On rhotics in a bilingual community: A preliminary UTI research

Lorenzo Spreafico & Alessandro Vietti, Language Study Unit, Free University of Bozen-Bolzano

Abstract

In this paper we offer an Ultrasound Tongue Imaging (UTI) based description of rhotics in bilingual speakers from South-Tyrol. In particular we examine whether adult Italian/Tyrolean bilinguals display differentiated patterns of articulation for rhotics in each language they speak and whether bilinguals' articulatory patterns in each examined language are similar to those used by almost monolingual speakers or not. Intraspeaker comparison shows that very late sequential bilinguals do not present distinct articulatory patterns for rhotics in the two languages, while the simultaneous bilingual do. Besides interspeaker comparison shows that articulatory patterns for rhotics used by simultaneous monolinguals differ from those used by the very late sequential bilingual speakers. This data helps to understand how phonological categories are organized by bilinguals, and tackles the long debated issue regarding the possibility that bilinguals make use of a single shared phonological system or of two separate ones.

1. Introduction

1.1 Background

This study[1] is part of a project aimed at collecting a socially-stratified articulatory corpus using the UTI technique. The participants included in the database are bilingual speakers of Italian and of Tyrolean as they are spoken in South Tyrol. From a sociolinguistics point of view, South Tyrol is characterized by a societal bilingualism with two quite separate linguistic communities: Tyrolean and Italian. These two communities exhibit marked asymmetries in their linguistic repertoires (Table 1). The linguistic repertoire of the members of the Tyrolean community is characterized by a medial diglossia, with Tyrolean – a southern Bavarian dialect (Wiesinger 1989; Barker 2005) – in lower position, and Standard German in high position (Ciccolone 2010; Lanthaler 1990). Moreover the repertoire of the German community very often includes Italian, especially if speakers with middle-high level of education and living in main towns such as the capital city Bozen-Bolzano are considered.

Part of
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In contrast, the members of the Italian community are not markedly bilingual with respect to Tyrolean, although they are likely to display discrete competence in an Italo-Romance dialect, – especially if they are of an older generation – or in Standard German, especially when they belong to the younger community and learnt it in school.

	Tyrolean community		Italian community	
	L1	L2	L1	L2
High	Standard German	Standard Italian	Italian	(Standard German)
Middle	(Bozner Deutsch)		Regional Italian	
Low	Tyrolean		(Italo-Romance dialect)	

Table 1 – Linguistic repertories in South Tyrol.

1.2 Rhotics in South Tyrol

What are the consequences of this situation on the phonetics and phonology of Italian and Tyrolean as they are spoken in South Tyrol? Unfortunately research on this topic is scant and actually limited to one volume (Tonelli 2002). Even scanter however are investigations offering data on rhotics. As for Italian spoken in the area we can refer to auditory investigations by Mioni (1990, 2001), Canepari (1990), Tonelli (2002) and to instrumental investigation by Vietti, Spreafico & Romano (2010), Spreafico & Vietti (2010), Vietti & Spreafico (2010) and Spreafico & Vietti (2011). As for Tyrolean, interesting exceptions are Klein & Schmitt (1969) and again Tonelli (2002).

Mioni's (1990) investigation limits itself to the utterances in Italian produced by informants living in the cities, and in particular it focuses on monolingual and bilingual students. As regards rhotics in Italian monolinguals, he affirms that the apicoalveolar tap usually prevails. As for the bilinguals, the author reports that all his informants (with no significant distinctions) use some sort of uvular rhotic, which, as far as he is concerned, reveals an influence of the Bavarian dialect substratum and, in a way, indexes speakers' ethnicity[1]. In contrast, on the basis of auditory analyses (of supposedly monolinguals' utterances only) Canepari (1990) reports on the tendency of using uvular pronunciation (e.g. [ʀ; ʁ̞]), which at times can even be accompanied by alveo-uvular pronunciations. Yet Tonelli

[1] This becomes even more evident if one takes into account that, as reported by Mioni (2001), the Italian phonology in these informants is properly acquired and it is substantially the same as the one used by the Italian native speakers around them.

(2002) shows that the only variant of the /r/ sound to be found in an Italian sample (again comprising monolinguals only) living in Bolzano is [ɾ], which is sometimes, and in marked pronunciation only, replaced by [r].

