What is and what is not an articulatory gesture in speech production: The case of lateral, rhotic and (alveolo)palatal consonants

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Abstract

Articulatory data are provided showing that, in languages in which they have phonemic status, (alveolo)palatal consonants, dark /l/ and the trill /r/ are articulated with a single lingual gesture instead of two independent tongue front and tongue body gestures. They are therefore simple, not complex segments. It is argued that tongue body lowering and retraction for dark /l/ and the trill /r/ is associated with manner of articulation requirements and with requirements on the implementation of the darkness percept in the case of dark /l/, and that tongue body raising and fronting for (alveolo)palatals results naturally from the contraction of the genioglossus muscle. These consonant units resemble truly complex palatalized and velarized or pharyngealized dentoalveolars regarding lingual configuration and kinematics, as well as coarticulatory effects and phonological and sound change processes. Contrary to some views, the study also contends that clear /l/ and the tap /ɾ/ are not complex segments but consonants articulated with a more or less neutral tongue body configuration which is subject to considerable vowel coarticulation.

Keywords: segmental complexity, (alveolo)palatal consonants, alveolar lateral and alveolar trill.

Resumen

Datos articulatorios muestran que, en lenguas en las cuales las consonantes alveolo-palatales tienen rango fonológico, la lateral velarizada /l/ y la vibrante ápico-alveolar /r/ son producidas mediante un único gesto lingual en vez de dos gestos linguales, uno anterior y otro dorsal. Así pues se trata de segmentos simples y no de segmentos complejos. El artículo argumenta lo siguiente: el descenso y la retracción del dorso de la lengua durante la producción de la lateral velarizada y de la vibrante están asociados con sus correspondientes requisitos de modo de articulación, y también con la implementación de la velarización en el caso de /l/ velarizada; la elevación y anteriorización del dorso lingual durante la producción de las consonantes alveolo-palatales son consecuencia natural de la contracción del músculo geniogloso. Estas dos consonantes se asemejan a las consonantes dentoalveolares complejas ya sean palatalizadas o velarizadas o faringealizadas, tanto por lo que respecta a la configuración y cinemática linguales como a los efectos

coarticulatorios y a los procesos fonológicos y de cambio fonético. En desacuerdo con otros puntos de vista, el presente estudio también postula que la /l/ no velarizada y la rótica /ɾ/ no son segmentos complejos sino consonantes articuladas con una configuración lingual más o menos neutra, que está sujeta a efectos de coarticulación vocálica considerables.

Palabras clave: segmentos complejos; consonantes alveolo-palatales; lateral alveolar y vibrante alveolar.

Introduction

The goal of this paper is to argue for an appropriate use of the concept of *articulatory gesture*. According to Articulatory Phonology, articulatory gestures are phonological primitives which characterize high-level phonological units in place of distinctive features.[1] Examples of articulatory gestures are lip and tongue dorsum closing for bilabial and velar stop consonants, respectively. In recent times, gestural status has been attributed to the activity of tongue body regions which are not involved directly in the formation of the primary closure or constriction for consonants, as in the case of tongue body retraction for dark /l/ and the alveolar trill /r/ and tongue body raising and fronting for alveolopalatal and palatal consonants such as /ɲ/ and even /j/. According to this view, these tongue body actions correspond to secondary lingual gestures which are activated independently from the primary tongue front gesture whether it involves the tongue tip, blade or predorsum. The issue is whether, in parallel to pharyngealized and palatalized dentoalveolars in languages like Arabic and Russian, respectively, those consonantal units should be treated as complex segments endowed with two simultaneous lingual gestures or as simple segments specified for a single tongue gesture.

1. Browman and Goldstein, “Articulatory phonology: an overview” (1992).

The claim that the tongue body actions referred to above for dark /l/, the trill and (alveolo)palatals should qualify as secondary gestures is supposed to come from different sources of evidence. Supporting evidence has been claimed to derive from specific articulatory events such as considerable tongue-to-palate contact and the presence of a /j/-like component at consonant release in the case of (alveolo)palatal consonants, and tongue body lowering/backing prior to tongue tip raising during a preceding front vowel in the case of dark /l/ and the trill /r/. Another aspect in support of the independent existence of a tongue body gesture for these consonants

appears to be their low degree of articulatory variability whether measured across contextual conditions (contextual variability) or across tokens (random variability), which may be indicative that the tongue region in question is subject to active control by the speaker. According to earlier proposals, additional evidence is to be sought in specific sound changes and phonological processes such as the insertion of the glides [w] before dark /l/ and [j] before or after an (alveolo)palatal consonant, the argument being that gestural decomposition has taken place in this case.[2]

In contrast with this line of thought, we believe that these (co)articulatory characteristics as well as related sound change and phonological processes should not be taken in support of the existence of an independent tongue body gesture. More specifically, we argue that the parallel behaviour between the consonants under study and true complex segments such as palatalized and pharyngealized dentoalveolars follows simply from the fact that two sets of consonants are articulated similarly. Thus, for example, the presence of a relatively long temporal lag between the activity of the tongue body and the tongue front at the release of an alveolopalatal consonant, which may give rise to an off-glide through segmental categorization of the CV acoustic transitions, depends on the relative independence between the two articulatory structures during given productions of the simple, non-complex consonant of interest. Similar instances of on-glide or off-glide insertion may be triggered by simple consonants of other places of articulation.[3] Moreover, we cannot accept the view that phonological units may be specified as simple or complex independently of the available phonetic data since, among other reasons, this approach places phonology outside the real world and does not contribute to explaining the causes of sound change.

