or

else to gestural blending between two heterorganic consonants produced with a front lingual gesture and a back lingual gesture in the case of changes like N[j], NG*e,i* > [ɲ] (Section 2.2). When the first consonant of a /Cj/ sequence is an oral stop, stop lengthening and/or glide fricativization or affrication result from an increase in intraoral pressure due to glide constriction narrowing induced by adjacency to stress or other factors, which in principle may take place independently of syllable affiliation (Ohala & Solé 2010). Moreover, had palatal consonants been long in Early Romance it is doubtful that conditioned diphthongization in cases like those discussed in Sections 2.3.3 and 3 (also [e] > *oi* in dialectal French *consoil* CONSILIU and *vermoil* VERMICULU; Sánchez Miret, personal communication) would have taken place since the target vowels would have been too short to undergo lengthening; indeed, it is a well known fact that vowels are shorter before geminates than before non-geminates (Maddieson 1985). Generally speaking, the approach we take here is that syllables should not be taken as given but subsequent to production mechanisms and detectable changes in the acoustic signal (Ohala & Kawasaki-Fukumori 1997).

Another earlier proposal is that in the case of specific lexical items vowel inflection could be associated with etymological factors. Thus, for example, the stressed vowel of Fr. *truite* TRŬCTA 'trout' and *lutte* LŬCTA 'fight' is high front rounded (as in *dur* DŪRU) instead of high back rounded (as in *rouge* RŬBEU) not because the palatal glide [j] triggered [o] raising to [u] but because it prevented [ʊ] (Y̆) from lowering to [o] (Lausberg 1970: 252, La Chaussée 1982: 117). This argument risks being circular however: the quality of the Latin vowel needs to be changed in order to accommodate the phonetic behavior of specific words in a group of Romance languages. In other instances, vowel raising has been attributed to the metaphonic influence of a contextual high vocalic segment present in the same word or to analogical pressures (Menéndez Pidal 1968: 63).

While these explanatory attempts may be more or less appropriate to explain the implementation of specific sound changes (or why certain changes did not occur), the production-based approach advocated in the present study states that vowel assimilation should be more prone to operate before some palatal consonants than others due to consonant-dependent articulatory characteristics such as degree of dorsopalatal contact and tongue dorsum raising and fronting. The rationale underlying this assumption is that prominent coarticulatory effects involving consecutive phonetic segments in the speech chain may be phonologized by listeners thus giving rise to categorical assimilations (Section 1.1). Along these lines, the present study investigates whether the raising of [e ɛ a] to a higher front vowel and of [ɔ o] to a higher back vowel as a function of a following palatal consonant in Early Romance may result from prominent anticipatory tongue dorsum raising effects towards the hard palate.

The remaining sections of the manuscript are organized as follows. Section 2 provides information on vowel assimilation cases which occurred in Spanish, Catalan, Occitan, Portuguese, and French, and explores the extent to which those sound changes were conditioned by the quality of the target vowel and by the articulatory and acoustic characteristics of the following palatal consonant. In order to test the relationship between vowel assimilations and related C-to-V coarticulatory effects, acoustic data for the latter will be subjected to evaluation in the same section. Section 3 complements the findings reported in Section 2 with descriptive data taken from Italian and Romansh. Section 4 discusses the analysis results in relation to a production-based account of vowel assimilation and to theories of sound change.

2. Early Romance

In order to provide adequate explanations for the vowel assimilation cases subject to investigation, it is convenient to review in some detail the articulatory properties and the Latin origin of the single consonants and consonant sequences which triggered the sound change processes under study.

2.1 Articulatory characteristics

The consonants [ʎ ɲ c ɟ j] are often produced with a single laminodorsal articulator simultaneously at the alveolar and palatal zones and thus, in front and behind the alveolar ridge (also Straka 1965). Moreover, as shown in Figure 1, the four consonants may differ in closure or constriction fronting in the progression [ʎ] > [ɲ] > [c] (also [ɟ] not shown) > [j] (see also Recasens 2013). Indeed, [ʎ] may be not only alveolopalatal but also purely alveolar and in any case more anterior than the stops [ɲ] and [c ɟ] and the approximant [j], since the formation of lateral outlets for the passage of airflow causes the lingual articulator to occupy a fairly front position. On the other hand, [ɲ] and [c ɟ] may not only differ in manner of articulation but also in place of articulation, the oral stops being often more posterior than the nasal stop since a higher intraoral pressure level for the production of a relatively salient burst is required in the case of the former consonants vs. the latter; thus, while all three consonants are alveolopalatal most of the time, [c ɟ] may be purely palatal more often than [ɲ]. The approximant [j] may exhibit a central lingual constriction at the alveolopalatal zone or, as shown in Figure 1, at the palatal zone. Finally, [ʃ ʒ] (and the corresponding affricates [tʃ dʒ]) are palatoalveolar rather than alveolopalatal and thus articulated most frequently at the back alveolar zone with the tongue blade and possibly the predorsum, and involve a raised

tongue dorsum. According to the figure, there is a trend for dorsopalatal contact size for all these consonants to vary inversely with closure or constriction fronting, and thus to be largest for [j], and larger for [c ɟ] than for [ɲ] and for these three stops than for [ʎ] and [ʃ ʒ]. In spite of the articulatory differences just referred to and for the sake of clarity and simplicity, not only [ʎ ɲ c ɟ j] but also [ʃ ʒ tʃ dʒ] will be often labeled "palatal" in the present study.

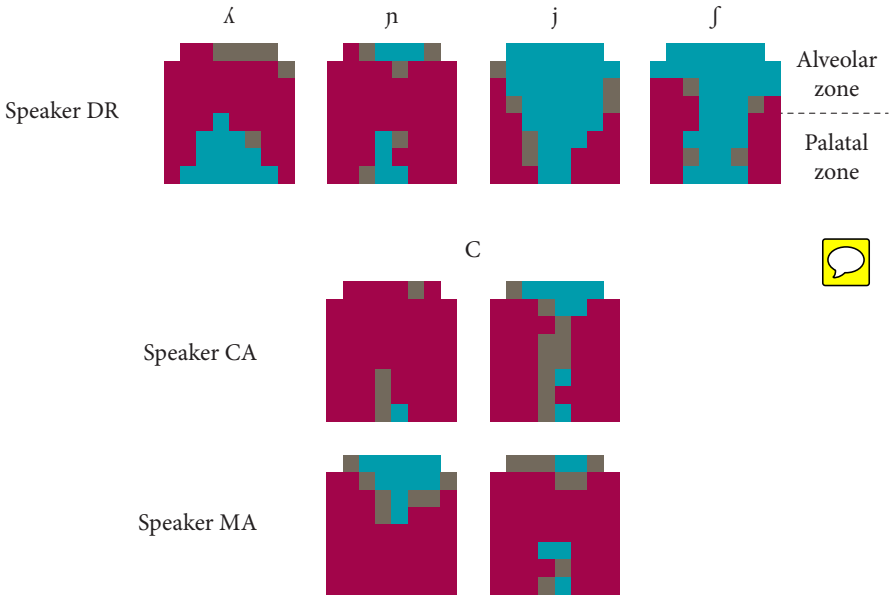

Figure 1. Electropalatographic linguopalatal contact configurations gathered at closure or constriction midpoint for [ʎ ɲ j ʃ] (Eastern Catalan speaker DR) and for [c] (Majorcan Catalan speakers CA and MA) in intervocalic position next to the vowel [a]. Tongue contact data for [c] are comparable to those for the voiced cognate [ɟ], not shown. The 62 squared subdivisions in the linguopalatal contact patterns indicate the position of 62 electrodes on the alveolar and palatal zones of the artificial palate. They have been filled with different color shades depending on contact activation (black: 80–100%; grey: 40–80%; unfilled: 0–40%)

Sequences composed of [j] (C1) and a following dental or alveolar consonant (C2) may differ regarding two essential articulatory dimensions: dorsopalatal contact degree for C2; temporal independence between the dorsal gesture for [j] and the apical or laminal gesture for C2 and thus the probability that [j] is anticipated more or less with regard to C2 during the preceding vowel. There are reasons to believe that these two dimensions are inversely related to each other such that gestural independence should increase as tongue dorsum contact for the dental or alveolar consonant decreases in the progression [jɾ] > [js jz] > [jt]. A high degree

of gestural independence between the two consecutive consonants in the case of the sequences [jɾ js jz] follows from the fact that, while [j] involves tongue dorsum raising and fronting, the production of the alveolar rhotic and the alveolar fricatives requires some tongue predorsum lowering in order to facilitate the tongue tip raising gesture and, in the case of [s z], the formation of a precise central groove for the passage of airflow as well (Ladefoged & Maddieson 1996). As for the sequence [jt], on the other hand, the tongue body may occupy a relatively high position not only for the glide but also for the stop [t], which may be articulated with full laminal contact at the dentoalveolar zone in this particular case.

2.2 Etymological origin

Palatal consonants were derived from Latin single consonants in some cases. This is so for Latin [j] which must have been realized as [ɟ] at some stage in Early Romance except in falling diphthongs (Sp. *laico* LAICU 'secular'), and also for [k g] which must have also exhibited an (alveolo)palatal stop realization before [i e j] throughout the Romania and before [a] in Old French.[2] Whether associated with these Latin consonants or with consonant sequences with [j] (see below), the outcome [ɟ] could later develop into [j] or zero through weakening ([j]: Sp. *mayo* MAIU 'may', Fr. *payer* PACARE 'to pay'; [ø]: Sp. *deseo* DESIDIU 'desire') or else into an affricate through the categorization of the stop burst as its fricative element ([d(:)ʒ]: Cat. *gel* GELU 'ice', *corretja* CORRIGIA 'strap').

For the most part palatal consonants were issued from Latin consonant sequences through the articulatory mechanisms described next (see also Wireback 2009, 2010), and their formation must have been completed for the most part by the time that vowel assimilation occurred.

(i) The consonants [ʎ ɲ ɟ ʃ ʒ] could derive from [lj nj dj sj zj], respectively, through maximal temporal overlap between the dorsal gesture for [j] and the front lingual gesture for the preceding dentoalveolar (see Table 1.1). In these circumstances, the two gestures blended into a single lingual gesture produced at an intermediate articulatory location encompassing the alveolar and palatal zones (regarding the term "gestural blending", see Browman & Goldstein 1990). As the examples in the table show, it is also assumed that the intervocalic sequence [tj] yielded a [ɟ]-like realization and that the geminates [t:j k:j]

2. The graphic representation *jj* of intervocalic [j] in Latin could correspond to the palatal stop [ɟ] (Niedermann 1953: 105). It should be stated at this stage that it is utterly impossible to know what the exact phonetic realization of [ɟ] was in Early Romance, namely, whether it was produced as a stop, as an affricate, or as an approximant depending on etymological origin, word position, and language.

gave rise to the voiceless cognate [c]. Moreover, these two palatal stop realizations must have been more anterior than [ɟ] derived from [dj] since their final outcome was an alveolar affricate or fricative rather than an (alveolo)palatal or palatoalveolar consonant ([z]: Fr. *raison* RATIONE 'reason' and [s]: *place* PLATEA 'square', as opposed to [dʒ]: Cat. *desitjar* DESIDIARE). Palatal [c] and [ɟ] could also result from a labial stop + [j] sequence through developments such as [bj] > [bɟ] > [ɟ] > [dʒ] or [bj] > [bɟ] > [bdʒ] > [dʒ] and thus, [j] constriction narrowing followed by elision of the preceding labial stop ([ʒ]: Fr. *rage* RABIE 'rage').

Several Latin [Cj] sequences could be resolved through the formation of a palatalized consonant followed by [j] rather than of a single alveolopalatal and, at a later stage, the palatalized consonant in question could segregate an on-glide after which C2 = [j] dropped and the palatalized consonant ceased to be palatalized. Thus, [sj] yielded [js] in Fr. *graisse* *GRASSEA 'grease' presumably through the changes [sj] > [sʲj] > [jsʲj] > [js]. A similar development may have given rise to [jz] out of SY, as in Cat. *besar* BASIARE. In this case on-glide segregation appears to be phonetically more realistic than categorical metathesis (i.e. [sj] > [js]). Regarding the heterosyllabic cluster [sc], it is assumed that forms with [js] such as Fr. *faisse* FASCIA 'cord' came to exist through the depalatalization of the late phonetic stage [ʃ] into [jsʲ] (i.e. [sc] > [stʃ] > [sʃ] > [ʃ] > [jsʲ]; Lausberg 1970: 378).

(ii) Gestural blending also accounts for the formation of alveolopalatal consonants out of sequences composed of [j] and a following dentoalveolar (see Table 1.2). Thus, for example, after syllable-final [k] and [l] vocalized into [j], the outcomes [js] of [ks] and [jt] of [kt lt] blended into [ʃ] and [c], respectively (see Section 1 for the possible alternative development [kt] > [c]). This case may also be considered an instance of progressive palatalization.

Sequences with C1 = [j] and a dentoalveolar C2 did not always give rise to a palatal consonant. This is so for the sequence [jɾ] which may have been generated either through the development [ɾj] > [ɾʲj] > [jɾʲj] > [jɾ] (Cat. *era* AREA 'area') or after vocalization of the coda consonant in a consonant cluster (Sp. *entero*, Port. *inteiro* INTEGRU 'whole'). Unlike the sequences referred to above, the alveolar tap failed to undergo progressive palatalization presumably because this articulatory characteristic does not sit easily on rhotics (Kavitskaya et al. 2009). Dental stops and [s] also failed to yield a palatal consonant after [j] in lexical forms such as Occ. *estreit* STRICTU ([kt] > [jt]), Sp. *cuidar* COG(I)TARE 'to take care of' ([ɟd] > [jd]), and Port. *muito* MULTU 'much' ([lt] > [jt]) and *mais* MAGIS 'more'. [j] may not be the vocalized outcome of [ɟ] in the sequence [ɟd] but could have been triggered as an on-glide by [dʲ], i.e., [ɟd] > [dʲ] > [jd] (Morin, personal communication). Also labial stops

could fail to palatalize whenever preceded by an on-glide (Sp. *quepa* < **caipa* CAPIAT 'to fit, 1 sbjv.') or before [j] (Cat. *sépia*, Sp. *jibia* SEPIA 'cuttlefish').

