Articulatory Indicators of Syllable Affiliation in Word Initial Consonant Clusters in Italian

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Abstract

In a study using electromagnetic midsagittal articulography (EMMA) with two speakers, we provide evidence that Italian word initial consonant clusters generally form complex onsets, but that those clusters beginning with a sibilant are exceptions. We thus contribute further motivation for treating clusters with 'impure-s' in Italian as heterosyllabic.

1 Introduction

Many languages have /s/C clusters word initially. Articulatory patterns for word initial /s/C and /s/CC clusters in English indicate that /s/ forms part of a complex onset (see Figure 1), despite the fact that such onsets can incur a sonority violation (e.g. if C is a plosive). Two measures have been proposed to ascertain whether a sequence of consonants forms a complex onset:

(i) In a complex onset, the C-center, also referred to as 'temporal center of gravity' [8], remains stable with respect to the vowel, measured as the distance between the mean of consonantal targets in the onset and the vowel target [2,6].

(ii) In a complex onset, the distance decreases between the rightmost consonant within the cluster and the vowel, measured as the time from the target of the rightmost consonant to the vowel target [5,9].

Recent studies have shown that in languages which have been analysed as not allowing complex onsets, and where thus only the rightmost consonant in word initial clusters belongs to the target syllable (such as Tashlhiyt Berber: *mun*, *s-mun*, *t-s-mun*) the timing between the vowel and the rightmost consonant [5] is stable. Similar results were obtained for Moroccan Arabic [9], thus confirming that it is possible to recover signatures of syllable structure from the timing of articulatory movements [7].

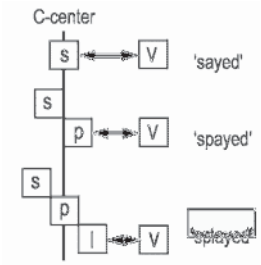

Figure 1: *Articulatory patterns for onsets in English, adapted from [3]*

The aim of this study is to investigate the temporal articulatory pattern for word initial clusters in Italian. More specifically we compare clusters beginning with a sibilant (e.g. /sp/, /zv/ and /spl/) to those without a sibilant (e.g. /pl/). Italian word initial clusters in which /s/ is followed by a consonant are referred to as 'impure-s'. They are treated differently from other clusters or from plain /s/ in the morphology (definite article alternation, [4] e.g. *il sale*, *il premio* but *lo studente)*. Moreover, there are indications from psycholinguistic studies that /s/ is neither clearly part of the onset of the first syllable of a word nor part of the coda of the preceding syllable [1].

2 Method

We recorded two native Italian speakers, one female speaker in her mid-forties (Apulia, Southern Italy) and one male speaker in his mid-thirties (Trentino, Northern Italy) with an electromagnetic midsagittal articulograph (EMMA) and a time-synchronised DAT-recorder. We placed sensors on upper and lower lip, tongue tip and tongue body (4 sensors: 1cm, 2cm, 3cm, and 4cm behind the tongue tip). For labial

consonants, we calculated the Euclidian distance between upper and lower lip (Lip Aperture index).

We recorded target words, containing simplex onsets and clusters with and without sibilants. See Table 1 for a word list. The target words were embedded in the carrier sentences *Per favore dimmi la __ di nuovo* ('Please say __ again'), ensuring an alternation of high and low vowels throughout the sequence.

Table 1: *Structure of target words*

Dataset (a)

C	CC	/s/CC
Lina (proper name)	plina (logatome)	splina (logatome)
rima ('rhyme')	prima ('first')	sprima (logatome)
rema ('s/he rows')	prema ('press')	sprema ('squeeze')

Dataset (b)

C	/s/C
Pina (proper name)	spina ('thorn')
fila ('line')	sfila ('s/he unthreads')
vita ('life')	svita ('s/he unscrews')
China ('China')	schina (logatome)

A total of 340 sentences were analysed (17 target words x 10 repetitions x 2 speakers).[1] All acoustic and articulatory landmarks were displayed and labelled by hand using the EMU speech database system. In the acoustic record we labelled the onset and offset of the target word and its segments. In the articulatory record, we labelled movements in the vertical plane, identifying minima and maxima in the respective velocity trace (vertical velocity and/or tangential velocity). For vowel-to vowel articulation, we labelled targets for [a] and [i]. For consonants, we labelled onsets, maximum targets and offsets in the movements of the primary constrictors.

For the analysis we calculated the distance of *(i)* the C-center to the vocalic target and *(ii)* the rightmost consonant to the vocalic target. Figure 2 illustrates how the landmarks are annotated for those measures.

[1] Further target words were recorded in the same session but will not be dealt with here.