The existence of a tongue body gesture has also been assigned to consonants which show no clear tongue body activation. Thus, in PROCTOR's view,[4] clear /l/ and the alveolar tap /ɾ/ in Spanish also ought to be specified as complex, given that the tongue body is less sensitive to contextual coarticulation during their production than during that of other dentoalveolars. Likewise, according to OPERSTEIN,[5] the fact that all dentals and alveolars may trigger prevocalization or on-gliding proves that these consonants must be endowed with a tongue body vowel gesture independently of whether they involve some lowering and backing of the tongue body or not. Several

2. OPERSTEIN, *Consonant structure and prevocalization* (2010).

3. ALBANO, *O gesto e suas bordas: esboço de fonologia acústico-articulatória do português brasileiro* (2001).

4. PROCTOR, "Gestural characterization of a phonological class: the liquids" (2009).

5. OPERSTEIN, *Consonant structure and prevocalization* (2010).

arguments will be provided later against this claim.

The following sections will deal with the issue of segmental complexity in (alveolo)palatals,[6], dark and clear /l/,[7] and the trill /r/ and the tap /ɾ/.[8] Reference will be made to articulatory and acoustic data for these consonants as well as for true complex consonants such as palatalized and pharyngealized dentoalveolars. The last section[9] draws some general conclusions about segmental complexity based on the production data reported in the preceding sections.

6. (Alveolo)palatal consonants, p. 27.
7. The alveolar lateral, p. 32.
8. The alveolar trill, p. 36.
9. Discussion and conclusions, p. 38.

(Alveolo)palatal consonants

A two-gestural status has been assigned to consonants such as /ɲ/, /ʎ/ and /j/ labeled often as *palatal* in the phonetics literature.[10] These consonantal productions have been treated as complex segments specified for a Coronal node and a Dorsal node and thus, for two independent lingual gestures which are activated more or less simultaneously. Moreover, this gestural specification has been meant to apply not only to alveolopalatal realizations whose closure or constriction encompasses the alveolar and palatal zones, but also to purely palatal productions which are articulated at the hard palate exclusively. Even palatoalveolar consonants such as the fricative and affricate sounds of the English words *shoe* and *catch* are assigned two gestures in the above-cited studies.

10. KEATING, "Coronal places of articulation" (1991); KEATING, "Phonetic representation of palatalization versus fronting" (1993); LAHIRI and EVERS, "Palatalization and coronality" (1991); CALABRESE, *Markedness and economy in a derivational model of phonology* (2008); GUSSENHOVEN and JACOBS, *Understanding Phonology* (2013).

The assigment of complex status to (alveolo)palatals in languages in which these consonants are phonemic is in disagreement with several articulatory facts. Regarding place of articulation, lingual configuration and linguopalatal contact data strongly suggest that (alveolo)palatal and palatoalveolar consonants are produced with a single articulatory gesture in these languages.[11] Palatoalveolars are articulated with the tongue blade generally at the postalveolar zone; alveolopalatals are implemented with the tongue blade, the tongue predorsum or both at a constriction location which includes the alveolar and front palatal areas as a general rule; purely palatals are realized with the tongue dorsum at the hard palate. The exact closure or constriction location of (alveolo)palatal consonants may vary depending on factors such as manner of articulation, speaker and language. Thus, the lateral /ʎ/, as in the Italian word *aglio* "onion", may be alveolar or alveolopalatal but not purely palatal and thus more anterior than the nasal /ɲ/ (Italian word

11. RECASENS, "On the articulatory classification of (alveolo)palatal consonants" (2013).

bagno “bath”) and the oral stop /c/ (Romansh word *notg* “night”), which are mostly alveolopalatal but may be purely palatal as well. On the other hand, syllable-onset /j/, as in English *yes* and Spanish *raya* “line”, is often purely palatal though may also be articulated with an alveolopalatal central constriction. In light of these place of articulation characteristics, it may be ascertained that tongue dorsum raising behind closure or constriction location for palatoalveolar and alveolopalatal consonants is not triggered by the separate activation of the tongue body but by the coupling effects between the primary laminal or predorsal articulator and more posterior tongue dorsum regions, such that the latter are automatically raised as the former become involved in closure or constriction formation.

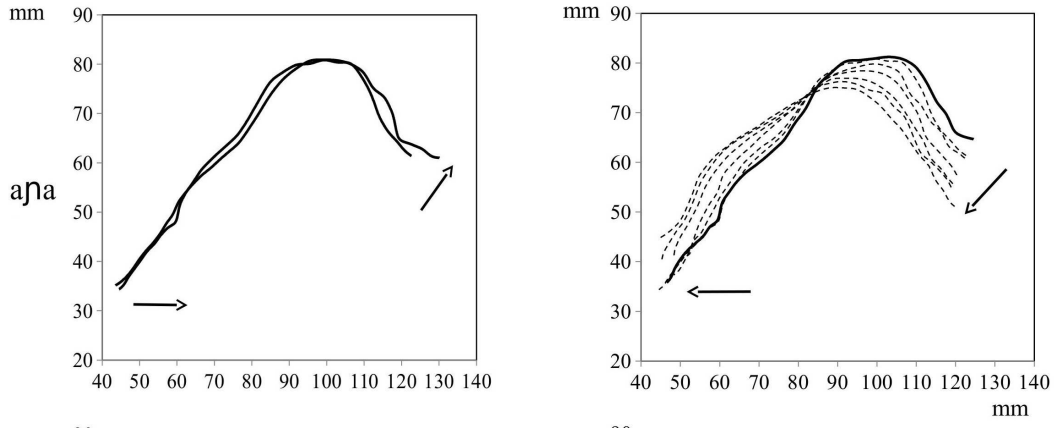
Additional evidence in support of the simple, non-complex nature of (alveolo)palatals comes from lingual movement trajectories associated with these consonants. Indeed, an analysis of the lingual trajectories for productions of the sequence /aɲa/ by several Catalan speakers, starting at V1, continuing during the closure or constriction period and ending at V2, reveals that the spatiotemporal characteristics of the alveolopalatal nasal consonant are not related to gestural complexity but to the physico-mechanical properties of the tongue blade and dorsum. EMA (electromagnetic midsagittal articulometry) data for this VCV sequence show that, while the tongue dorsum is activated before the tongue blade before closure onset and the reverse applies after closure release, the laminodorsal region travels a somewhat smaller distance at a slower speed and for a longer time during the latter period than during the former.[12] Moreover, the temporal lag between the tongue blade and tongue dorsum displacement maxima during the production of intervocalic /ɲ/ is very short (shorter than 10 ms according to EMA data for one Catalan speaker reported by Recasens and Romero,[13] which confirms the existence of a single articulator. Electropalatographic (EPG) data collected during the closure period for the Catalan alveolopalatal nasal also speaks in favour of a single gesture:[14] the degree of tongue contact at closure location increases towards the front alveolar zone and towards the back palate from closure onset to about closure midpoint, which appears to be related to an increase in laminodorsal contact against the palate as closure is being formed; the closure release, on the other hand, proceeds from front to back and therefore occurs at the tongue blade before it does at the tongue dorsum since the former, less sluggish, tongue region travels faster than the latter. Moreover, the reason why