(iii) Gestural blending also operated in consonant sequences composed of a front lingual consonant followed by a dorsal consonant other than [j]. Thus, [ʎ ɲ] could originate from [lɟ nɟ] and [ʃ] from [sc] (see Table 1.3: a, c, e) where, as pointed out above, the palatal stop may derive from a front velar stop or from a dentoalveolar + [j] sequence. Blending may also result from dorsal + front lingual combinations. As exemplified in Table 1.3 (b), the tautosyllabic clusters [kl gl] may have yielded [ʎ] presumably through the intermediate forms [kʎ gʎ] where the palatal lateral resulted from blending of the dorsal gesture for the velar stop and the apical gesture for the alveolar lateral (Repetti & Tuttle 1987). Likewise gestural overlap between the back lingual gesture for a velar and the front lingual gesture for an alveolar may account for the outcome [ɲ] of the realization [ŋn] of the Latin sequence *gn* (Table I.3 (d); Straka 1965: 141, Baglioni 2014). The derivations [kl gl] > [kʎ gʎ] > [ʎ] and [ŋn] > [ɲ] just referred to appear to be as plausible as or more plausible than other alternative developments which have been proposed elsewhere, namely, [kl gl] > [jl] > [ʎ] and [gn] > [jn] > [ɲ].

Table 1. Consonant sequences which have given rise to single palatal consonants through blending in Romance

1. [Cj] sequences	
a. [ʎ] < [lj]	(Cat. *all* ALIU 'garlic')
b. [ɲ] < [nj]	(Cat. *vinya* VINEA 'vineyard', Port. *sonho* SOMNIU 'dreams')
c. [ɟ] < [tj dj]	(Cat. *malesa* MALITIA 'malice', Sp. *rayo* RADIU 'beam')
d. [c] < [t:j k:j]	(Fr. *pièce* PETTIA 'piece', *face* FACIA 'face')
e. [ʃ] < [sj]	(Cat. *baix* BASSIU 'low')
f. [ʒ] < [zj]	(Port. *cerveja* CERVESIA 'beer')
2. [jC] sequences	
a. [ʃ] < [js] < [ks]	(Cat. *eix* AXE 'axis', *caixa* *CA[ks]A< CAPSA 'box')
b. [tʃ] < [c] < [jt] < [kt lt]	(Sp. *mucho* MULTU 'much', *hecho* FACTU 'done, fact')
3. Other sequences	
a. [ʎ] < [lɟ]	(Cat. *cull* COLL(I)GIT 'he/she catches')
b. [ʎ] < [kʎ gʎ]	(Cat. *ull* OC(U)LU 'eye', *rella* REG(U)LA 'plowshare')
c. [ɲ] < [nɟ]	(Cat. *vergonya* VERECUNDIA 'shame')
d. [ɲ] < [ŋn]	(Cat. *llenya* LIGNA 'wood')
e. [ʃ] < [sc]	(Cat. *conèixer* COGNOSCERE 'to know', *aixa* ASCIA 'axe', *puix* POSTIU 'since')

It should be stated at this stage that, differently from palatalized dentoalveolars and in contrast with earlier proposals (see Section 1.2), the single palatals [ʎ ɲ c ɟ] are not likely to develop an on-glide (see also Lausberg 1970: 260, Straka 1965: 145). The reason for this restriction lies in the fact that the F2 transition in VC sequences with those consonants is too short and proceeds too rapidly to be integrated as an independent segment by the listener.[3] A transitory on-glide is more prone to be heard in the case of the palatoalveolar fricative [ʃ] which is longer and articulated with less central contact than the lateral and stop cognates. Indeed, in dialects such as Western Catalan, [jʃ] corresponds not only to Latin [ks] where [j] may be traced back to the velar stop ([ejʃ] AXE 'axis') but also to other consonant sequences where [j] was not available originally and therefore must have been generated by the palatoalveolar fricative itself ([fejʃ] FASCE). In support of the inverse relationship between on-gliding and tongue contact degree for the palatal consonant trigger, the chances that an on-glide develops before [ʎ] and [ɲ] increase after these consonants become palatalized or plain alveolar in syllable-final position, as exemplified by the French derivation *[baɲ] *BANEU 'bath' > *[bajn] > [bɛ̃] (also *coin* CUNEU 'wedge, corner', *sein* SIGNU 'sign', *poing* PUGNU 'fist').

2.3 Vowel assimilation patterns

Before analyzing in detail the assimilatory effect of palatal consonants on a preceding stressed vowel in Early Romance, it has to be shown that the vowel quality changes of interest have been truly triggered by these contextual consonants and therefore have not operated in other contextual conditions. This section explores this issue with the lexical forms for Spanish, Catalan, Occitan, French, and Portuguese listed in the Appendix. Data for Italian or Romansh will be treated separately in Section 3 given that vowel raising has had a limited impact in the former language and, after being raised contextually, stressed vowels may have regressed to their original quality in Romansh (Lausberg 1970: 255).

2.3.1 *Mid high vowels*

In Spanish, Occitan, and Portuguese, the raising processes [e] > [i] and [o] > [u] may be attributed to the following palatal consonant since the two vowels have stayed regularly mid high in other segmental contexts in the three languages ([e]: Sp. *cadena* CATENA 'chain', Port. *verde* VIR(I)DE 'green', Occ. *pel* PILU 'hair'; [o]: Sp. *torre* TURRE 'tower', Port. *amor* AMORE 'love', Occ. *gola* GULA 'throat'). Therefore, there has been vowel assimilation in Spanish lexical forms such as *jibia*

3. This does not imply that on-gliding cannot take place before single palatal consonants (see Recasens 2014 for some relevant examples in Romance dialects).

SĒPIA 'cuttlefish' and *puño* PŬGNU, but not in *ceja* CĬLIA 'eyebrow' and *escaloña* ASCALŌNIA 'shallot', where the contextual palatal has not caused [e] and [o] to close to a high vowel (see Appendix 1.1). In Catalan, where mid high vowels stay mid as a general rule ([ɛ]: *cadena* CATENA 'chain'; [o]: *torre* TURRE 'tower'), the outcomes [i] from [e] and [u] from [o] may also be attributed to the assimilatory action of the following palatal consonant in lexical forms like *tinya* TĬNEA 'moth' and *rebuig* REPŬDIU 'rejection' (Appendix 1.2).

There is no clear explanation for several Spanish words where [we] has been derived from [o] before [jɾ] (*agüero* AUGURIU 'luck', *salmuera* SALE MURIA 'brine', *Duero* DORIU 'name of a Spanish river'), [jz] (*sabueso* SEGUSIU 'hound'), and [ɲ] (*risueño* *RISONEU, *cigüeña* CICONIA, *vergüenza* VERECUNDIA). According to Menéndez Pidal (1968: 65), these lexical forms may be accounted for through [o]-raising followed by the replacement of [uj] by the more frequent rising diphthong [we]. It has also been proposed, at least for the sequence [ojɾ], that [we] was achieved not through vowel inflection but the development [oj] > [oe̯] > [we] (Krepinsky 1962: 90, Pensado 1989).

The situation for French is more complex. In this language, the vowels [e o] evolved differently in open and checked syllables presumably because they were longer in the former position than in the latter. In open syllables, the two mid high vowels diphthongized in the first place and underwent further changes at a later date: [e] > [ej] > [oj] > [wa], as in *toile* TELA 'cloth', *avoir* HABERE 'to have'; [o] > [ow] > [ew] > [œ], as in *fleur* FLORE 'flower', *heure* HORA 'hour'. In checked syllables, [e] stayed mid high initially and did not open into [ɛ] until about the 16th century as in *messe* MISSA 'Mass' and *mettre* MITTERE 'to put' (Morin 2009), while [o] closed to [u] as in *ours* URSU 'bear' and *bouche* BUCCA 'mouth'. Before palatal consonants, [e o] underwent no assimilation in most cases (see Appendix 1.5). Thus, when followed by [j], [ej] and [oj] evolved analogously to [ej] derived from [e] in open syllables and thus yielded [wa] (*roi* 'king', *courroie* 'belt', *foire* 'fair', *toit* 'roof', *gloire* 'glory', and *angoisse* 'anguish' have [wa], the same as *toile* 'cloth'). In words such as Fr. *coin* CUNEU 'wedge, corner' and *poing* PUGNU 'fist', the final phonetic outcome was not [wã] but [wɛ̃]. On the other hand, when occurring before [ʎ ɲ bj], the two mid high vowels developed as in checked syllables before other consonants: [e] stayed mid and [o] raised to [u] or stayed mid ([ɛ]: *conseil* 'advice', *teigne* 'moth', *sèche* 'cuttlefish'; [u]: *genou* 'knee', *rouge* 'red'; [ɔ]: *vergogne* 'shame'). As for the lack of vowel assimilation in *paresse* PIGRITIA 'laziness', see the argument for *pièce* in Section 2.3.3.

In some cases, French mid high vowels were raised under the action of the following palatal consonant (Appendix 1.5). Vowel assimilation may account for the shift [e] > [i] before [ʎ] in Fr. *cil* and Old Fr. *til*, and for the derivation [oj] > [uj] > [yj] > [ɥi] in lexical forms like Old Fr. *cuide* COG(I)TAT 'he/she takes

care' which parallels the evolution of [uj] as in Fr. *fruit* FRŪCTU 'fruit' (see also Fouché 1952–1961: 286).

2.3.2 *Low vowel*

A following palatal consonant may have caused [a] to raise to a mid front vowel in all languages subject to investigation (Appendix 2.1–2.5). This assimilation process has taken place, for example, in Sp. *enero* IANUARIU 'January', where the string [ajɾ] shifted to [eɾ] through [ejɾ], but not in Sp. *extraño* EXTRANEU 'strange', where the low vowel has stayed low in spite of being followed by [ɲ].

In French, contextually conditioned [a] raised to [ɛ] (as in *aire* AREA) which differs from the early [e] outcome of [a] in open syllables (as in *chanter* CANTARE). Analogously to the scenario for stressed [e o] (see Section 2.3.1), [a] before [ʎ ɲ bj] and before [c] derived from Latin [k:j t:j] stayed low rather than raising to a mid vowel and thus shows the same outcome as [a] in checked syllables before any consonant (*travail* 'work', *montagne* 'mountain', *rage* 'rage', *glace* 'ice', *place* 'square', as for *âne* ASINU, *carte* CHARTA; Appendix 2.5). The presence of a rising diphthong in words such as Fr. *premier* PRIMARIU 'first' suggests that the initial outcome [ɛ] of [a] before [jɾ] merged with [ɛ] after which the mid low vowel diphthongized to [jɛ] in open syllables (Section 2.3.3).

2.3.3 *Mid low vowels*

The assimilation scenario for [ɛ] and [ɔ] differs from that for [e a o] in relevant respects. In Spanish, palatal consonants could prevent [ɛ] from diphthongizing into [je] and [ɔ] into [we], which are the regular mid low vowel outcomes in this language (*bien* BENE 'well', *cien* CENTU 'one hundred', *puerta* PORTA 'door', *pues* POST 'then'). Thus, as shown in Appendix 3.1, there has been a closing effect of the vowel in *medio* 'half', *lecho* 'bed', *ocho* 'eight' and *ojo* 'eye' which are pronounced with [e] and [o], though not in *viejo* 'old' and *dueño* 'owner' which are produced with [je] and [we]. While philologists have related the presence of a diphthong in *viejo* VĚCLU to the influence of the co-occurring lexical form with the same meaning *viedro* VĚTERE (Gulsoy 1997, Craddock 1980), the low assimilatory strength of [ʎ] could explain the presence of a rising diphthong instead of the inflected vowel [e] in this case.

Mid low vowel assimilation is also the rule in Portuguese where [ɛ] and [ɔ] have shifted regularly to [e] and [o] before a palatal consonant while staying mid low in the other contextual conditions. Thus, there is [ɛ] in *pedra* PETRA 'stone' but [e] in *engenho* 'engine, talent' and [ɔ] in *roda* ROTA 'wheel' but [o] in *sonho* 'dream' (Appendix 3.4).

In Occitan and Catalan, [ɛ] and [ɔ] followed by a palatal consonant developed generally into [jɛ] and [wɔ] instead of staying mid, which is the regular outcome

in both languages ([ɛ]: Occ. *mel* MEL 'honey', [e]:Cat. *temps* TEMPU 'time'; [ɔ]: Occ. *roda* ROTA 'wheel', Cat. *cor* CHOR 'heart'). It has been hypothesized that [ɛ ɔ] diphthongization before a palatal consonant in Early Romance was not contextually conditioned but occurred spontaneously, as for stressed vowels in open syllables (Sánchez Miret 1998). This proposal finds some support in the fact that glide insertion in VC sequences should take place next to the triggering consonant and thus at vowel offset rather than at vowel onset, as for example in the case of the phonetic variant [pɛa̯l] of /pɛl/ 'hair' in dialectal Catalan. It does not seem to explain other facts however: when applying before [jC], mid low vowel diphthongization occurred in a checked syllable and cannot be easily attributed to a lengthening process since vowels followed by a palatal consonant do not happen to be particularly long; in Occitan, Romansh, and Northern Italian dialects, the diphthongization process [ɛ ɔ] > [jɛ wɔ] took place before a palatal consonant exclusively.

Those rising diphthongs underwent later changes: in Catalan, [jɛ] and [wɔ] became systematically [i] and [u], respectively (Cat. *sis* SEX 'six', *ull* OC(U)LU 'eye'; Appendix 3.2); in Occitan, [jɛ] stayed and occasionally became [i], while [wɔ] stayed or fronted to [wɛ] (Occ. *mielhs*, *milh* MELIUS 'better', *fuolha*, *fuelha* FOLIA 'leaf'; Appendix 3.3). It should be stated that the raising of [ɛ] to [i] and of [ɔ] to [u] must have been triggered simultaneously by the following and preceding closing consonants, namely, two flanking palatals in the case of [ɛ] and a following palatal and preceding [w] in the case of [ɔ] (Cat. *pit* < **p*[jej]*t*, *fulla* < **f*[woʎ]*a*).