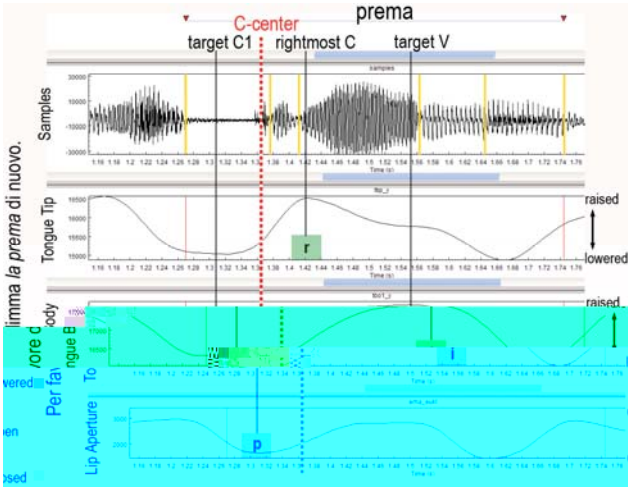

Figure 2: *Labelling example for /prema/*

3 Results

We calculated the variables *(i) C-center* and *(ii) rightmost consonant* relative to the vocalic target to investigate the temporal pattern for simplex onsets and clusters (see Table 1). We deal with both datasets separately.

3.1 Analysis of dataset (a)

(i) C-center variable: For two out of three target word sets, we found a C-center effect, when comparing C with CC (latencies in Table 2 *(i)*). For speaker MS the latencies for the C-center to the vocalic target remain stable (t-test; $p>0.05$, n.s.) in */lina/* (Δ 203 ms) vs. */plina/* (Δ 208 ms), and */rima/* (Δ 166 ms) vs. */prima/* (Δ 167 ms). The same pattern was found for speaker AR (t-test; $p>0.05$, n.s.), showing a stable timing from C to CC in */lina/* (Δ 227ms) vs. */plina/* (Δ 232 ms), and */rima/* (Δ 182 ms) vs. */prima/* (Δ 200 ms). No C-center effect was found for either speaker for */rema/* vs. */prema/*, where the distance from the C-center to the vowel increases from C to CC (t-test; $p<0.001$).

Table 2: *Distance of C-center and rightmost consonant to vocalic target, both speakers, all triads*

		(i) C-center to V			(ii) Rightmost C to V		
	triads	C	CC	/s/CC	C	CC	/s/CC
MS	*lina*	203	208	243	203	165	158
	rima	166	167	212	166	117	113
	rema	151	177	230	151	124	128
AR	*lina*	227	232	287	227	155	158
	rima	182	200	273	182	122	134
	rema	189	219	269	189	140	135

However, when comparing CC clusters with those containing a sibilant (/s/CC), no C-center effect was found. In all cases, the C-center latencies relative to the vowel considerably increase from CC to /s/CC (t-tests; p<0.001). E.g. for speaker MS, we found larger latencies when comparing */plina/* vs. */splina/* (on average 35 ms), */prima/* vs. */sprima/* (on average 45 ms), and */prema/* vs. */sprema/* (on average 53 ms). C-center measures for speaker MS and speaker AR are presented in Figures 3 and 4.

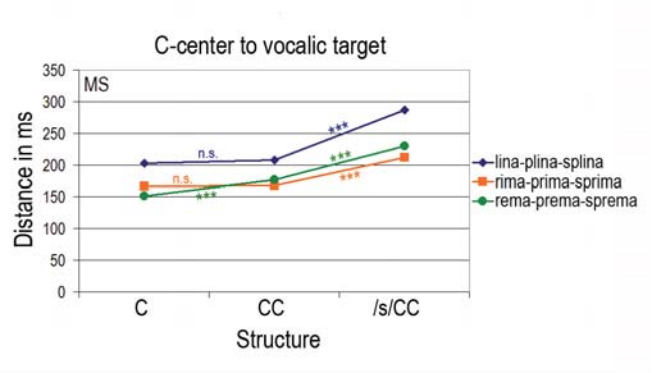

Figure 3: *C-center measures, speaker MS.*

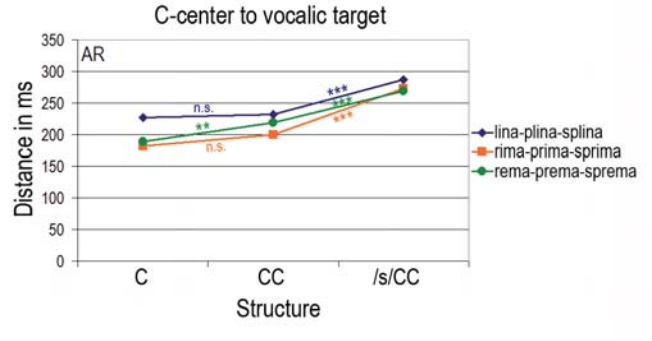

Figure 4: *C-center measures, speaker AR.*

To sum up, we found stable C-center effects in two out of three cases for C vs. CC clusters, indicating that in Italian both consonants of a CC cluster belong to the syllable onset. This could not be confirmed by */rema/* vs. */prema/*.

Whenever 'impure-s' is added to the onset, there is no adjustment of the timing of the other consonants in relation to the vowel so that we cannot assume a C-center effect here. This leads to the assumption that /s/ does not belong to the onset.