12. Recasens and Espinosa, “Lingual kinematics and coarticulation for alveolopalatal and velar consonants in Catalan” (2010).

13. Recasens and Romero, “An EMMA study of segmental complexity in alveolopalatals and palatalized alveolars” (1997).

14. Recasens, Fontdevila, and Pallarès, “A production and perceptual account of palatalization” (1995).

(alveolo)palatal consonants (also palatoalveolars) are highly resistant to coarticulatory effects in tongue dorsum lowering/backing from low and back vowels is not to be sought in the existence of an independent tongue dorsum gesture but in the fact that the contraction of the genioglossus muscle and an increase in tongue-to-palate contact during the closure or constriction period constrains the entire body of the tongue considerably.



(a) Sequence /aɲ/. **(b)** Sequence /ɲa/.

Figure 1: Ultrasound data for the sequence /aɲa/ produced by a Catalan speaker. See fig. 4, p. 40.

Ultrasound data for the /aɲ/ portion of the sequence /aɲa/ produced by a Catalan speaker, plotted in fig. 1 (a), reveal that, as shown by the sense of the arrows, the tongue body moves frontward and upward gradually and holistically as it travels from V1 onset to the maximum displacement for the nasal consonant during the closure period. A slow and holistic tongue lowering/backing motion from closure offset (thick line) to V2 offset may also be observed during the /ɲa/ portion of the same sequence, in fig. 1 (b). There is therefore no sign of two separate tongue components which correspond to separate lingual gestures.

A different scenario holds in languages in which alveolopalatal consonants can only occur as realizations of a dentoalveolar + /j/ sequence, mostly in casual speech, as for example the [ɲ]-like and [ʎ]-like realizations of the sequences /nj/ and /lj/ in English words such as *onion* and *scalion*. The realizations in question are not phonemic and thus alternate with [nj] and [lj] and with other intermediate realizations exhibiting different degrees of spatiotemporal proximity between the laminoalveolar gesture for the alveolar consonant and the dorsopalatal gesture for the palatal consonant. This is a typical blending scenario in which two separate lingual gestures yield a single articulatory outcome exhibiting an intermediate

closure or constriction location between the closure or constriction locations for the two consonants in succession.[15] In fact, to the ears of speakers of languages in which [ɲ] and [ʎ] have phonemic status such as Spanish, Catalan or Czech, those phonetic realizations sound more like the bigestural palatalized productions of Russian (see below) than like their own simple, non-complex consonant productions. In Early Romance, the realizations [ɲ] and [ʎ] of Latin /nj/ and /lj/ (also [ʃ] of /sj/) became systematic and gave rise to the phonemic units /ɲ/ and /ʎ/ (also /ʃ/) which are found in the present-day Romance languages, as exemplified by /ʎ/ and /ɲ/ in the Italian words *aglio* "garlic" and *bagno* "bath", which can be traced back to the Latin cognates /áljo/ ALIU and /bánjo/ *BANEU < BALNEU. In sum, a given alveolopalatal production may correspond at the same time to a blended realization of the primary gestures for two successive consonants (as in English) and to a phonemic unit implemented through a single lingual gesture (as in the Romance languages).

15. Browman and Goldstein, "Articulatory gestures as phonological units" (1989).

In the phonologists' view, evidence for segmental complexity in (alveolo)palatal consonants may be derived from specific sound change and phonological processes such as on-glide and off-glide insertion. On-gliding triggered by /ʎ/ and /ɲ/ has occurred in Northern Portuguese *abeilha* 'Portuguese *abelha*' "bee" and in Asturian Spanish [peˈkejɲo] 'Spanish *pequeño*' "little". Off-gliding triggered by [c] may be exemplified with Fassan [cjaf] derived from Latin CAPUT "head",[16] and also with the French word *chièvre* "goat" derived from Latin CAPRA, whose [j] must have been appended at the time that the originary velar stop was realized as [c] and therefore before this (alveolo)palatal oral stop shifted to [ʃ] through the intermediate outcome [tʃ].[17] An example of a phonological process which is supposed to reflect the complex nature of (alveolo)palatal consonants is the splitting into [jn], or better into [jN], in which the nasal [N] is unmarked for place, of preconsonantal word-final /ɲ/ in Majorcan Catalan ([ˈajmbɔ] /áɲbɔ/ *any bo* "good year"). In our opinion, there is no need to assume that these phonetic realizations are achieved through gestural dissociation and thus, temporal separation of two existing gestures. Indeed, electropalatographic and acoustic data reveal that on-gliding before (alveolo)palatal consonants is achieved through the perceptual integration as a separate segment /j/ of the VC formant transitions, which may be longer syllable finally than intervocalically whenever the alveolar contact maximum is delayed considerably relative to the dorsopalatal contact maximum.[18]