Also in French, [ɛ ɔ] followed by a palatal consonant diphthongized into [jɛ] and [wɔ], after which vowel raising took place (Appendix 3.5): [jɛ] > [i] (*six* SEX); [wɔ] > [u] > [y] (*cuir* CORIU 'leather'). However, this raising process did not operate on [ɛ] before [ʎ ɲ c bj] and to some extent before [jɾ], nor on [ɔ] before [ʎ]. In these contextual conditions, after diphthongizing, [ɛ] and [ɔ] evolved the same as they did in open syllables: [ɛ] stayed as [jɛ] (*vieil* 'old' VECLU, Old French *engiegne* INGENIAT 'to design', *pièce* PETTIA, *liège* LEVIU, as in *pierre* PETRA 'stone', *fièvre* FEBRE 'fever'), while [ɔ] turned into [œ] through the evolution [ɔ] > [wɔ] > [we] > [œ] (*feuille* FOLIA 'leaf', as in *coeur* CHOR 'heart', *neuf* NOVU 'new'). The presence of a diphthong for [ɛ] before [ʎ ɲ c bj] and for [ɔ] before [ʎ] must have been conditioned by the following palatal consonant since, if the two mid low vowels had been treated as if they had been in a checked syllable (as for [e a o]; see Sections 2.3.1–2.3.2), they would have remained mid low as for *herbe* HERBA 'grass', *sept* SEPTE 'seven' and *porte* PORTA 'door'. The vowel [ɔ] could also remain [ɔ] before a palatal consonant occasionally (*poche* POPIA).

2.4 Testing hypotheses

The main goal of the present investigation is to explore the extent to which the vowel assimilation patterns associated with a following palatal consonant just described in Section 2.3 have a phonetic basis. The assumption underlying this working hypothesis is that the chances that vowel assimilation applies ought to increase with the prominence of the C-to-V coarticulatory effects in tongue dorsum raising and F2 frequency leading towards a higher vowel realization. Regarding [ɛ ɔ], the relationship between assimilation and coarticulation will be tested essentially for Spanish and Portuguese since, as pointed out in Section 2.3.3, mid low vowels underwent diphthongization before a palatal consonant in the remaining languages.

A first research topic is to ascertain whether the frequency of occurrence of vowel assimilations is conditioned not only by the phonetic characteristics of the consonant but also by those of the target vowel. In particular, if vowel raising is favored by the articulatory and acoustic proximity between the vowel and the following palatal consonant, the prediction is that the process should be most prone to operate on [e] and to a lesser extent on [ɛ] than on low and back rounded vowels since only front vowels are articulated with a dorsopalatal constriction. To the extent that tongue dorsum fronting and raising towards the hard palate is directly related to the F2 frequency (Fant 1960), listeners could mistake the original mid front vowel for its higher cognate, namely, [e] (which has an F2 frequency of about 1800 Hz) for [i] (F2 = 2000 Hz) and [ɛ] (F2 = 1600 Hz) for [e] (F2 = 1800 Hz). On the contrary, vowel assimilation is expected to affect mostly [a] and the mid back rounded vowels [ɔ o] (and perhaps [ɛ] as well) if favored by an increase in tongue body displacement during the vowel and thus, in vowel-to-consonant articulatory distance. This should be so since, differently from palatal consonants, [a] is produced at the lower pharynx with the tongue root and exhibits a low predorsum position, [ɔ o] are articulated at the upper pharynx with the tongue postdorsum and show a lowered predorsum and lip rounding, and front [ɛ] is also articulated with considerable tongue-to-palate distance. The raising of [a] to [ɛ] involves an increase in tongue dorsum height and in F2 (F2 is about 1200–1500 Hz for [a] and about 1600 Hz for [ɛ]), while the changes [o] > [u] and [ɔ] > [o] require some tongue postdorsum raising towards the velar region, some concomitant tongue predorsum lowering and an increase in lip rounding which result in F2 lowering (F2 is about 1200 Hz for [ɔ], 1000 Hz for [o], and 800 Hz for [u]).

Depending on the articulatory characteristics of the vowel and the following consonant or consonant sequence, the predictions presented in (i) and (ii) below may be made about the typology and prominence of the C-to-V coarticulatory effects, which ought to be in accordance with the vowel assimilation processes which have taken place historically in Romance.

(i) An increase in dorsopalatal contact and F2 during [a] (and perhaps during [ɛ]), and thus the chances that the low vowel becomes mid front, ought to take place as dorsopalatal contact for the following single palatal consonant increases in the progression [j] > [ɕ ʝ] > [ɲ] > [ʎ ʃ] (Section 2.1). Regarding the contextual [jC] consonant sequences (which should be most prone to affect the vowel since [j] belongs to the same syllable; see also Pensado 1984: 510), it deserves to be seen whether an increase in F2 during the vowel occurs with greater temporal independence between the two consonantal gestures and thus with the degree of [j] anticipation (and therefore in the progression [jɾ] > [js jz] > [jt] in sequences with a dentoalveolar C2), or else with a larger dorsopalatal contact size for C2 (in the reverse progression [jt] > [js jz] > [jɾ]). Two special contextual cases deserve special attention: [ʃ] may often be realized as [jʃ] and therefore may behave as a [jC] sequence rather than as a simple palatal consonant (see Section 2.2); regarding the sequence [bj], the fact that [j] is postposed to the labial consonant could render dorsal anticipation for [j] less likely than in the [jC] sequences.

(ii) Regarding [o] (and perhaps [ɔ]), the chances that the vowel is heard as /u/ ought to be highest before simple palatal consonants involving considerable dorsopalatal contact and thus causing presumably the postdorsal constriction for the vowel to approach the velar zone as the tongue dorsum is raised towards the hard palate; see (i) for consonant-dependent differences in dorsopalatal contact size. It should also be kept in mind in this respect that an increase in dorsopalatal contact at the back palate for [o] before palatal consonants should yield a higher though not more retracted [ɯ]-like realization exhibiting a higher F2 frequency than the vowel in isolation or in a neutral consonantal context (Fant 1960). It is hypothesized that, in the absence of a high back or central unrounded vowel phoneme in the language, this realization of /o/ could be heard as close to /u/ by listeners, which would account for why [o] has shifted to [u], for example, in Sp. *puño* PŬGNU. Regarding contextual [jC] sequences, the chances that [o] becomes [ɯ]-like could also increase with dorsopalatal contact size for C2 and thus whenever the vowel was followed by [jt] rather than when it occurred before other [jC] sequences; see also (i).

(iii) As for [e], an increase in tongue-to-palate contact for the consonant should cause F2 for the vowel to increase and thus to approach the F2 frequency of the vowel [i].

2.5 Methodology

Two different analyses have been carried out in order to determine the phonetic causes of stressed vowel assimilation to a following palatal consonant in Early Romance.

First, the frequency of occurrence of assimilation cases was computed for [e ɛ a ɔ o] as a function of the single palatals [ʎ ɲ c ɟ j ʃ] and the sequences [jt jɾ js jz bj] using the database for Spanish, Catalan, Occitan, French, and Portuguese provided in the Appendix. Assimilation percentages for [ʃ] and [bj] include those for [sʲ] and [jb], respectively. Three values were assigned to each vowel-consonant combination: 1 to VC combinations showing vowel assimilation in essentially all words; 0 to VC combinations showing no vowel assimilation cases; 0.5 whenever vowel assimilation takes place in at least 25% of the words taken into consideration. The prediction is that vowel shifts ought to be more frequent for some specific VC combinations than for others in ways that are consistent with the hypotheses described in Section 2.4 .

A word needs to be said about the criteria that was applied for building up the database presented in the Appendix. The number of words per vowel, consonant and language is by no means exhaustive but we believe truly representative of the lexical items which have been affected by the assimilatory process. Thus, the database includes common, frequently used words in the language which, as argued in Section 1.1 , indicate that the assimilatory process applied quite extensively in the palatal consonant context condition. Regarding the size of the database, the numbers within parentheses in the bottom tables of Figures 2 and 3 show that the vowel assimilation counts for two factor combinations ("vowel" x "language", "vowel" x "consonant") may be quite high except in a few cases apparently due to lexical restrictions. Thus, excluding [jz] and [bj], there are less than ten observations in only five out of 30 VC combinations. It should also be noticed that several VC combinations have been assigned a relatively high number of cases in order to account for the fact that they happen to trigger or fail to trigger assimilation fairly often in a particular language (this is so for [e] + [ʎ ɲ] and [o] + [ɲ] in Occitan, for [e] + [ʎ] in French and Portuguese, and for [a] + [ʃ] in Catalan).

In order to achieve a better understanding of the relationship between vowel assimilation and coarticulation, acoustic data on C-to-V coarticulatory effects were also recorded and analyzed. F2 values for [e ɛ a ɔ o] were collected in nonsense [VCə] and [VCCə] words with the consonants [ʎ ɲ ɟ j ʃ] and the consonant sequences [jt jɾ jz bj]. All nonsense words were read seven times in the carrier sentence '*sap__poc*' 'he/she knows__ a little' by a native speaker of Eastern Catalan of 62 years of age. Spectral data for a single speaker may seem not to be representative enough of the entire speakers' population. The fact is however that this

speaker's F2 trajectories and vowel frequency values for VC sequences with palatal consonants are highly consistent across vowel conditions and with the principles of the acoustic theory of speech production, and thus ought to be in close agreement with those for other subjects.

The vowels [e ɛ a ɔ o] and the consonants [ʎ ɲ j ʃ] occur in the Eastern Catalan dialect. The voiced palatal stop [ɟ] was produced by imitation of Majorcan Catalan where [c] and [ɟ] are systematic allophones of the phonemes /k/ and /g/, respectively. Acoustic recordings were made with a Shure SM48 microphone and a PreSonus Audio Box 22VSL external sound card connected to a portable computer. The acoustic waveform was acquired at 22,050 Hz using the MultiSpeech program of Kay Pentax and downsampled to 11,025 Hz for spectrographic and spectral analysis. Vowel onset was identified at the onset of the vowel formants, and vowel offset at the boundary between the offset of vowel formant structure and the onset of the frication noise for [ʃ] or the stop closure for [ð], and at an intensity and spectral discontinuity whenever the vowel was followed by the sonorants [ʎ ɲ j]. LPC F2 trajectories were obtained during the entire vowel portion for all recorded sequences using a 25 ms full-Hamming window and 14 coefficients, and overlaid for cross-token averaging taking the vowel midpoint as reference.

2.6 Results

2.6.1 *Vowel assimilation*

2.6.1.1 *Vowel-dependent differences.* Figure 2 plots cross-consonantal assimilation percentages for each vowel and language and across languages (top graph in the figure), and the corresponding number of assimilation cases over the total number of observations (bottom table).

According to the figure, cross-language inflection percentages decrease with the target vowel in the progression [ɛ] (97.9%, 92 cases over a total of 94 counts), [ɔ] (94.4%, 101/107) > [a] (54.9%, 78/142) > [o] (38.9%, 54/139) > [e] (16.2%, 18/111). These percentages reveal that too much articulatory and acoustic proximity between the vowel and the following palatal consonant (as in the case of [e]) disfavors vowel assimilation, while a considerable articulatory and acoustic distance between the vowel and the consonant may favor it. Whether implemented through a rising diphthong or a high vowel (Section 2.3.3), quality changes affecting [ɛ] and [ɔ] take place 90%–100% of the time in Catalan, French, and Occitan; in Spanish and Portuguese, where vowel diphthongization has not occurred, [ɛ ɔ] raise to [e o] before a palatal consonant as a general rule. There are some relevant language-dependent differences in frequency of assimilation mostly regarding low [a] (Occitan shows almost no low vowel raising instances) and [o] (in this case vowel raising percentages are lower for Occitan and French than for the three other languages).

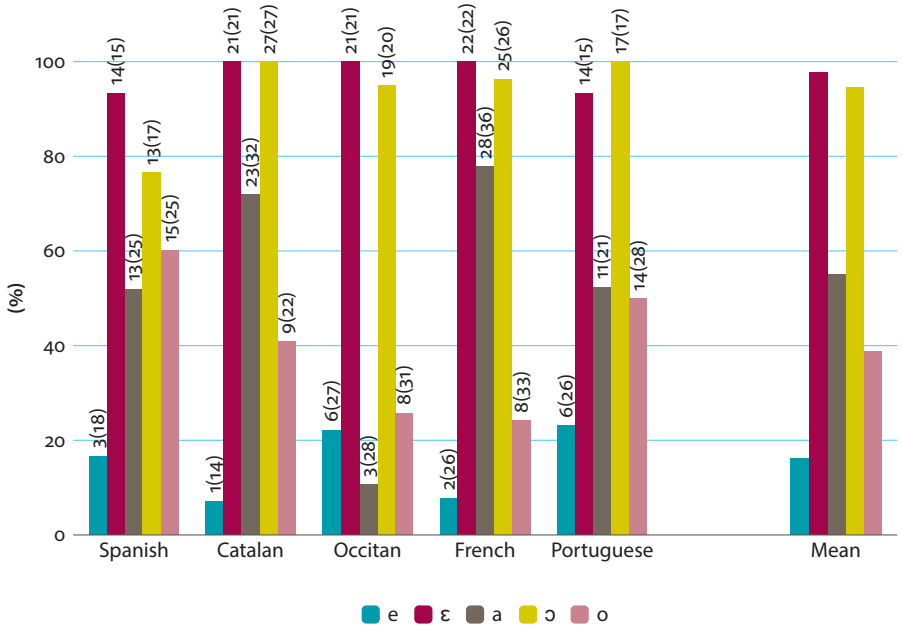

Figure 2. (Top) Frequency of occurrence of inflection cases plotted for each vowel and language and across languages. (Bottom) Number of assimilation cases and partial totals

2.6.1.2 *Consonant-dependent effects.* Cross-language percentages allow investigating the frequency of occurrence of vowel assimilations as a function of each target vowel/triggering consonant combination. Figure 3 displays assimilation percentages (top graph) and number of cases over the total number of observations (bottom table) for those simple consonants and consonant sequences which occur most frequently in the database, namely, [ʎ ɲ ʒ ʃ jt jɾ jz bj]. Among the consonants and consonant sequences not shown, [j] and [js] may trigger vowel raising only when preceded by [a] and stressed vowels are highly reluctant to assimilate to following [c].