(ii) Rightmost consonant variable: Figures 5 and 6 show the temporal pattern for the distance from the rightmost consonant with respect to the vocalic target for speaker MS and AR. First, we compare C to CC clusters. In all cases, latencies from the rightmost C to the vowel decrease (t-test; p<0.001) showing that the consonant is shifted considerably towards the vowel (speaker AR: rightwards shift in */lina/* vs. */plina/* on average 72 ms; in */rima/* vs. */prima/* on average 60 ms; in */rema/* vs. */prema/* on average 51 ms).

These clear results for all triads show a significant decrease from C to CC. The rightmost C is shifted rightwards to make room for the added consonant.

However, the addition of /s/ to a CC cluster does not cause the rightmost consonant to shift further towards the vocalic target. This is the case for all /s/CC clusters for both speakers (t-test; p>0.05, n.s.).

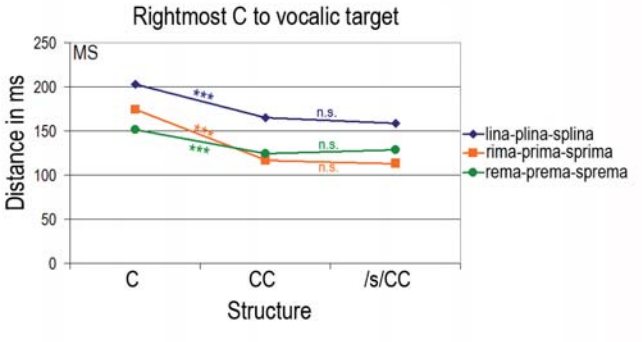

Figure 5: *Rightmost consonant measures, speaker MS.*

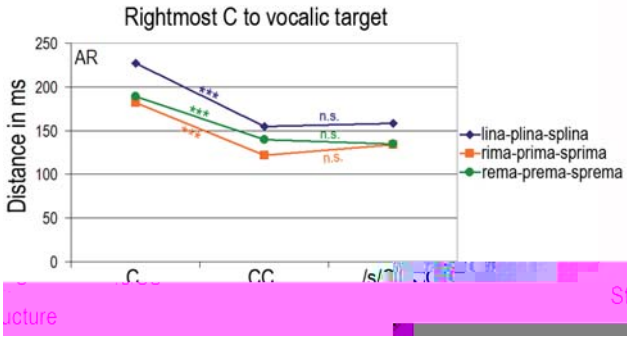

Figure 6: *Rightmost consonant measures, speaker AR.*

3.2 Analysis of dataset (b)

(i) C-center variable: The results for dataset (b) confirm the findings in dataset (a) that clusters containing a sibilant in word initial position are timed differently from those without. In contrast to C vs. CC (see above), where latencies remain stable (C-center effect), we found no C-center effect comparing C to /s/C. In all cases, the distance from the C-center to the vowel increases significantly (p<0.001), e.g. in */pina/* vs. */spina/* (speaker MS: on average 45 ms; speaker AR: on average 79 ms).

(ii) Rightmost consonant variable: When comparing C to /s/C clusters, no rightwards shift is found. That is, we found the same pattern for C vs. /s/C as for CC vs. /s/CC clusters. Thus, adding the sibilant to the onset does not affect the timing of the rightmost C relative to the vocalic target, e.g. in */pina/* (Δ 267 ms; speaker AR) vs. */spina/* (Δ 271 ms; speaker AR) the distance of the rightmost consonant remains stable (t-test; $p>0.05$ n.s.)

4 Discussion and conclusion

Our results provide evidence for a C-center effect on non-sibilant-initial clusters in Italian. This is schematized in Figure 7.A for */rima/* vs. */prima/,* in which the distance from the C-center to the vowel target remains stable, and the distance from the rightmost consonant to the vowel target decreases, indicating that non-sibilant clusters form complex syllable onsets. However, when 'impure-s' is added to the beginning of a word (either /s/C or /s/CC), the target of the rightmost consonant is not shifted towards the vowel, but remains stable (see Figure 7.B and 7.C). Furthermore, we show with dataset (b) that this effect is independent of the number of consonants in a cluster.

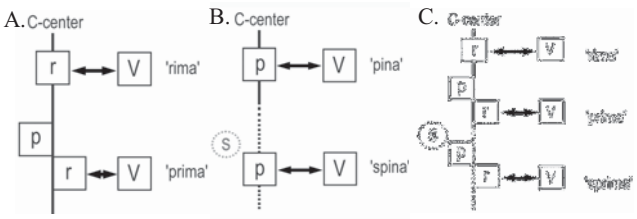

Figure 7: *C-center effect for C vs. CC clusters (A). No effect for clusters containing a sibilant (B, C).*

Although both variables show similar results, the variable of the rightmost consonant appears to be more stable, in line with [10].

We thus provide articulatory evidence that Italian word initial consonant clusters generally form complex onsets, but that those clusters beginning with /s/ are exceptions, thus contributing further evidence for the special status of the 'impure-s' in Italian.

As suggested by [5,9] the syllabification of initial /s/-clusters is language specific. Moreover we have shown that articulatory coordination can be used as a diagnostic for syllable constituency even *within* a language.

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