16. Elwert, *Die Mundart des Fassa-Tals*, p. 67 (1943).

17. Recasens, *Coarticulation and sound change in Romance* (2014).

18. Recasens, Fontdevila, and Pallarès, "A production and perceptual account of palatalization" (1995).

Therefore, the dissociation of articulatory events does not have to be identified with gestural dissociation, which may certainly take place in the case of bigestural consonants such as the bilabial nasal /m/ in syllable- final position.[19]

It has also been proposed that fronted velars need to be specified as complex in order to account for the fact that they may front into (alveolo)palatal stops, as exemplified by the change /gj/ > [ɟ] in the word *ghianda* "acorn" in Tuscan. Thus, according to CALABRESE,[20] this change involves the promotion of the coronal articulator from secondary in the original fronted velar to primary in the outcoming (alveolo)palatal stop. This analysis cannot possibly hold since the tongue front stays in a low position and inactive during the production of dorsovelars whether front before front vowels or back before low or back rounded vowels.

Within the autosegmental phonology framework, the depalatalization of an (alveolo)palatal into an alveolar is attributed to the delinking of the Dorsal node in the complex consonant. This change takes place in Alguerese Catalan, in which preconsonantal word-final /ɲ/ is realized as an alveolar nasal assimilated in place to the following consonant ([ˈambɔ] /áɲbɔ/ *any bo* "good year"). In our view, the depalatalization in question may be accounted for through articulatory reduction and thus a decrease in tongue contact size all over the palate surface without assuming that a dorsal gesture is present. It may be considered to be just the opposite of the palatalization of /n/ into [ɲ], which may take place through articulatory strengthening, and thus an increase in tongue contact in prominent positions (Asturian [ˈɲuðo] *ñudo* from Latin NODU "knot") or whenever the alveolar has an intrinsic long duration (Spanish [ˈaɲo] *año* from Latin ANNU "year").

In view of these considerations, it may be concluded that (alveolo)palatal consonants are implemented through a single lingual gesture in languages in which they have phonemic status. Complex segments exhibiting a secondary tongue dorsum raising and fronting gesture are only available in palatalized consonants of languages like Russian, in which palatalization applies extensively to labials, dentoalveolars and dorsovelars. The independent status of the primary and secondary gestures in this case is consistent with the presence of a 20-30 ms lag between the tongue front and tongue dorsum displacement maxima for Russian /nj/ in a word like *niet* "no".[21] Gestural independence also accounts for the fact that, in compari-

19. KRAKOW, "Physiological organization of syllables: a review" (1999).

20. CALABRESE, *Markedness and economy in a derivational model of phonology*, p. 311 (2008).

21. RECASENS and ROMERO, "An EMMA study of segmental complexity in alveolopalatals and palatalized alveolars" (1997).

son to alveolopalatals, palatalized dentoalveolars show a more anterior closure or constriction location (which is nevertheless more retracted than that for non-palatalized dentoalveolars).

The alveolar lateral

It has been claimed that dark /l/ is specified for two lingual gestures, a primary apical gesture and a secondary tongue body gesture.[22] This claim is based on production data for American English /VlV/ sequences with a front vowel showing that the tongue body is activated before the tongue tip in the case of dark /l/ while the two tongue regions are activated more or less simultaneously, or else tip activation precedes tongue body activation in the case of clear /l/. Moreover, it has also been suggested that, in addition to the consonantal apical raising gesture, all /l/ varieties have a vocalic tongue body gesture which is realized through more or less lowering and retraction depending on the degree of darkness.[23] This section critically evaluates the arguments which have been put forth in support of the complex nature of the alveolar lateral consonant and, in particular, of its dark variety.

An argument in support of the existence of a tongue body gesture for /l/ is the fact that the transition from strongly dark to clear varieties of the consonant proceeds gradually instead of categorically. This may be taken to mean that a tongue body gesture is available in all cases, which may be realized through a more or less lowered and retracted tongue body position depending on factors such as syllable position, language and speaker. This possibility is consistent with the existence of no clearcut differences in /l/ darkness degree among languages and among syllable positions within the same language.[24] Thus, languages may have a strongly dark variety of /l/ (Russian), a moderately dark /l/ variety (Eastern Catalan) or a clear variety of the consonant (Italian). Moreover, in languages of the former group, a strongly dark realization of /l/ occurs typically in all syllable positions, while languages of the second groups show a clearer realization of the alveolar lateral at syllable onset than at syllable coda.

In any case, this scenario appears to be partly contradicted by the existence of languages showing two extrinsic allophones of /l/ in onset and coda position, namely, strongly clear and strongly dark varieties in the syllable-initial and syllable-final positions, respectively

22. Browman and Goldstein, "Gestural syllable position effects in American English" (1995); Sproat and Fujimura, "Allophonic variation in English /l/ and its implications for phonetic implementation" (1993); Gick, "Articulatory correlates of ambisyllabicity in English glides and liquids" (2003).

23. Sproat and Fujimura, "Allophonic variation in English /l/ and its implications for phonetic implementation" (1993); Proctor, "Towards a gestural characterization of liquids: evidence from Spanish and Russian" (2011); Proctor, "Gestural characterization of a phonological class: the liquids" (2009).