Assimilation percentages for [a] displayed in the middle of the top graph reveal that the raising process takes place to a larger extent when the vowel is followed by a [jC] sequence (also [j]; see above) than when it occurs before other simple palatal consonants and [bj]. According to Section 2 of the Appendix, the individual languages show this same general trend as well as other more specific assimilatory patterns: all [jC] sequences trigger generally low vowel assimilation in Spanish, Catalan, and French, while this is so for three out of five [jC] sequences in Portuguese and only for [jɾ] in Occitan; [bj] triggers no assimilation while the reversed sequence [jb] does in Spanish but not in Portuguese; in all five languages, [a] fails to raise to a mid vowel when followed by [ʎ ɲ c], and is more prone to be inflected by [ʃ] (systematically in French and partially in Spanish, Catalan, and

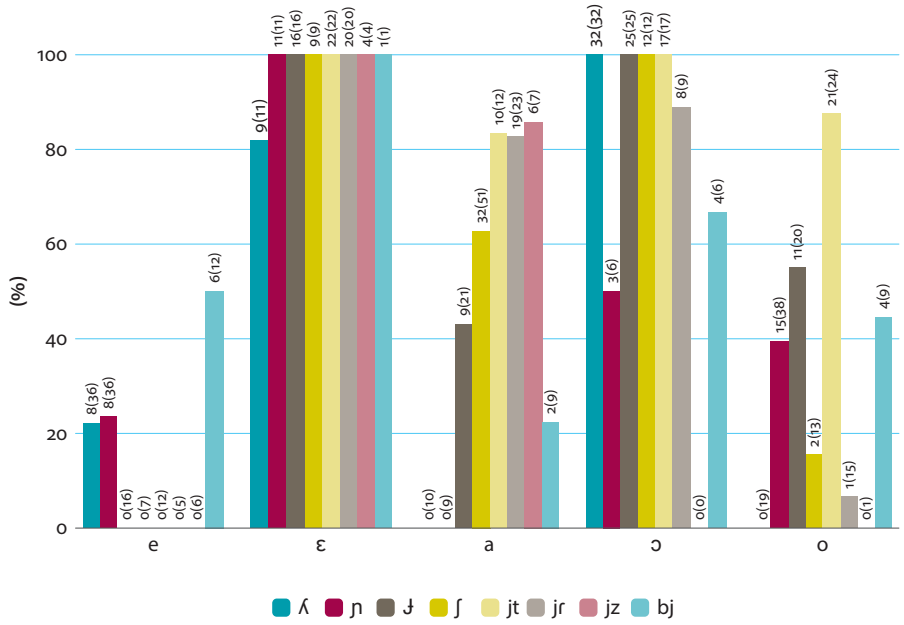

Figure 3. (Top) Frequency of occurrence of vowel inflection cases plotted for each vowel and contextual consonant condition across languages. (Bottom) Number of assimilation cases and partial totals

Portuguese, but not in Occitan) than by [ɟ] (generally in French and partially in Spanish, but not in the other three languages).

As shown in Section 1 of the Appendix, the vowel [e], which has been reluctant to undergo quality changes, may assimilate to [ʎ] (partially in Occitan, Portuguese, and French), [ɲ] (partially in Catalan, Occitan, and Portuguese) and [bj] (only in Portuguese and partially in Spanish), though not to [ɟ ʃ] or to [jC] sequences with a dentoalveolar C2. The vowel [o], on the other hand, shows more asimilations before [jt] (all the time in Spanish, Catalan, and Portuguese and less often in Occitan and French), [ɲ] (partially in Spanish, Catalan, Occitan, and Portuguese, but not in French) and [ɟ] (partially in all languages) than before [ʃ] (essentially in Spanish and less so in French, but not in Catalan, Occitan, and Portuguese), [bj] (only in Spanish and partially in Portuguese) and [ʎ jɾ jz] (there are essentially no assimilation cases before these consonantal segments in any of the languages under analysis). There are no data for [ec] and [oc] in the Appendix.

Regarding [ɛ ɔ], which underwent quality changes more than 90% of the time, raising to [e o] in Spanish and Portuguese may have failed to apply in the case of the segmental sequences [ɛʎ ɛc] (Portuguese, Spanish) and [ɔɲ ɔjɾ] (Spanish) (Appendix 3). Moreover, there may have been no vowel diphthongization and a later change into a high vowel in the case of [ɛ] before [c] in Catalan and Occitan

and of [ɔ] before [bj] in Occitan and French, as revealed by the words for PETTIA (Cat., Occ.), NOVIU (Occ.) and POPIA, LAUBIA (Fr.) in Sections 3.2, 3.3, and 3.5 of the Appendix. Vowel inflection has also failed to occur in the words for NERVIU and FORTIA not listed in the Appendix presumably since [bj] and [c] do not appear immediately after the target vowel in any of them: Sp. *fuerza*; Cat., Occ. *n*[ɛ]*rvi*, *f*[ɔ]*rça*; Port. *n*[e]*rvo*, *f*[ɔ]*rça* (there has been vowel assimilation in Sp. *n*[e]*rvio* however, which should have yielded **niervo* otherwise).

2.6.1.3 *Summary.* Data presented in this section show that the chances that stressed mid and low vowels assimilate to a following palatal consonant may have been favored by an increase in the articulatory and acoustic distance between the target vowel and the triggering consonant. Therefore, [a o] as well as [ɛ ɔ] are more prone to change quality than [e].

In most cases vowels have been found to differ among themselves regarding the degree to which assimilation occurs and the typology of the consonant-dependent assimilatory effects in ways which are largely consistent with our initial predictions made in Section 2.4.

(i) As for [a], assimilation is especially favored by tongue dorsum anticipation for [j] in [jC] sequences and also by [ʃ], which may develop an on-glide. Assimilation may also take place before single palatals involving considerable dorsopalatal contact and thus before [j] and, less so, before [ɟ] (which may have been realized as [j] in some of the languages under analysis when vowel inflection applied; see Section 2.2) rather than before [ʎ ɲ] which show no low vowel assimilations. This scenario is in agreement with the initial prediction that [a] should be inflected by [j] anticipation in [jC] sequences and by an increase in dorsopalatal contact for simple palatals.

(ii) Regarding [o] and also in agreement with our initial hypothesis, vowel inflection has been mainly conditioned by an increase in dorsopalatal contact in the following single palatal consonant and thus, its frequency of occurrence happens to vary in the progression [ɲ ɟ] > [ʃ] > [ʎ]. A similar effect may account for why raising takes place before [jt] rather than before [jɾ jz].

In other cases, however, our predictions are not clearly supported by the data. Thus, the finding that [e] raising may operate before the single palatals [ʎ ɲ] but not before [ɟ ʃ] or before [jC] sequences with a dentoalveolar C2 is not in agreement with the prediction that the mid high front vowel should raise preferably before palatals exhibiting considerable tongue contact at the palatal zone. Another special scenario is that of VC sequences with the voiceless palatal stop [c] and the sequence [bj], which we will return to in Section 4: in spite of being produced with large amounts of dorsopalatal contact, [c] does not trigger vowel assimilation; on

the other hand, vowel assimilation before [bj] occurs essentially in Spanish and Portuguese only.

2.6.2 *Acoustic data*

The goal of this section is to gain some understanding about the relationship between the major vowel raising patterns described in Section 2.6.1 and the typology and prominence of the phonetic coarticulatory effects exerted by palatal consonants on vowels. As pointed out in Section 2.4 , this relationship ought to hold mostly for F2 since this formant frequency is known to increase with tongue dorsum raising for low and front vowels in the progression [a] > [ɛ] > [e] > [i], and to decrease with tongue postdorsum height at constriction location and with lip rounding for back rounded vowels in the progression [ɔ] > [o] > [u].

The F2 frequency values for all vowels displayed in Figures 4–8 show similar consonant-dependent differences. For all vowels, F2 is higher before consonant sequences than before simple palatals which is in line with [j] occurring syllable finally in the former contextual condition. Moreover, among consonant sequences, F2 is consistently higher for [jɾ] than for [jt jz bj] and often lower for [jt] than for [jz] and/or [bj]. It is thus the case that, to a large extent, F2 increases as the degree of gestural independence between C1 and C2 increases and dorsopalatal contact for C2 decreases. Among simple palatals, on the other hand, the vowel F2 is consistently higher next to contextual consonants showing greater dorsopalatal contact ([ɟ ɲ j]) than to those exhibiting less contact ([ʎ ʃ]).

These F2 coarticulatory effects are partly in agreement with the vowel assimilatory patterns described in Section 2.3 .

(i) Regarding [a], a higher F2 before consonant sequences with [j] than before single consonants is in line with vowel assimilation occurring mostly before [jC] sequences with a dental or alveolar C2. Also as expected, a higher vowel F2 before [jɾ] than before other [jC] sequences accords with the raising process applying only in the former contextual condition in Occitan (Section 2.6.1.2).[4] Regarding simple palatals, F2 turned out to be higher and vowel raising especially prone to occur before consonants showing considerable dorsopalatal contact such as [ɟ] and [j]. The apparent contradiction between a relatively high frequency of assimilations and a low F2 and moderate dorsopalatal contact for [a] before [ʃ] can be accounted for assuming that the palatal fricative may develop an onglide. The sequence [bj] requires a special explanation since it does not trigger [a] raising while causing the vowel to exhibit a relatively high F2 (see Section 4).

4. There are indications that [a] raising occurred earlier before [jɾ] than before other single consonants and [jC] sequences in Old Catalan, and thus in the case of *era* than in that of *prendré*, *més*, *freixe*, or *fet* (see Appendix 2.2; Rasico 1982).

(ii) Let us now turn to the front vowels [e ɛ]. In comparison to the other vowels, [e] shows a smaller F2 frequency distance between consonant sequences and single palatals, and thus less C-to-V coarticulation. Less context-dependent F2 frequency dispersion for this than other vowels (see Figure 5) is consistent with [e] being highly reluctant to undergo assimilatory raising. The consonantal coarticulatory effects could account perhaps for why [ʎ] or [ɲ], which cause both [e ɛ] to exhibit a relatively low F2, may disfavor the raising of [ɛ] but not for why they may favor the raising of [e] (Section 2.6.1.2 and Appendix 1 and 3). The sequence [bj], which may trigger [e] raising, causes the vowel to exhibit a relatively high F2.

(iii) Regarding back rounded vowels, the coarticulatory data appear to be largely in agreement with [o] raising taking place before single palatals rather than before consonant sequences given that the vowel F2 frequency is lower in the former contextual condition than in the latter. However, contrary to the relation between C-to-V coarticulatory effects and the vowel assimilation data referred to in Section 2.6.1.2, F2 during [o] and to a large extent [ɔ] does not seem to be particularly low (and thus more [u]-like) before consonant sequences and single consonants involving more dorsopalatal contact than before those showing less contact and thus lower before [jt] vs [jɾ jz bj] and before [ɲ ɟ] vs. [ʎ ʃ]. A possible interpretation of these data along the lines suggested in Section 2.4 will be provided in Section 4.

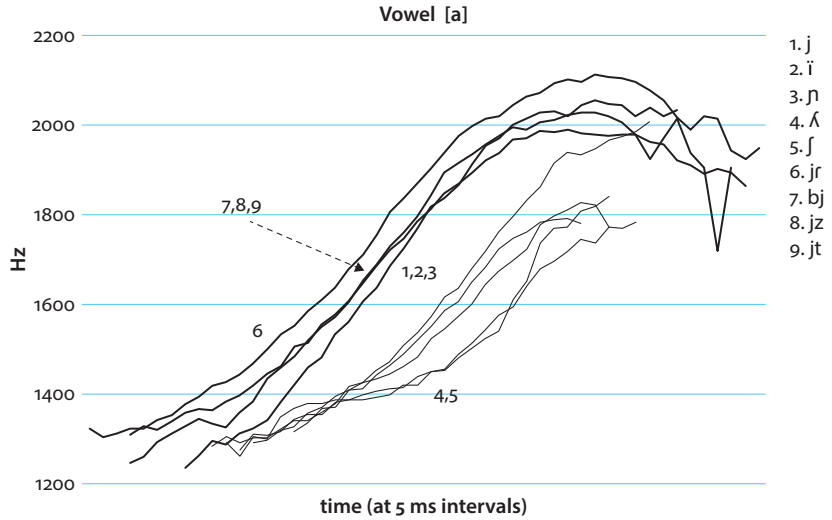

Figure 4. F2 trajectories from onset to offset of [a] as a function of the following palatal consonant or [jC] sequence. The line up point (not shown) has been inserted at the vowel midpoint

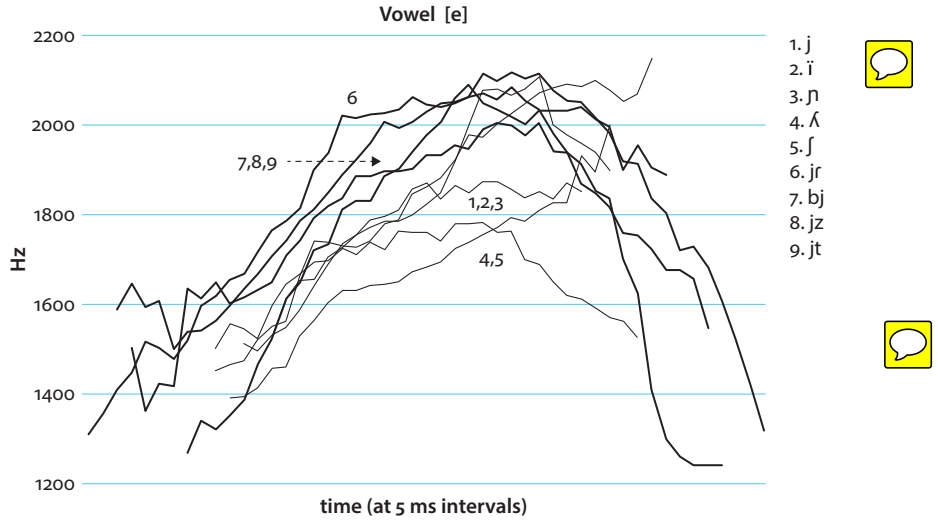

Figure 5. F2 trajectories from onset to offset of [e] as a function of the following palatal consonant or [jC] sequence. The line up point (not shown) has been inserted at the vowel midpoint