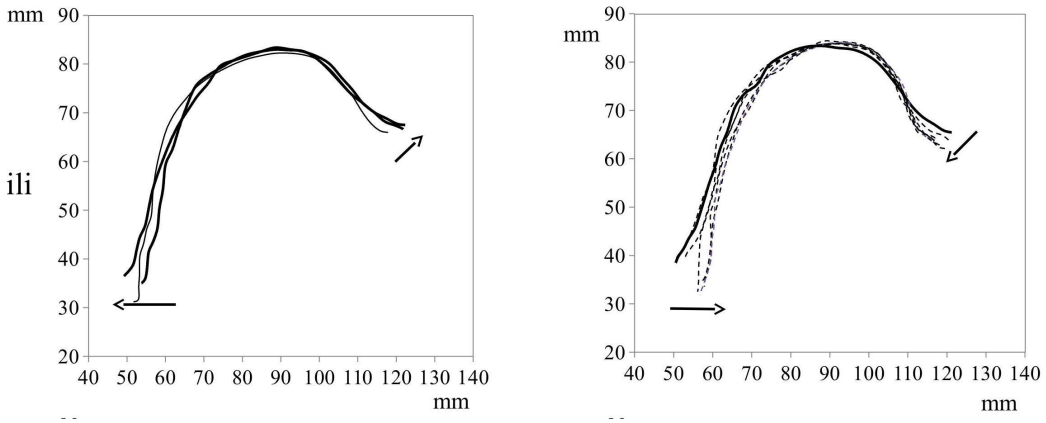
24. Recasens, "A cross-language acoustic study of initial and final allophones of /l/" (2011).

(Dutch).

Another piece of evidence in support of the complex nature of dark and clear /l/ is that the tongue body is quite resistant to vowel coarticulation in the case of the two consonant varieties, which could be indicative that this lingual region is subject to active control by the speakers,[25] and, in the case of dark /l/ and as referred to above, that the tongue body precedes the action of the tongue tip during a preceding front vowel. We would like to argue that the specific tongue body configuration for alveolar laterals (whether clearer or darker) is to a large extent conditioned by laterality requirements. Indeed, the need to let airflow exit through the mouth sides may account for why the consonant is apical and at the same time its production involves more predorsum lowering and jaw opening than in the case of other dentoalveolars.[26] Therefore, the tongue body lowering and retraction motion as well as a restricted degree of contextual variability associated with these lateral consonants could be conditioned by these manner of articulation requirements rather than by the independent activation of the tongue body.

25. PROCTOR, "Gestural characterization of a phonological class: the liquids" (2009); PROCTOR, "Towards a gestural characterization of liquids: evidence from Spanish and Russian" (2011).

26. LINDBLAD and LUNDQVIST, "[l] tends to be velarised, apical as opposed to laminal, and produced with a low jaw, and these features are connected" (2003).



(a) Sequence /il/. **(b)** Sequence /li/.

Figure 2: Ultrasound data for the sequence /ili/ produced by a Catalan speaker. See fig. 4, p. 40.

Ultrasound data for several Catalan speakers show that productions of /l/ which are neither strongly clear nor strongly dark exhibit some more tongue body retraction towards the velar or pharyngeal zones than other dentoalveolars such as /t, d, n/. This tongue body action may be seen during the /il/ portion of the sequence /ili/ in fig. 2 (a); indeed, as shown by the arrows in the graph, during the vowel preceding the alveolar lateral, the tongue body retracts gradually mostly at its upper region and thus at the velar zone as the tongue front is being raised. On the other hand, according to fig. 2 (b), some tongue

body fronting occurs as the anterior portion of the tongue front is lowered from closure release (thick line) until about V2 midpoint and thus during the /li/ portion of the sequence /ili/.

We would also like to claim that the extra u-shaped tongue configuration for dark /l/ is associated with the need to give rise to a darkness acoustic percept by retracting the tongue body and lowering the tongue predorsum and the jaw considerably. If so, even though dark /l/ is articulated with a similar tongue configuration to the pharyngealized dentoalveolar consonants of Arabic, the latter consonants, but not the former, should be treated as complex segments involving a secondary tongue body lowering/backing gesture. Another good reason for this assumption is that the tongue body lowering/backing motion may be superimposed on several dentoalveolar consonants in Arabic, while the darkness characteristic is only available for /l/ in English or Portuguese. The fact that dark /l/ and pharyngealized consonants exhibit a similar overall lingual configuration accounts for several common characteristics, which should not be taken to imply that dark /l/ is a complex segment: all these consonants may be highly resistant to lingual coarticulatory effects exerted by contextual phonetic segments; the common u-like configuration explains why, as also in the case of pharyngealized dentoalveolars, tongue body activation precedes tongue tip raising before closure and, therefore, much C-to-V anticipatory coarticulation may be available.[27]

Differences in contextual variability and coarticulatory direction between dark /l/ and clear /l/ run against the notion that clear /l/ should be treated as a complex segment. Indeed, dark /l/ is much more vowel coarticulation resistant than clear /l/, and prevalence of the anticipatory over the carryover direction of the C-to-V coarticulatory effects is by no means obvious in the case of the latter consonantal variety.[28] Proctor's argument that clear /l/ ought to be specified for a tongue body gesture because it shows less coarticulation than [ð] in Spanish cannot be valid since, as revealed by ultrasound data for Catalan and by acoustic data for this language and for Spanish, the dental approximant is far more sensitive to lingual coarticulatory effects than other dentals and alveolars, due to its being realized with an open constriction and involving no strict manner of articulation requirements.

Presumable evidence for segmental complexity in /l/ also comes from sound change. It has been contended in this respect that the vocalization of /l/ into [w] if dark

27. WATSON, "The directionality of emphasis spread in Arabic" (1999); WATSON, *The phonology and morphology of Arabic* (2002).

28. RECASENS and FARNETANI, "Articulatory and acoustic properties of different allophones of /l/ in American English, Catalan and Italian" (1990).

and into [j] if clear speaks in support of the existence of a vocalic tongue body gesture;[29] thus, the tongue body gesture would take over once the tongue tip gesture is reduced and apical contact ceases to occur. We think that the change in question is better accounted for without assuming the presence of a tongue body gesture. Thus, regarding dark /l/, reduction of the apical gesture is prone to take place syllable-finally before consonants allowing apical contact loss, such as labials and velars,[30] as revealed by vocalization examples like Occitan [ˈawbo] Latin ALBA "dawn" and [fawˈku] FALCONE "falcon".[31] After contact loss has occurred, the /w/-like tongue configuration may give rise to a /w/-like acoustic realization whose spectrum has an F2 frequency of about 1000 Hz or less. As to the vocalization of clear /l/ into [j], apical reduction may account for the syllable-final cases reported below, but not for those occurring syllable-initially, which may be attributed more easily to either acoustic similarity, and thus to the fact that both clear /l/ and /j/ share a high F2 frequency above 1500 Hz,[32] or to the presence of an intermediate alveolopalatal lateral stage in the development from /Cl/ to [Cj] (i.e., /Cl/ > [Cʎ] > [Cj]).

(/l/ > [j] syllable finally) Central Italian dialects *aitro* ALTERU "another one", Ligurian *suicu* SULCU "furrow", *vuipe* VULPE' "fox", Emilian *aibre* ALBARU "popplar".[33]

(/l/ > [j] syllable initially) Tuscan and Central Italy *fiore* FLORE "flower", *chiave* CLAVE "key", *pieno* PLENU "full".[34]

Another sound change which can be interpreted without reference to an underlying tongue body gesture is the insertion of an on-glide before the dark alveolar lateral, as in the case of the phonetic variants [awl] ALTU "high" in Sursilvan Rhaetoromance and *aurdeia* for *aldeia* "village" in Northern Portuguese.[35] The phonemic categorization of the on-glide as /w/ in phonetic variants such as these may occur when the falling VC transitions are highly prominent and correspond to the lowering/backing activity of the tongue body prior to the raising of the tongue front during the vowel.

A final issue needs to be raised, namely, how dark /l/ has originated and why it is prone to occur syllable finally rather than syllable initially. In parallel to the change /r/ > [ʀ],[36] it may be hypothesized that dark realizations of /l/ originated from clearer productions of the alveolar lateral in syllable-final position, where consonants are often articulated with less tongue-to-palate contact than in syllable-onset position. This view

29. Proctor, "Towards a gestural characterization of liquids: evidence from Spanish and Russian" (2011).

30. Browman and Goldstein, "Gestural syllable position effects in American English" (1995); Lin, Beddor, and Coetzee, "Gestural reduction, lexical frequency, and sound change: a study of post-vocalic /l/" (2014).

31. Camproux, *Essai de géographie linguistique du Gévaudan*, p. 316 (1962).

32. Ohala, "Phonetic explanation in phonology" (1974).

33. Rohlfs, *Grammatica storica della lingua italiana e dei suoi dialetti (Fonetica)*, pp. 344–346 (1966).

34. Rohlfs, *Grammatica storica della lingua italiana e dei suoi dialetti (Fonetica)*, pp. 243, 247, 252 (1966).

35. Loriot, "Les caractères originaux du dialecte du Val Tujetsch (Tavetsch) dans la famille des parlers sursilvains" (1952); Vasconcellos, *Esquisse d'une dialectologie portugaise*, p. 96 (1987).

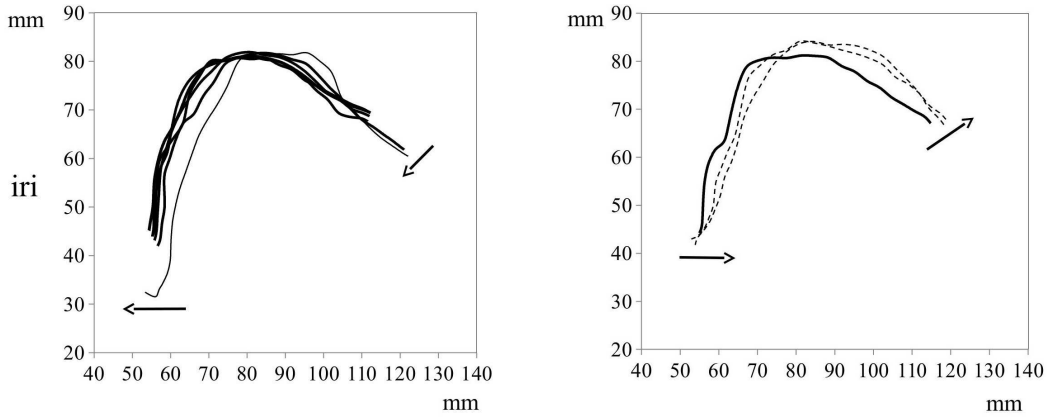
36. The alveolar trill, p. 36.

is consistent with the existence of dialects exhibiting extrinsic allophones (clear in onset, dark in coda), and also of other dialects which, in spite of having one of the two /l/ varieties across the board, show a somewhat darker realization of the consonant syllable-finally than syllable-initially (see above).

The alveolar trill

It has also been claimed that the alveolar trill /r/ is specified for two lingual gestures, since it is produced with some tongue body lowering and retraction, as when surrounded by high front vocalic sounds, and is highly resistant to the coarticulatory effects in lingual configuration exerted by contextual vowels and other phonetic segments.[37] Ultrasound data for the sequence /iri/ produced by a Catalan speaker reveal indeed some tongue body backing and predorsum lowering as we proceed from V1 onset to about the trill midpoint (fig. 3 (a)), and the opposite tongue motion, i.e., tongue body fronting and tongue predorsum raising, from the last apical contact for the trill (thick line) to V2 offset (fig. 3 (b)).