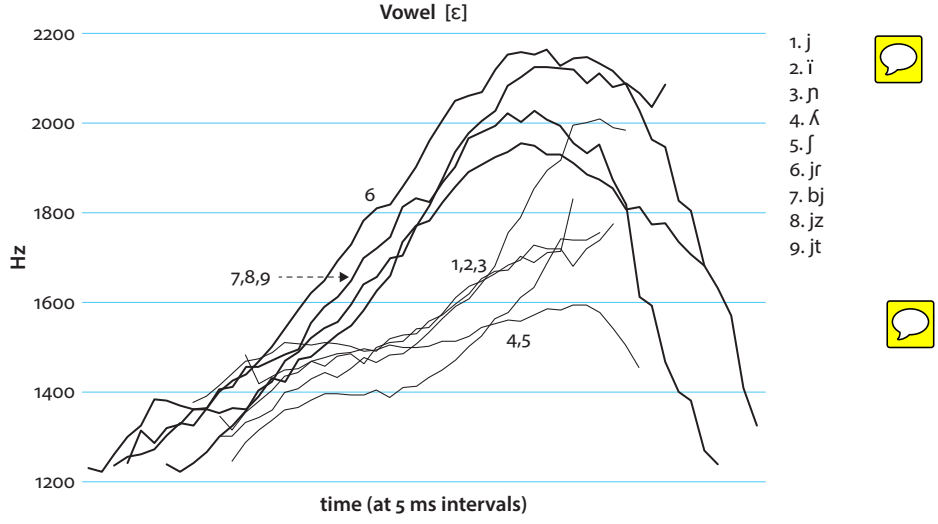

Figure 6. F2 trajectories from onset to offset of [ɛ] as a function of the following palatal consonant or [jC] sequence. The line up point (not shown) has been inserted at the vowel midpoint.

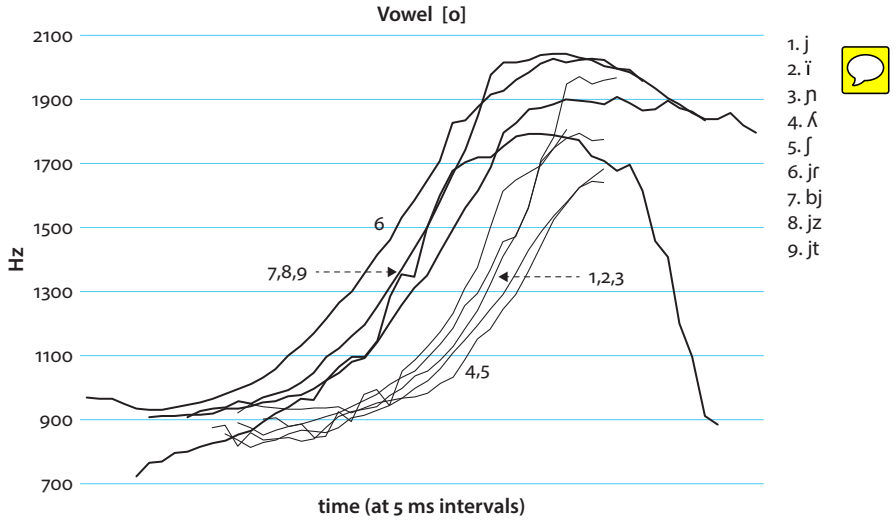

Figure 7. F2 trajectories from onset to offset of [o] as a function of the following palatal consonant or [jC] sequence. The line up point (not shown) has been inserted at the vowel midpoint

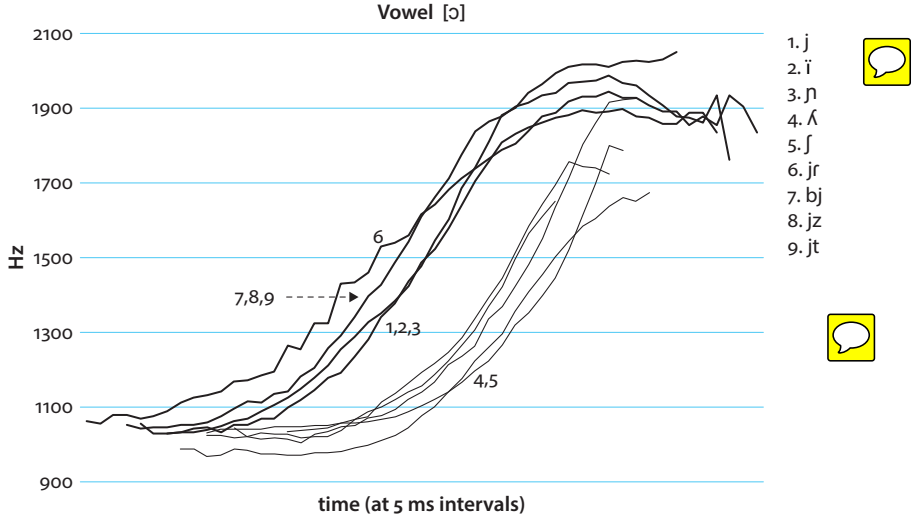

Figure 8. F2 trajectories from onset to offset of [ɔ] as a function of the following palatal consonant or [jC] sequence. The line up point (not shown) has been inserted at the vowel midpoint

3. Italian and Romansh

Mid and low vowel assimilation before single palatal consonants may also occur in Italian and Romansh, albeit to a lesser extent than in the languages reviewed in Section 2. Italian shows no [a] raising cases before the contextual consonants of interest (*faggio* FAGEU 'beech', *fascio* FASCE 'sheaf', *rabbia* RABIE 'rage').[5] Regarding mid high vowels, [e] may have shifted to [i] before [ʎ ɲ] but not before [ɟ ʃ] (*consiglio* CONSILIU 'advice', *ferrigno* FERRINEU 'ferrous', but *legno* LIGNU 'wood', *re* REGE 'king', *pesce* PISCE 'fish'), while the change [o] > [u] may have taken place before [ɲ bj] but not before [ʎ ɟ ʃ] (*pugno* PUGNU 'fist', *dubbio* DUBIU 'doubt', but *ginocchio* GENUCULU 'knee', *vergogna* VERECUNDIA 'shame', *angoscia* ANGUSTIA 'anguish', 17th c. *stoggio* STUDIU 'affectation').[6] On the other hand, the mid low vowels [ɛ] and [ɔ] may have raised to [e] and [o] only before [ɲ]; thus, there is [e] in *convegno* CONVENIO 'convention' and [o] in *sogno* SOMNIU 'dream', but [ɛ] in *meglio* MELIOR 'better', *peggio* PEIOR 'worse', and *esce* EXIT 'he/she leaves', and [ɔ] in *foglia* FOLIA 'leaf', *oggi* HODIE 'today', and *coscia* COXA 'thigh'. These data support the notion that single palatals may affect mid high vowels but not [a], and that [ɲ] may exert a stronger coarticulatory influence than [ʎ ʃ] on mid vowels in line with differences in dorsopalatal contact involved during the production of these consonants (Section 2.1).

Northern Italian dialects differ from Tuscan Italian and parallel other Romance languages in that they may show [a] raising to [ɛ] before consonant sequences with C1 = [j] (Piedmontese, Lombard, Emilian *era* AREA 'area', Lombard [lɛtʃ] LACTE 'milk', Ligurian *ègua* ACQUA 'water'). Moreover, in contrast with the scenario for Early Romance described in Section 2.6.1.2, low vowel raising has also operated before simple palatals perhaps since, as suggested by the shifting of [a] to [ɛ] in open syllables in the same dialectal area, [a] could have been especially anterior and thus [ɛ]-like at the time that the assimilatory process occurred (*mè* MAGIS 'more', Lombard [ʃkɛɲ] SCAMNU 'stool' and [brɛtʃ] BRACCHIU 'arm'; Rohlfs 1966: 35–36, 39–42). Also in contrast with Tuscan Italian and analogously to Catalan, Occitan, and French, [ɛ ɔ] have diphthongized before a palatal consonant in Northern Italian dialects: [ɛ] yielded [je] (Ligurian, Venitian [ˈvjedʒa] VECLA 'old, fem.', Lombard *sies* SEX 'six', Venitian *pieto* PECTU 'chest', Ligurian *viegne* VENIT 'he/she comes' and *piezo* 'peggio' 'worse'), while [ɔ] yielded [ø] through the development [ɔ] > [wɔ] > [we] > [ø] (Lombard [øʎ] OC(U)LU 'eye',

5. Vowel inflection cannot be analyzed before the outcome [jt] of Latin [kt] in Tuscan Italian since this stop cluster underwent regressive assimilation into [tt] in this dialect (*latte* LACTE).

6. It is assumed that [kj] in *ginocchio* GENUCULU derived from the original cluster [kl] through the evolution [kl] > [kʎ] > [kj]. See also Section 2.2.1.

[ˈtøsi]TOXICU 'poisonous', and [søɲ] SOMNIU 'dream', Ligurian, Piedmontese [ˈtɾøja] TROIA 'sow', Piedmontese [nøtʃ] NOCTE 'night'). The fact that this diphthongization process has not operated on [ɛ] and [ɔ] in other segmental context conditions in some of the Northern Italian dialects of interest suggests that mid low vowel diphthongization was indeed triggered by the following palatal consonant and therefore did not occur spontaneously.

In Romansh dialects, i.e. Surselvan, Sutselvan, Surmeiran, and Engadinian (Caduff 1952, Lutta 1923, Pult 1897, Luzi 1904), [ɛ ɔ] also diphthongized into [je wɔ] before a single palatal consonant or a [jC] sequence. At a later date and as exemplified for several consonant environments as follows, [je] could shift to [i] or simplify into [e], and [wɔ] could raise to [uj] or else front to [ø] or [e] through the intermediate diphthong [we]: [ʎ] ([viʎ], [veʎ] VECLU 'old'; [ˈf(w)eʎa], [ˈføʎa] FOLIA 'leaf'); [ɲ] ([inˈdʒiɲ] INGENIU 'complete', [baˈzeɲts], [baˈziɲts], [bzøɲ] *BISONIU); [ɟ] (*pir* PEIOR 'worse', *m(i)ets* MEDIU 'half'; [ˈpwedza] PODIU 'platform', [møts]MODIU 'a dry measure'); [ʃ] (*s(e)is* SEX 'six'; [ˈkujʃa], [ˈkweʃa] COXA 'thigh'); [jɾ] (*e/antir* INTEGRU 'complete'; [c]*er*, [c]*ir* CORIU 'leather'); [jt] ([litʃ], [lec] LECTU 'bed'; [nwets] NOCTE 'night'). There are reasons to believe that vowel diphthongization has also been triggered by contextual palatal consonants in Romansh, namely, the fact that [ɔ] has not diphthongized in open or closed syllables (Surselvan *roda*, *mort*, and similarly Sutselvan, Surmeiran, and Engadinian), and that [ɛ] breaking into [ˈia ja] has applied only before opening consonants such as the alveolar lateral and the alveolar rhotic (Surmeiran [ˈtiaˌl] CAELU 'heaven', [ˈɛaˌrva] HERBA 'grass').

4. Discussion and conclusions

This study provides some support for the view that vowel assimilation as a function of palatal consonants is positively associated with the prominence of the coarticulatory effects in tongue dorsum height and in F2 frequency exerted by the consonant on the vowel. Low [a], mid high back [o], and even mid low [ɛ ɔ] have been found to undergo assimilation more often than mid front [e] apparently because they exhibit more articulatory/acoustic space for the implementation of the consonant-induced tongue dorsum raising gesture. The latter vowel shows few assimilation cases presumably since it allows F2 coarticulatory effects of little salience as a function of the following palatal consonant.

The present data interpretation differs in important respects from Menéndez Pidal's account of vowel inflection by palatal consonants in Old Spanish (Menéndez Pidal 1968: 49). I believe that Menéndez Pidal was right in attributing the small number of [e] assimilations to the articulatory affinity between this vowel and

palatal consonants. However, I do not think that vowel raising occurred more often in the case of [a] than of [o] because the articulatory configuration for the low vowel happens to be more distant from that of the consonant (see Pensado 1985 for a similar view), and that these vowel-dependent differences in frequency of assimilation should be indicative of the fact that vowel inflection occurred later for [a] than for [o]. As shown in Sections 2.4 and 2.6.1.1, the acoustic distance between [a] and [o] and palatal consonants is even larger for [o] than for [a], regressive assimilation took place about 40–50% of the time for both [a] and [o] in Early Romance, and the assimilatory patterns for the two vowels appear to conform to articulatory factors to a large extent. Indeed, assimilatory trends and coarticulatory effects appear to be mostly favored by gestural independence between C1 and C2 in consonant sequences with [j] in the case of [a], and by single palatals in the case of [o]. The presence of a higher F2 for consonant sequences with [j] than for single palatals during the two vowels is in agreement with vowel raising occurring most often before the former in the case of [a] and before the latter in the case of [o].

It should be pointed out however that the raising action of [o] is not as straightforward as that of the low vowel since, while single palatal consonants cause [o] to exhibit a lower F2 and thus to acquire a more [u]-like quality than [jC] sequences, this formant frequency is still too high to approach the appropriate F2 frequency for [u] (i.e., according to Figure 7, F2 for [o] before single palatals is about 1100 Hz while F2 for [u] is about 800 Hz). As suggested in Section 2.4 , in order to account for this complication it may be hypothesized that the change /o/ > [u] may be implemented through an intermediate high central [ɯ]-like realization which may be categorized as /u/ by listeners of languages where this vowel has no phonemic status. It may be that the F2 frequency of this centralized or central vowel needs to be low enough to be identified as /u/, which may explain why the change /o/ > [u] occurred before consonants triggering some but not too much F2 raising and thus before single palatals produced with considerable dorsopalatal contact rather than before [jC] sequences (F2 for [ɯ] may range between 1100 Hz and 1700 Hz according to data from the literature; Kiliç & Öğüt 2004).

Other relevant aspects regarding vowel assimilation appear also to be in line with the C-to-V coarticulation patterns both in the case of simple palatals (i) and of consonant sequences (ii).

(i) Regarding simple palatals, an important prediction was that vowel raising should be more prone to occur before consonants showing more vs. less dorsopalatal contact and triggering a higher vs. lower vowel F2, and thus that it ought to vary with the following consonant in the progression [j] > [c ɟ] > [ɲ] > [ʎ ʃ]. Assuming that [ʃ] may take an on-glide and thus may act as a

sequence rather than as a single consonant, the above scale could be reformulated as [j] > [c ɟ] > [ɲ] > [ʎ].

Several vowel assimilation cases in Early Romance appear to be consistent with this hierarchy scale: in all or most languages under analysis, [a] raising has taken place more or less often depending on the following palatal consonant in the progression [j ʃ] > [ɟ] > [ʎ ɲ]; [ɛ] and [ɔ] raising may have failed to apply essentially before [ʎ] and [ɲ], respectively, in languages where these vowels did not diphthongize before a palatal consonant; in French, [ʎ] and/or [ɲ] failed to trigger the raising of [jɛ wɔ] derived from [ɛ ɔ] to a high vowel (Section 2.3.3). The Tuscan Italian data are only in partial agreement with this articulatory account in that the sound changes [ɛ ɔ] > [e o] and [o] > [u] have operated before [ɲ] but not before [ʎ ɟ ʃ], and that [e] has shifted to [i] before [ʎ ɲ] but not before [ɟ ʃ] (Section 3).

The reluctance on the part of [c] to induce changes in the preceding low or mid vowel may be related to the fact that, whether realized as a palatal stop or as [ts], the consonant was too anterior in Early Romance to cause the preceding vowel to raise. This articulatory characteristic could account for why, when occurring in this consonant environment, mid and low vowels did not shift to a high and mid vowel, respectively (Fr. *pièce*, *nièce* 'niece', *face* FACIE 'face', *place* PLATEA 'square', *paresse* PIGRITIA 'laziness', Sp. *amenaza* MINACIA 'menace', *maleza* MALITIA 'weeds'), and also why [ɛ ɔ] diphthongized instead of becoming [e o] in Spanish (*fuerza* FORTIA 'force', *pieza* PETTIA 'piece').

Other vowel assimilation trends for VC sequences with simple palatals do not clearly agree with the F2 coarticulation data and thus with our initial prediction. Thus, while [o] raising was found to vary with the consonant in the progression [ɲ ɟ] > [ʃ] > [ʎ], no clear F2-dependent differences were found to occur as a function of these consonants or else this vowel formant frequency was lower, not higher before [ʎ ʃ] than before [ɲ ɟ] (see in any case a possible account of this presumable inconsistency above in this same section). It also remains unclear why [e] has been prone to raise to [i] before [ʎ] (also before [ɲ]) and thus a consonant which does not exhibit much dorsopalatal contact and thus also an especially high F2 frequency.

(ii) As for consonant sequences, there could also be a positive relationship between assimilation and coarticulation in the fact that [a] inflection is most prone to occur before [jɾ] (gestural independence between C1 and C2 is particularly high in the case of this consonant sequence), while [o] inflection takes place most often before [jt] (in comparison to the other consonant sequences, [jt] involves more dorsopalatal contact and less gestural independence between C1 and C2). The F2 data reported in this study are consistent with the former trend ([jɾ] triggers a higher vowel F2 than other [jC] sequences) and to some

extent with the latter mostly so if we assume that [t] could be more or less palatalized when occurring after [j] ([jt] may trigger a lower vowel F2 than other [jC] sequences).

However, the behavior of [bj] needs to be accounted for. This consonant sequence has been reluctant to trigger the raising of [a] in Early Romance with the exception of Spanish, where the low vowel was followed by the metathesized variant [jb]. As for mid vowels, [bj] may have prevented [ɔ] from undergoing diphthongization and [e o] from raising in Catalan, Occitan, and French, but not [e] and [o] from raising in Spanish and Portuguese and [o] in Tuscan Italian, respectively. A possible articulation-based account of this assimilatory behavior is that vowel assimilation was more prone to apply in languages where [bj] maintained the glide (Spanish, Portuguese, Tuscan Italian) than in those where it was resolved early into [(d)ʒ] whose production does not involve much dorsopalatal contact and is essentially the phonetic realization that we find today (in French and to some extent in Occitan and Catalan).[7] These data also suggest that [bj] may have been realized as [(d)ʒ] rather as [ʝ] at the time that the vowel changes of interest occurred in the three latter languages.

The articulation-based approach taken in the present study complements previous accounts proposed in the literature based on chronological, etymological, analogical, or phonological factors. Thus, as argued earlier in this section, the fact that vowel raising applied to a greater or lesser extent in Early Romance does not seem to depend necessarily on whether the palatal consonant was preceded by an onglide for a longer or shorter period of time among other things because there is no reason to suppose that a [j]-like segment was ever preposed to consonantal realizations such as [ʎ ɲ c ʝ]. Also, vowel raising failed to operate before [ʎ ɲ] in French not necessarily because the vowel was situated in a closed syllable (see Section 1.2), but since these consonants, mostly [ʎ], did not have enough coarticulatory strength to trigger the change. Indeed, in this language, assimilation also took place before [jC] in a considerable number of instances where the target vowel occurred in a checked syllable; moreover, the two consonants [ʎ] and [ɲ] failed to induce the raising of [a] in all Romance languages subject to investigation and not only in French, as well as the raising of [ɛ ɔ] or of their diphthongal outcomes [jɛ wɔ] in a good number of cases (Fr. *vieil* VECLU 'old', Old French *engiegne* INGENIAT 'he/she designs', *orgueil* *URGOLI 'pride', though Old Fr. *pigne* PECTINE 'comb'). An articulatory account of all these phenomena is in line with

7. A distinction needs to be made between words like RABIA and RUBEU where the phonetic outcomes in Romance derive from [bj], and the words for 'rain' which go back to PLUVIA in Spanish and Portuguese but presumably to *PLOIA in Catalan, Occitan, and French.

production data showing that [ʎ] is more anterior and involves less dorsopalatal contact than [ɲ ʝ j] but also that [ɲ] may exhibit a more anterior closure and less tongue dorsum contact than [ʝ j]. It has also been argued that the reason why vowel assimilation failed to occur before [c] derived from [k:j t:j] and before [bj] may not be related to syllable structure either, namely, to the fact that the vowel was checked by a geminate stop in the former case and by a syllable-final labial stop in the latter. Assuming that all those sequences were realized as anterior palatal stops or as affricates at the time that inflection took place, the process in question may have failed to occur because the contextual consonants in question were too anterior and did not have enough dorsopalatal contact.

The findings reported in this paper are relevant to the theoretical aspects about sound change referred to in Section 1.1. A major conclusion is that, as shown in other studies, the analysis of phonetic detail is crucial for achieving a proper understanding of the causes of sound change or at least for formulating appropriate hypotheses for their identification and subsequent evaluation. Along these lines the implementation of a good number of vowel assimilation processes described in the present paper appears to depend on the size of the C-to-V coarticulatory effects such that the larger the effect, the higher the chances that the assimilatory process will take place. This regularity may also account for why to a large extent the probability that vowels of different qualities undergo assimilation tends to increase with the articulatory and acoustic distance that these vowels show with respect to the contextual palatal consonant. Another illustrative case is that of [a] assimilation, which applies most frequently before [jC] sequences (mostly [jɾ]) and least often before [ʎ ɲ], in line with context-dependent differences in F2 frequency and tongue dorsum raising during the vowel.

As pointed out in the Introduction, hypocorrection may explain why prominent anticipatory effects such as those exerted by palatal consonant on preceding low and mid vowels may be categorized as a higher vowel by listeners. In Early Romance, this assimilatory change took place at a time in which palatal consonants were being formed and becoming fully integrated in the phonological system of the language. Following current approaches to the study of sound change there may have been an element of surprise involved in this assimilatory change and the prominence of the acoustic cues for the palatal consonants in question may have also contributed to its implementation (Hume & Mailhot 2013; Section 1.1). This possibility could also account for why the vowel shifts of interest operated on commonly used words but did not extend to other contextual conditions in other words of the language.

5. Summary

This study has adduced some evidence in support of the relation between anticipatory coarticulation and vowel raising/fronting assimilation and diphthongization in VC sequences with palatal consonants and [j] + dentoalveolar consonant sequences in Early Romance. To a large extent descriptive data on the assimilatory phenomena of interest appear to be in agreement with differences in F2 height during the vowel and in closure fronting, dorsopalatal contact, and gestural independence among the contextual consonantal segments subject to analysis. Several findings are consistent with the initial hypothesis that the chances that vowel assimilation applies are directly conditioned by the nature and size of the related C-to-V coarticulatory effects. For example, as expected, [a] raising turns out to occur most frequently before [j] + dentoalveolar sequences and before palatals involving maximal dorsal contact, while [o] raising is most prone to take place in the latter contextual condition. Additional explanations have been proposed in order to account for the coarticulatory and assimilatory behavior of specific VC sequences such as those with [c] and [bj].

The phonetic account of vowel assimilation reported in the present investigation supports the notion that phonetic detail should contribute to improve our knowledge about the strategies used by listeners for the phonemic categorization of segmental coarticulatory effects, and complements other explanatory proposals for vowel inflection by palatal consonants in Early Romance based on syllabification, chronological, and etymological factors.

Further work should involve the statistical quantification of more extensive lexical and acoustic databases than those used in the present study and a more thorough investigation of whether the frequency load of the different palatal consonants across the lexicon may have had any relevant effect on regressive vowel assimilation in the Romance languages.

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Appendix

This Appendix includes lexical variants with a stressed mid or low vowel which has (ASS) or has not (NO ASS) assimilated to a following palatal consonant in Early Romance. The target stressed vowel is represented in boldface or in phonetic transcription. In the former event, the following grapheme-sound correspondences hold: (Spanish, Catalan, Occitan, Portuguese) *e* = [e], *e̲* = [ɛ]; *o* = [o], *o̲* = [ɔ]; *u* = [u]; *ei, ey* = [ej]; *ai* = [aj]; *au* = [aw]; *oi* = [oj]; *ui, uy* = [uj]; *ie* = [je], *ie̲*, *ie̲i* = [jɛ], [jɛj]; *ue* = [we], *ue̲*, *ue̲i* = [wɛ], [wɛj], *uo̲*, *uo̲i* = [wɔ], [wɔj]; (French) *e̲*, *ai* = [ɛ], but [a] when *ai* is followed by [ʎ]; *o̲* = [ɔ]; *u* = [y]; *oi* = [wa], [wɛ̃]; *ou* = [u]; *oui* = [uj]; *ui* = [ɥi]; *ie* = [je], *ie̲* = [jɛ]; *ue*, *eu* = [œ].[8] A considerable number of Occitan lexical forms with stressed [o] existed in Old Occitan prior to the spontaneous raising of this vowel to [u] and its later fronting to [y]. In Lisbon Portuguese, stressed [e] has shifted to [ə] before a palatal consonant (Mateus & d'Andrade 2000).

8. Data presented in this Appendix have been taken from several sources: all languages (Meyer Lübke 1911); Spanish (Menéndez Pidal 1968, Corominas & Pascual 1980–1991); Catalan (Badia 1951, Coromines 1980–1991); Occitan (Alibèrt 1966, Anglade 1921, Levy 1909); Portuguese (Williams 1962); French (Pope 1934, Fouché 1952–1961, Wartburg 1922–).

1. Mid high [e] (Ē, Ĭ) and [o] (Ō, Ŭ)

1.1 Spanish

[e]$_{\text{ASS}}$	[bj]	*ji**b**ia* SEPIA, *li**m**pio* LIMPIDU, *ven**d**imia* VINDEMIA
[e]$_{\text{NO ASS}}$	[ʎ]	*ce**j**a* CILIA, *cons**e**jo* CONSILIU, *ab**e**ja* APICULA, *re**j**a* REGULA
	[ɲ]	*se**ñ**a* SIGNA, *le**ñ**a* LIGNA
	[ɟ]	*pere**z**a* PIGRITIA, *ve**a*** VIDEAT, *corre**a*** CORRIGIA
	[jt]	*estre**ch**o* STRICTU, *dere**ch**o* DIRECTU, *te**ch**o* TECTU
	[jɾ]	*fe**r**ia* FERIA
	[jz]	*cer**v**eza* CERVESIA
	[bj]	*se**p**ia* SEPIA
[o]$_{\text{ASS}}$	[ɲ]	*pu**ñ**o* PUGNU, *cu**ñ**o* CUNEU, *terru**ñ**o* TERRONEU, *escalu**ñ**a* ASCALONIA
	[ɟ]	*hu**y**o* FUGIO, *estu**ch**e* STUDIU
	[ʃ]	*emp**u**ja* IMPULSAT
	[jt]	*l**u**cha* LUCTA, *tr**u**cha* TRUCTA, *m**u**cho* MULTU, *esc**u**cha* AUSCULTAT, *b**u**itre* VULTURE, *c**u**it/da* COGITAT
	[bj]	*r**u**bio* RUBEU, *ll**u**via* PLUVIA
[o]$_{\text{NO ASS}}$	[ʎ]	*hin**o**jos* GENUCULOS, *cosc**o**jo* CUSCULIU, *pi**o**jo* PEDUCULU *desp**o**ja* DESPOLIAT, *m**o**ja* MOLLIAT
	[ɲ]	*escal**o**ña* ASCALONIA, *ot**o**ño* AUTUMNU; Old Sp. *cal**o**ña* CALUMNIA
	[ɟ]	*arr**o**yo* ARRUGIA, *p**o**zo* PUTEU.