37. PROCTOR, "Towards a gestural characterization of liquids: evidence from Spanish and Russian" (2011).



(a) Sequence /ir/. **(b)** Sequence /ri/.

Figure 3: Ultrasound data for the sequence /iri/ produced by a Catalan speaker. See fig. 4, p. 40.

Little contextual variability both at the alveolar constriction location and in tongue dorsum contact at the palatal zone has been reported to occur for /r/ in Spanish and Catalan,[38] and ultrasound data for the latter language also reveal considerable resistance to tongue body coarticulatory effects during the production of the alveolar trill.

38. RECASENS, "Lingual Coarticulation" (1999).

There are good reasons to believe that the tongue configuration and kinematic characteristics of the alveolar trill are not associated with the presence of an in-

dependent tongue body gesture. It has been shown in this respect that the overall tongue shape and the small changes in lingual configuration induced by the adjacent vowels are mainly conditioned by the aerodynamic and articulatory mechanisms required for apical trilling.[39]

As pointed out for dark /l/, the fact that the tongue body configuration for /r/ is similar to that for pharyngealized dentoalvelars does not mean that the trill is a complex segment. In many respects, this lingual configuration also resembles that of retroflex alveolars, which, to our knowledge, have not been characterized as complex in the phonetics and phonology literature: /r/ and retroflex consonants share a retracted tongue tip closure or constriction (postalveolar for /r/, postalveolar or prepalatal for retroflexes) and a lowered predorsum and a retracted tongue body position.[40]

As attested by data on sound change and phonological processes, the alveolar trill also parallels both pharyngealized dentoalveolars and retroflex consonants in that it favours anticipatory C-to-V and C- to-C effects in clusters (see BHAT, "Retroflexion: an areal feature" (1973) and HAMANN, "The phonetics and phonology of retroflexes" (2003) for retroflex consonants, and RECASENS, *Coarticulation and sound change in Romance* (2014), WATSON, "The directionality of emphasis spread in Arabic" (1999) and WATSON, *The phonology and morphology of Arabic* (2002) for /r/ and pharyngealized dentoalveolars). Thus, among other regressive changes, /r/ may cause a preceding front vowel to lower and back (Auvergnat [faˈrado] FERRATA "bucket", Ardennes [lo:r] LARDU "lard"),[41] and a preceding dental stop to become alveolar as in the case of the heterosyllabic Catalan sequence /tr/ (*set rams* "seven branches").

Proctor's assumption that the alveolar tap [ɾ] exhibits a dorsal gesture cannot hold since it lies on the finding that this consonant shows less coarticulation than the dental approximant [ð], which is highly sensitive to coarticulatory effects from vowels.[42] Ultrasound and electropalatographic (EPG) data for Catalan VCV sequences collected by ourselves reveal no differences in tongue body lowering and retraction or in coarticulation between the alveolar tap and other dentoalveolar consonants such as /t, d, n/, and acoustic data also show a low degree of coarticulatory resistance for this consonant as a function of /i/ vs /a/, which is consistent with its being extremely short.[43]

In parallel to the thoughts about the genesis of dark /l/,[44] a word needs to be said about the relationship

39. SOLÉ, "Aerodynamic characteristics of trills and phonological patterning" (2002).

40. NARAYANAN, BYRD, and KAUN, "Geometry, kinematics, and acoustics of Tamil liquid consonants" (1999); SCOBBIE, PUNNOOSE, and KHATTAB, "Articulating five liquids: a single speaker ultrasound study of Malayalam" (2013).

41. CAMPROUX, *Essai de géographie linguistique du Gévaudan*, p. 96 (1962); BRUNEAU, *Étude phonétique des patois d'Ardennes*, p. 233 (1913).

42. The alveolar lateral, p. 32.

43. RECASENS and PALLARÈS, "A study of /ɾ/ and /r/ in the light of the 'DAC' coarticulation model" (1999).

44. The alveolar lateral, p. 32.

between apical /r/ and the uvular rhotic /ʀ/, which may be found in all word positions in present-day French and Portuguese dialects. The uvularization of the apical rhotic is prone to have originated through apical contact loss and simultaneous tongue dorsum raising in syllable-final position.[45] This hypothesis is in line with the existence of instances of double articulated rhotics exhibiting a primary apical constriction and a dorsouvular or dorsopharyngeal constriction in utterance-final position in Canadian French.[46]

45. STRAKA, "Contribution à l'histoire de la consonne R en français" (1965).

46. MORIN, "From apical [r] to uvular [ʀ]: what the apico-uvular r in Montreal French reveals about abrupt sound changes" (2013).

Discussion and conclusions

Articulatory data for phonemic (alveolo)palatal consonants and the alveolars dark /l/ and the trill /r/ reveal that there is no apparent reason why in languages in which palatalization and pharyngealization/velarization is not distinctive, these consonants should be considered complex segments composed of a primary tongue front gesture and a secondary tongue body gesture which are activated independently by the speaker. Spatiotemporal lingual characteristics, degrees of coarticulatory resistance and sound change and phonological processes associated with these consonants, which have been taken as evidence for segmental complexity, may be attributed to other factors. These simple consonants parallel truly complex palatalized and pharyngealized dentoalveolars in that are produced with a similar tongue body configuration. A contrast has also been established between the blended realizations [ɲ] and [ʎ] of the phonemic sequences /nj/ and /lj/ in English or Early Romance and the phonemic units /ɲ/ and /ʎ/ in Spanish or Czech.