1.2 Catalan

[e]$_{\text{ASS}}$	[ɲ]	*t**i**nya* TĬNEA
[e]$_{\text{NO ASS}}$	[ʎ]	*cons**e**ll* CONSILIU, *c**e**lla* CILIA
	[ɲ]	*ll**e**nya* LIGNA
	[ɟ]	*r**ei*** REGE, *mal**e**sa* MALITIA, *per**e**sa* PIGRITIA, *corr**e**tja* CORRIGIA
	[ʃ]	*p**ei**x* PISCE
	[jt]	*dr**e**t* DIRECTU, *estr**e**t* STRICTU
	[jz]	*cerv**e**sa* CERVESIA
	[bj]	*ver**e**ma* VINDEMIA, *s**é**pia* SEPIA
[o]$_{\text{ASS}}$	[ɲ]	*c**u**ny* CUNEU, *p**u**ny* PUGNU, *j**u**ny* JUNGIT, *m**u**ny* *MUNGIT
	[ɟ]	*f**u**jo* FUGIO, *rebu**i**g* REPUDIU
	[jt]	*ll**u**ita* LUCTA, *tr**u**ita* TRUCTA, *c**u**ida* COGITAT
[o]$_{\text{NO ASS}}$	[ʎ]	*cosc**o**ll* CUSCULIU, *p**o**ll* PEDUCULU, *gen**o**ll* GENUCULU

	[ɲ]	*verg**o**nya* VERECUNDIA, *cig**o**nya* CICONIA, *cod**o**ny* COTONEU
	[ɟ]	*est**o̲i**g* STUDIU
	[ʃ]	*b**oi**x* BUXU, *m**oi**x* MUSTIU, *ang**oi**xa* ANGUSTIA
	[jɾ]	*tis**o**res* TONSORIAS, *volt**o**r* VULTURIU
	[bj]	*r**o̲i**g* RUBEU

1.3 Occitan

[e] $_{\text{ASS}}$	[ʎ]	*merav**i**lha* MIRABILIA, *c**i**lha* CILIA, *rov**i**lh* RUBICULU, *m**i**lh* MILIU
	[ɲ]	*l**i**nh* LIGNU, *t**i**nha* TINEA
[e]$_{\text{NO ASS}}$	[ʎ]	*c**e**lha* CILIA, *aur**e**lha* AURICULA, *t**e**lh* TILIU, *m**e**lh* MILIU, *som**e**lh* SOMNICULU, *ab**e**lha* APICULA, *merav**e**lha* MIRABILIA, *cons**e**lh* CONSILIU
	[ɲ]	*t**e**nha* TINEA, *l**e**nh* LIGNU, *t**e**nh* TINCTU, *d**e**nh* DIGNU
	[ɟ]	*corr**e**ja* CORRIGIA, *r**e**i* REGE
	[jsʲ]	*cr**ei**sser* CRESCERE, *p**ei**s* PISCE
	[jt]	*dr**ei**t*, *dr**e**ch* DIRECTU, *estr**ei**t*, *estr**e**ch* STRICTU
	[jz]	*cerv**e**sa* CERVESIA
	[bj]	*vend**e**mia* VINDEMIA, *s**e**pia*, *s**e**pcha* SEPIA
[o]$_{\text{ASS}}$	[ɲ]	*p**u**nh* PUGNU, *c**u**nh* CUNEU, *j**u**nher* IUNGERE
	[ɟ]	*est**u**g*, *est**u**it* STUDIU, *ref**u**g* REFUGIU
	[jt]	*l**u**ta*, *l**u**cha* LUCTA, *c**u**ida*, *c**u**ja* COGITAT
	[jɾ]	*l**u**(i)ria* LUTRA
[o]$_{\text{NO ASS}}$	[ʎ]	*gen**o**lh* GENUCULU, *pes**o**lh* PEDUCULU, *cosc**o**lha* CUSCULIU
	[ɲ]	*p**o**nh* PUGNU, *c**o**nh* CUNEU, *cod**o**nh* COTONEU, *j**o**nher* IUNGERE, *verg**o**nha* VERECUNDIA, *cig**o**nha* CICONIA
	[ɟ]	*est**o**ch* STUDIU, *m**o̲g**, m**o̲i**(t)* MODIU
	[jsʲ]	*ang**oi**ssa* ANGUSTIA, *m**oi**s* MUSTEU, *b**oi**s* BUXU
	[jt]	*l**oi**ta*, *l**o**cha* LUCTA, *tr**oi**ta*, *tr**o**cha* TRUCTA
	[jɾ]	*dormid**o**r* DORMITORIU, *l**oi**ra* LUTRA, *volt**o**r* VULTURIU, *tos**oi**ras* TONSORIAS
	[bj]	*r**o**g*RUBEU.

1.4 Portuguese

[e]$_{\text{ASS}}$	[ʎ]	*m**i**lho* MILIU, *marav**i**lha* MIRABILIA
	[ɲ]	*t**i**nha* TINEA
	[bj]	*s**i**ba* SEPIA, *vind**i**ma* VINDEMIA, *t**í**bio* TEPIDU

[e]$_{\text{NO ASS}}$	[ʎ]	*ce**l**ha* CILIA, *cons**l**ho* CONSILIU, *te**l**ha* TEGULA, *abe**l**ha* APICULA, *ore**l**ha* AURICULA, *arte**l**ho* ARTICULU
	[ɲ]	*estame**n**ha* STAMINEA, *empe**n**hos* from *IMPIGNARE, *le**n**ha* LIGNA
	[ɟ]	***rei*** REGE, *ve**j**o* VIDEO
	[ʃ]	*pe**i**xe* PISCE, *cre**s**ce* CRESCIT, *me**x**o* MISCEO
	[ʒ]	*cer**v**eja* CERVESIA
	[jt]	*estr**ei**to* STRICTU, *b**e**nto* BENEDICTU
	[jɾ]	*fe**i**ra* FERIA, *mist**e**rio* MYSTERIU, *most**ei**ro* MONASTERIU
[o]$_{\text{ASS}}$	[ɲ]	*c**u**nho* CUNEU, *testem**u**nho* TESTIMONIU, *p**u**nho* PUGNU, *cara-m**u**nha* QUERIMONIA
	[ɟ]	*f**u**jo* FUGIO
	[jt]	*entr**u**do* INTROITU, *l**u**ta* LUCTA, *tr**u**ta* TRUCTA, *esc**u**to* AUSCULTO, *m**ui**to* MULTU, *ab**u**tre*VULTURE, *c**ui**do* COGITO
	[bj]	*ch**u**va* PLUVIA, *r**ui**vo* RUBEU
[o]$_{\text{NO ASS}}$	[ʎ]	*pi**o**lho* PEDUCULU, *jo**e**lho* < *ge**o**lho* GENUCULU, *m**o**lha* MOLLIAT
	[ɲ]	*ceg**o**nya* CICONIA, *ris**o**nho* *RISONEU, *verg**o**nha* VERECUNDIA
	[ɟ]	*est**o**jo* STUDIU
	[ʃ]	*r**o**xo* RUSSEU, *cong**o**xa* ‘anguish’
	[jɾ]	*ag**oi**ro* AUGURIU, *salm**oi**ra* SALE MURIA, *tes**oi**ra* TONSORIA
	[bj]	*c**oi**ma* CALUMNIA, *g**oi**va* GUBIA.

1.5 French

[e]$_{\text{ASS}}$	[ʎ]	*c**i**l* CILIU, Old Fr. *til* TILIA
[e]$_{\text{NO ASS}}$	[ʎ]	*cons**e**il* CONSILIU, *verm**e**il* BERMICULU, *merv**e**ille* MIRABILIA, *v**e**ille* VIGILAT, *par**e**il* PARICULU, *somm**e**il* SOMNICULU, *or**e**ille* AURICULA, *ab**e**ille* APICULA
	[ɲ]	*t**e**igne* TINEA, *ens**e**igne* INSIGNIA, *d**e**igne* DIGNAT
	[ɟ]	***roi*** REGE, ***loi*** LEGE, *pl**oi**e* PLICAT, *courr**oi**e* CORRIGIA, *par**e**sse* PIGRITIA
	[jsʲ]	*cr**oî**t* CRESCIT
	[jt]	*t**oi**t* TECTU, *etr**oî**t* STRICTU, *dr**oi**t* DIRECTU
	[jɾ]	*f**oi**re* FERIA
	[jz]	*cerv**oi**se* CERVESIA, *arm**oi**se* ARTEMISIA
	[bj]	*s**è**che* SEPIA
[o]$_{\text{ASS}}$	[ɟ]	*f**ui**s* FUGIO, *ét**ui*** STUDIU, *m**ui**d* MODIU, *p**ui**ts* PUTEU
	[jsʲ]	*b**ui**s* BUXU
	[jt]	*tr**ui**te* TRUCTA, *l**u**tte* LUCTA; Old Fr. *c**ui**de* COGITAT

[o]$_{\text{NO ASS}}$	[ʎ]	*fen**ou**il* FENUCULU, *gren**ou**ille* *RANUCULA, *gen**ou*** GENUCULU, ***p**ou* PEDUCULU, *c**ou**ille* COLEU
	[ɲ]	*char**o**gne* *CARONIA, *verg**o**gne* VERECUNDIA, *bes**o**gne* *BISUNNIA, *Gasc*[ɔ]*gne* VASCONIA, ***c**oin* CUNEU, ***p**oing* PUGNU
	[ɟ]	*cr**oix*** CRUCE, ***n**oix* NUCE, ***v**oix* VOCE
	[jsʲ]	*ang**oisse*** ANGUSTIA; Old Fr. *con**oist***‘connaît’ COGNOSCIT, ***b**ois* BUXU
	[jt]	Old Fr. ***d**oit* DUCTU
	[jɾ]	*gl**oire*** GLORIA, *hist**oire*** HISTORIA, *ras**oir*** RASORIU, *dort**oir*** DORMITORIU; Old Fr. *tes**oire*** TONSORIA
	[jz]	***n**oise* NAUSEA
	[bj]	***r**ouge* RUBEU.

2. Vowel [a]

2.1 Spanish

[a]$_{\text{ASS}}$	[ɟ]	*-**é**n* -AGINE, *m**e**go* MAGICU
	[ʃ]	*t**e**jo* TAXU, ***e**je* AXE, *fr**e**sno* FRAXINU, *mad**e**ja* MATAXA
	[j]	*cant**é*** CANTAVI, Old Sp. *f**e**r* *FAIRE
	[jt]	*l**e**che* LACTE, *h**e**cho* FACTU
	[jɾ]	*en**e**ro* IANUARIU
	[jz]	*b**e**so* BASIU, *qu**e**so* CASEU
	[bj]	*qu**e**pa* CAPIAT, *s**e**pa* SAPIAT
[a]$_{\text{NO ASS}}$	[ʎ]	*p**a**ja* PALEA, ***a**jo* ALIU
	[ɲ]	*extr**a**ño* EXTRANEU, *ar**a**ña* ARANEA
	[c]	*l**a**cio* FLACCIDU
	[ɟ]	*r**a**yo* RADIU, *ens**a**yo* EXAGIU, *h**a**ya* FAGEA, *m**a**yo* MAIU
	[ʃ]	*c**a**ja* CAPSA, *f**a**ja* FASCIA, *h**a**z* FASCE
	[bj]	*r**a**bia* RABIA.

2.2 Catalan

[a]$_{\text{ASS}}$	[j]	*prendr**é*** PRENDERE + AYO, ***h**e* AYO, ***s**é* *SAYO, Old Cat. *cant**é*** CANTAVI
	[ʃ]	*fr**ei**xe* FRAXINU, *t**ei**x* TAXU, *mad**ei**xa* MATAXA, *t**ei**xell* TAXILLU, ***ei**x* AXE, *s**ei**x* SAXU, *qu**ei**x* *CAPSEU, *f**ei**x* FASCE, *p**éi**xer* PASCERE, *n**éi**xer* NASCERE, *gr**ei**x* GRASSEU, *x**ei**xa* *SASSIA
	[jt]	*f**e**t* FACTU, *ll**e**t* LACTE, *tr**e**t* TRACTU, *guar**e**t* VERACTU

	[jɾ]	*carrera* CARRARIA, ***e**ra* AREA, cat. ant. *qu**e**r* *CARIU, *f**e**r**e*FAIRE; Old Cat. *tr**e**r* TRAHERE
	[js]	*m**é**s* MAGIS
	[jz]	*b**e**s* BASIU, *cir**e**ra* CERASIA
[a]$_{\text{NO ASS}}$	[ʎ]	*pa**l**la* PALEA
	[ɲ]	*ba**n**y* *BANEU
	[ɟ]	*fa**i**g* FAGEU, *ass**a**ig* EXAGIU
	[ʃ]	*c**a**ixa* *CA[ks]A < CAPSA, *f**a**ixa* FASCIA, *gr**a**ixa* GRASSEA, ***a**ixa* ASCIA
	[bj]	*r**a**bia* RABIE.

2.3 Occitan

[a]$_{\text{ASS}}$	[jɾ]	*carri**e**ra* CARRARIA, *primi**e**r* PRIMARIU, ***e**ira*, *i**e**ra* AREA
[a]$_{\text{NO ASS}}$	[ʎ]	*pa**l**ha* PALEA, ***a**lh* ALIU
	[ɲ]	*estra**n**h* EXTRANEU, *ba**n**h**BANEU, *ara**n**ha* ARANEA
	[ɟ]	*ra**g**, *ra**i*** RADIU, *asa**g**, *asa**i*** EXAGIU, *fa**g*** FAGEU
	[jsʲ]	*na**i**sser* NASCERE, *fra**i**sse* FRAXINU, *ta**i**s* TAXU, *ca**i**s* *CAPSEU, *gra**i**ssa* GRASSEA, *mada**i**cha*, *mada**i**ssa* MATAXA, *ca**i**ssa* *CA[ks]A < CAPSA, ***a**is* AXE, ***a**issa* ASCIA
	[j]	***a**i* *AYO, 1 fut ending *-ara**i*** HABERE + AYO
	[jt]	*la**i**t*, *la**c**h* LACTE, *fa**i**t*, *fa**c**h* FACTU
	[jɾ]	***a**ira* AREA, *gla**i**ra* GLAREA, *fa**i**re* *FAIRE, *tra**i**re* TRAHERE
	[js]	*ma**i**(s)* MAGIS, *ca**i**s* QUASI
	[jz]	*ba**i**s* BASIU
	[bj]	*ra**u**ja* RABIA.

2.4 Portuguese

[a]$_{\text{ASS}}$	[j]	*am**e**i* AMAVI, *h**e**i* *AYO
	[ʃ]	*s**e**ixo* SAXU, *mad**e**ixa* MATAXA, *t**e**ixo* TAXU, ***e**ixo* AXE, *f**e**ixe* FASCE, *fr**e**ixo* FRAXINU
	[jt]	*l**e**ite* LACTE, *pr**e**ito* PLACITU
	[jɾ]	*prim**e**iro* PRIMARIU, ***e**ira* AREA
	[jz]	*b**e**ijo* BASIU
[a]$_{\text{NO ASS}}$	[ʎ]	***a**lho* ALIU, *pa**l**ha* PALEA
	[ɲ]	*ara**n**ha* ARANEA, *ba**n**ho* *BANEU
	[c]	*fa**ç**o* FACIO

	[ɟ]	*ra**i**o* RADIU, *fa**i**a* FAGEA, *ens**a**io* EXAGIU
	[ʃ]	*na**s**ce* NASCIT, *c**a**ixa* *CA[ks]A < CAPSA, *gr**a**xa* GRASSIA
	[js]	*ma**is*** MAGIS
	[bj]	*g**a**iva* CAVEA, *ra**i**va* RABIA, *s**a**iba* SAPIAM.

2.5 French

[a]$_{\text{ASS}}$	[ɟ]	*ra**i*** RADIU, *s**a**is* *SAYO, *ma**i*** MAIU, *ess**a**i* EXAGIU, *pla**i**e* PLAGA, *pa**i**e* PACAT, *pa**i**x* PACE
	[jsʲ]	*frêne* FRAXINU, *c**a**isse* *CA[ks]A < CAPSA, *gr**a**isse* *GRASSEA, *fa**i**x* FASCE, *l**a**isse* LAXAT, *fa**i**sse* FASCIA, Old Fr. *a**i**sse* ASCIA, *naît* NASCET, *paître* PASCERE, Old Fr. *ma**a**isse* MATAXA
	[j]	*porter**ai***-AYO, ***ai*** *AYO, *chant**ai*** CANTAVI
	[jt]	*fa**i**t* FACTU, *l**a**it* LACTE
	[jɾ]	***a**ire* AREA, *gl**a**ire* GLAREA, *janv**ie**r* IANUARIU, *pan**ie**r* PANARIU, *prem**ie**r* PRIMARIU, *tr**a**ire* TRAHERE, *fa**i**re* *FAIRE; Old Fr. *v**a**ir* VARIU
	[js]	*ma**is*** MAGIS
	[jz]	*b**a**ise* BASIAT
[a]$_{\text{NO ASS}}$	[ʎ]	*trav**a**il* TRIPALIU, *p**a**ille* PALEA, ***a**il* ALIU
	[ɲ]	*mont**a**gne* MONTANEA
	[c]	*men**a**ce* MINACIA, *gl**a**ce* GLACIA, *pl**a**ce* PLATEA
	[bj]	*r**a**ge* RABIA, *c**a**ge* CAVEA, *s**a**ge* SABIU, ***a**che* APIU.

3. Mid low [ɛ] (Ĕ) and [ɔ] (Ŏ)

3.1 Spanish

[ɛ]$_{\text{ASS}}$	[ʎ]	*espe**j**o* SPECULU
	[ɲ]	*enge**ñ**o* INGENIU, *ven**g**o* VENIO
	[ɟ]	*gr**e**y* GREGE, *m**e**dio* MEDIU, *s**e**a* SEDEAT, *pr**e**cio* PRETIU
	[ʃ]	*s**ei**s* SEX
	[jt]	*l**e**cho* LECTU, *p**e**cho* PECTU, *prov**e**cho* PROFECTU
	[jɾ]	*ent**e**ro* INTEGRU, *cad**e**ra* CATHEDRA
	[jz]	*cer**e**za* CERESIA
[ɛ]$_{\text{NO ASS}}$	[ʎ]	*v**ie**jo* VECLU
	[c]	*p**ie**za* PETTIA
[ɔ]$_{\text{ASS}}$	[ʎ]	*h**o**ja* FOLIA, ***o**jo* OCULU, *j**o**yo* LOLIU, *c**o**ge* COLLIGIT

	[ɟ]	*ho**y*** HODIE, *eno**j**o* IN ODIO, *po**y**o* PODIU
	[ʃ]	*co**j**o* COXU
	[jt]	*o**ch**o* OCTO, *no**ch**e* NOCTE, *bizco**ch**o* BISCOCTU
	[bj]	*no**v**io* NOVIU, *ho**y**a* FOVEA
[ɔ]$_{\text{NO ASS}}$	[ɲ]	*du**eñ**o* DOMINU, *su**eñ**o* SOMNIU, *lu**eñ**e* LONGE
	[jɾ]	*cu**e**ro* CORIU.

3.2 Catalan

[ɛ]$_{\text{ASS}}$	[ʎ]	*espi**ll*** SPECULU, cat. ant. *mi**ll**s* MELIUS
	[ɲ]	*(en)gi**n**y* GENIU, INGENIU
	[ɟ]	*mi**g*** MEDIU, *desi**g*** *DESEDIU; Old Cat. *lli**g*** LEGIT
	[ʃ]	*si**s*** SEX, Old Cat.*i**x*** EXIT, *ti**x*** TEXIT
	[jt]	*lli**t*** LECTU, *pi**t*** PECTU, *profi**t*** PROFECTU, *vi**t*** VECTE, *deli**t*** DELECTU
	[jɾ]	*fi**r**a* FERIA, *monesti**r*** MONISTERIU, *cadi**r**a* CATHEDRA; Old Cat. *enti**r*** INTEGRU, *fi**r*** FERIO, *qui**r*** QUAEREO, *mi**r*** MEREO
[ɛ]$_{\text{NO ASS}}$	[c]	*pe**ç**a* PETTIA
[ɔ]$_{\text{ASS}}$	[ʎ]	*vu**ll*** *VOLEO, *mu**ll**a* MOLIAT, *despu**ll**a* DESPOLIAT, *ju**ll*** LOLIU, *u**ll***OCULU, *ru**ll*** ROTULU, *escu**ll*** SCOPULU, *fu**ll**a* FOLIA, *tru**ll*** TORCULU, *cu**ll*** COLLIGIT
	[ɲ]	*Catalu**n**ya* CATALONIA
	[ɟ]	*enu**g*** INODIO, *pu**g*** PODIU, *avu**i***, *tru**j**a* TROIA, *plu**j**a* *PLOIA;Old Cat. *(h)**uy*** HODIE
	[ʃ]	*cu**i**xa* COXA, *gru**i**x* *GROSSIU, *pu**i**x* POSTIUS; Old Cat. *pru**x**me* PROXIMU
	[jt]	*cu**i**t* COCTU, *vu**i**t*, Old Cat.*(h)**uyt*** OCTO, *bu**i**t* VOCITU, *ni**t*** < Old Cat. *nu**i**t* NOCTE
	[jɾ]	*mu**i**r* MORIO, *cu**i**r(o)* CORIU
	[bj]	*nu**v**i* NOVIU.

3.3 Occitan

[ɛ]$_{\text{ASS}}$	[ʎ]	*mi**è̲**lhs*, *mi**l**h* MELIUS, *vi**è̲**lh* VECLU, *espe**l**h*, *espi**l*** SPECULU
	[ɲ]	*eng**e**nh*, *engi**n**h* INGENIU, *g**e**nh*, *g**i**nh* GENIU
	[ɟ]	*pi**e̲g*** PEIOR, *mi**e̲i***, *mi**e̲**ch* MEDIU
	[jsʲ]	*si**e̲i**s* SEX
	[jt]	*li**e̲i**t*, *li**e̲**ch* LECTU, *pi**e̲i**t*, *pi**e̲**ch* PECTU, *del**e̲i**t* DELECTU, *respi**e̲**ch* RESPECTU, *profi**e̲**ch*, *profi**e̲i**t* PROFECTU, *vi**e̲**ch*, *vi**e̲**t* VECTE

	[jɾ]	*mi**e**r* MEREO, *fi**e**r* FERIO, *fi**e**ira*, *fi**e**ra* FERIA, *mosti**e**r*, *monasti**e**r* MONASTERIU, *cadi**e**ra* CATHEDRA, *enti**e**r* INTEGRU
	[jz]	*cer**i**esa*, *cer**e**isa*, *cer**i**sa* CERASEA
$[ɛ]_{\text{NO ASS}}$	[c]	*pe**ç**a* PETTIA
$[ɔ]_{\text{ASS}}$	[ʎ]	*fu**e**lha*, *fu**o**lha* FOLIA, *u**e**lh*, *u**o**lh* OCULU, *cu**e**lh* COLLIGIT; *tru**e**lh*, *tru**o**lh* TROCULU, *ju**e**lh* LOLIU, *escu**o**lh*, *escu**e**lh* SCOPULU
	[ɟ]	*tru**e**ja*, TROIA, *u**e**i*, *u**o**i* HODIE, *enu**e**g* IN ODIO, *mu**e**g*, *mu**o**g* MODIU, *pu**o** g*, *pu**e**g* PODIU, *plu**e**ja* *PLOIA
	[jsʲ]	*cu**e**issa*, *cu**o**issa* COXA, *pu**e**i(s)*, *pu**o**i* POST
	[jt]	*u**e**ch*, *u**e**it*, *u**o**ch* OCTO, *nu**e**ch*, *nu**e**it*, *nu**o**ch* NOCTE, *vu**e**id*, *vu**e**g*, *vu**o**g* VOCITU
	[jɾ]	*mu**e**r* MORIO, *cu**e**r*, *cu**o**r* CORIU
$[ɔ]_{\text{NO ASS}}$	[bj]	*n**o**vi* NOVIU.

3.4 Portuguese

$[ɛ]_{\text{ASS}}$	[ʎ]	*esp**e**lho* SPECULU
	[ɲ]	*eng**e**nho* INGENIU, *v**e**nho* VENIO
	[ɟ]	*s**e**ja* SEDEAM, *m**e**io* MEDIU
	[ʃ]	*s**ei**s* SEX
	[ʒ]	*cer**e**ja* CERESIA
	[jt]	*desp**ei**to* DESPECTU, *l**ei**to* LECTU, *p**ei**to* PECTU, *prov**ei**to* PROFECTU
	[jɾ]	*mad**ei**ra* MATERIA, *cad**ei**ra* CATHEDRA, *int**ei**ro* INTEGRU
$[ɛ]_{\text{NO ASS}}$	[ʎ]	*v**e**lho* VECLU
	[c]	*pe**ç**a* PETTIA
$[ɔ]_{\text{ASS}}$	[ʎ]	*f**o**lha* FOLIA, ***o**lho* OCULU, *r**o**lha* ROTULA, *j**o**io* LOLIU, *esc**o**lho* SCOPULU
	[ɲ]	*s**o**nho* SOMNIU, *Sans**o**nha* SANXONIA
	[ɟ]	*h**o**je, p**o**io* PODIU, *en**o**jo* IN ODIO
	[ʃ]	*c**o**xo* COXU, *c**o**xa* COXA
	[jt]	*n**oi**te* NOCTE, ***oi**to* OCTO, *c**oi**to* COCTU
	[jɾ]	*c**oi**ro* CORIU, *m**oi**ro* MORIO
	[bj]	*n**oi**vo* NOVIU.

3.5 French

$[\varepsilon]_{ASS}$	[ʎ]	*vi**e**il* VECLU; Old Fr.*mi**e**us* MELIUS
	[ɲ]	Old French *engi**e**gne* INGENIAT, *vi**e**gne* VENIAT, *ti**e**gne* TENEAT, *pigne* PECTINE
	[c]	*pi**è**ce* PETTIA, *ni**è**ce* NEPTIA
	[ɟ]	*mi* MEDIU, *nie* NEGAT, *lire* LEGERE, *pire* PEIOR, *dix* DECE
	[jsʲ]	*sis* SEX, Old Fr.*ist* EXIT, *tist* TEXIT
	[jt]	*lit* LECTU, *profit* PROFECTU; Old Fr. *piz* PECTU, *vit* VECTE
	[jɾ]	*moutier* MONASTERIU, *entier*; Old Fr. *entir* INTEGRU
	[jz]	*cerise* CERESEA
	[bj]	*li**è**ge* LEVIU
$[ɔ]_{ASS}$	[ʎ]	*orgueil* *URGOLI, *treuil* TORCULU, *feuille* FOLIA, *veuille* VOLEAT, *seuil* SOLIU, *oeil* OCULU, *écueil* SCOPULU
	[ɟ]	*cuit* COCET, *nuit* NOCET, *hui* HODIE, *pluie* *PLOIA, *appui* ADPODIU, *muid* MODIU, *ennuie* INODIAT, *truie* TROIA; Old Fr. *puy* PODIU
	[jsʲ]	*puis* POST, *cuisse* COXA, *puisse* *POSSEAT
	[jt]	*nuit* NOCTE, *huit* OCTO, *cuit* COCTU, *vide* VOCITU
	[jɾ]	*cuir* CORIU; Old Fr.*muir* MORIO
$[ɔ]_{NO\ ASS}$	[bj]	*p**o**che* POPIA, *l**o**ge* LAUBIA.

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