Regarding tongue configuration and lingual coarticulation, the presence of tongue body lowering and retraction and a more or less pronounced dorsal constriction at the velar or pharyngeal zones appears to be associated with constraints imposed by trilling in the case of /r/ and with requirements on laterality and on the implementation of the darkness percept in the case of dark /l/. On the other hand, the contraction of the genioglossus muscle is responsible for the high and anterior position of the body of the tongue, and for the high degree of tongue body coarticulatory resistance, in the case of (alveolo)palatals and palatoalveolars. Clear /l/ and the tap /ɾ/ do not differ much from other dentoalveolar consonants both regarding tongue body position and coarticulatory resistance, though laterality demands may cause clear /l/

to be articulated with some more tongue predorsum lowering and tongue body retraction.

Specific sound changes like on-gliding and off-gliding are not generated from complex consonants through gestural dissociation, but are related to other factors such as an increase of the temporal lag between tongue front and tongue dorsum activation during the vowel preceding the consonant or immediately after closure release during the following vowel. The kinematic characteristics of all consonants under analysis are conditioned to a large extent by the physico-mechanical properties of the tongue front and the tongue body, as well as by the target configuration that these lingual regions must adopt for a successful consonant realization.

In sum, we believe that complex consonants involving a tongue front gesture and a tongue dorsum gesture should include only palatalized and velarized/pharyngealized consonants of languages where palatalization and velarization/ pharyngealization may apply to several consonants differing in primary place of articulation, but not to consonants from other languages which resemble the ones above regarding articulatory configuration and coarticulatory behavior due to their specific manner of articulation requirements.

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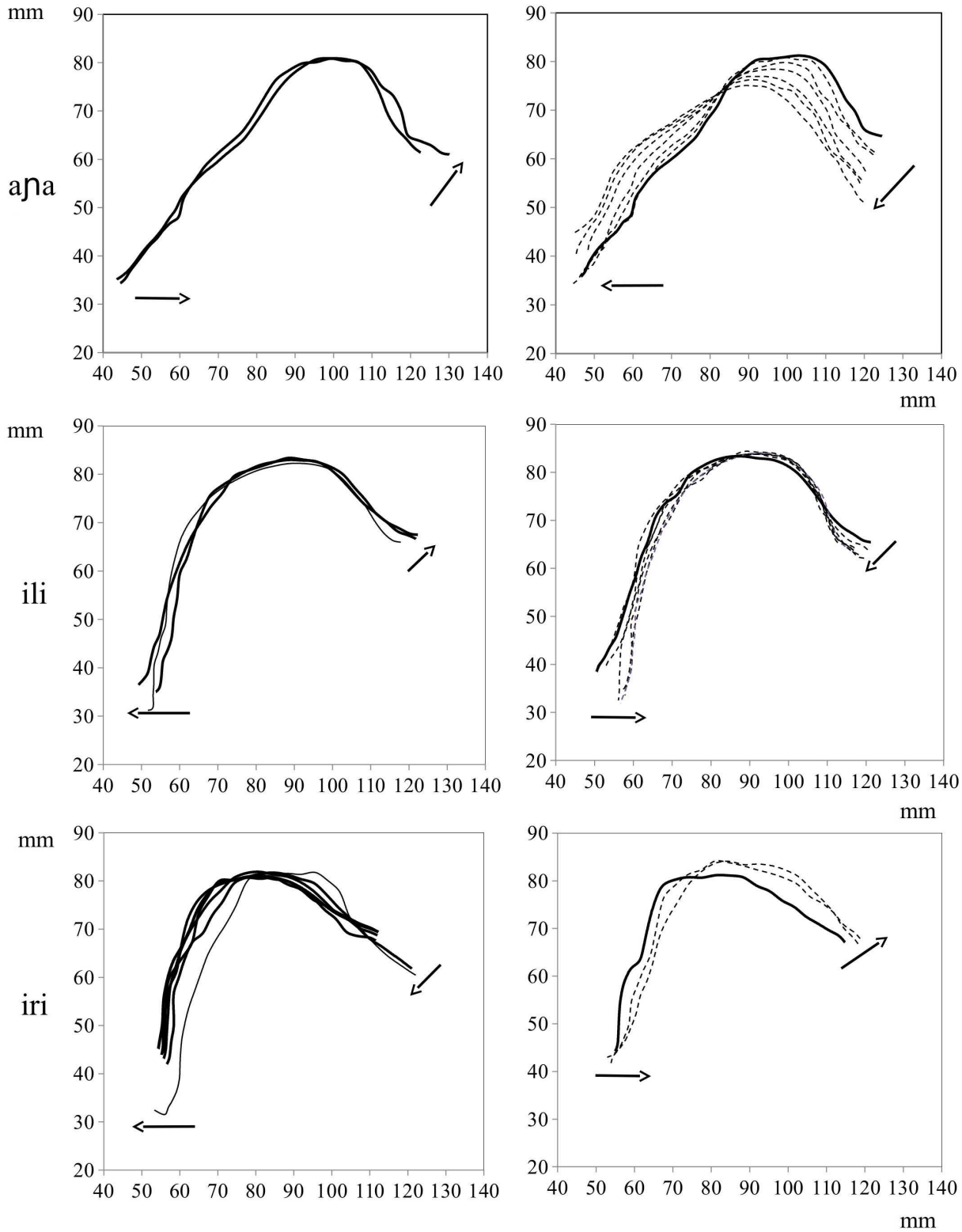

Figure 4: Lingual configuration data for the sequences /aɲa/, /ili/ and /iri/ produced by a Catalan speaker, collected with ultrasound. (Left graphs) Lingual splines from V1 onset to V1 offset (discontinuous lines) and from closure onset to about closure offset (thick lines). (Right graphs) Lingual splines at about closure offset (thick line) and from V2 onset to V2 offset (discontinuous lines). The temporal evolution of the splines is indicated by the orientation of the arrows. The front of the mouth is on the right edge of the graph.