Vietti & Spreafico (2010) offered a different picture of this phenomenon. They acoustically analyzed the type of /r/ realizations in Italian productions by South Tyrolean informants and pointed out that sometimes both apical and uvular realizations can be detected in utterances and even in isolated words produced by the same informant. They examine a sample of 11 speakers and about 500 occurrences and show that their informants make use of many more allophones than those documented in previous research: [ɾ][2]; [ϱ][3]; [ʁ̞]; [ʀ]; [χ]; [r]; [ɽ]; [ʐ]; [ɻ]; [ʁ]. In addition, they identify several instances of deletion, as well as other phones that could be hardly categorized mostly due to the fact that the acoustic and auditory data were contradictory.

Systematic research on rhotics in South Tyrolean is sparse and limited to the information provided by the *Tirolischer Sprachatlas* (Klein & Schmitt 1969). As for the analysis of the data including /r/ realizations in Klein & Schmitt (1969), it is worth noting that an extremely relevant diatopic variation emerges and that salient differences emerge across the broader area of South Tyrol[4]. For example the analysis of some of the maps in the volume on *Konsonantismus, Vokalquantität, Formenlehre* for the capital city of Bozen-Bolzano shows that uvular articulations are registered in six out of nine cases[5], while apicoalveolar articulations are reported for the rest. The alternation among front and back realizations seems also to affect the so-called *Bozner Deutsch*, which, according to Tonelli (2002) is characterized by [ʀ] and exceptionally by [r]. These observations are consistent with those reported in studies on bordering areas as in the case of Ulbrich & Ulbrich (2007) who remarks on Austrian German: they note that the spectroacoustic analysis of newsreaders' productions reveals a prevailing use of uvular realizations in onset position (especially [ʀ] and [ϱ], but also [χ] and [ʁ], which may be due to backing phenomena) and mainly vocalized variants of /r/ in coda position, although not excluding apical articulation.

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2 Both tap and – to a lesser extent – flap [ɾ].

3 Uvular tap. This sound, unknown in the IPA, is transcribed by the symbol [ϱ] according to a proposition made by Demolin et al. (ms).

4 E.g. deletions and apical realizations in the Western Pustertal *versus* uvular trills in the Easter Pustertal.

5 Uvular articulations are reported for: *Durst*, map 50; *Wurst*, map 51; *Werden*, map 58; *Hertz*, *Fertig*, *Wird*, map 54. Apicolaveolar articulations are registered for: *Feuer*, *Bauer*, *Bauertag*, map 91. It is worth noticing here that there seems to be an isogloss running NE-SW along the Eisack Valley separating /ʀ/ dialects in the West from /r/ dialects in the East.

The brief discussion offered above clearly shows the lack of systematic investigation of both Italian and Tyrolean dialect with respect to rhotics. Therefore, this research also contributes to fill the gap as it offers a preliminary instrumental description.

2. Methods

2.1 Informants

In order to answer the research questions on whether adult Italian/Tyrolean bilinguals display differentiated patterns of articulation for rhotics and on whether pattern of articulation in adult bilinguals are similar to those by monolingual speakers we collected a socially-stratified articulatory corpus using the UTI technique (Stone 2005; Iskarous 2005; Davidson 2012).

The nineteen informants included in the database are bilingual speakers of Italian and of Tyrolean as spoken in South Tyrol. They are all in their mid 30's and were born and raised in Bozen-Bolzano, the capital city of South Tyrol. Initially a questionnaire was used to determine the participants' length and amount of exposure to the two languages. Building on that each informant was assigned to one of four groups on a bilingualism discretum scale: simultaneous bilinguals, early sequential bilinguals, late sequential bilinguals and very late sequential bilinguals.

This was mostly on the basis of two parameters: the rate of bilingualism in the family, that is whether the informant's parents were native speakers of the same language or not, and the rate of dual language exposure, in other words whether the informant had been in contact with Italian and the Tyrolean dialect from birth, from nursery school on, from primary school on or from secondary school on only (as shown by Simonet 2010 for Catalan)[6].

In order to control for the real exposure to the two languages and to obtain a better understanding of the sociolinguistic *milieu* and hence of the sociophonetic environment each informant was inserted into (Khattab 2002), we collected social network data for each speaker using an egocentric approach which examines individuals' immediate neighbors and associated interconnections (Milroy & Milroy 1985; Scott 2000). This allowed us to assess the amount of Italian or Tyrolean each speaker was exposed to and actually resorted to in his/her daily life.

6 It is important to notice here that South Tyrol has a split school system with segregated Italian and German schools and that in the latter case lessons are supposed to be taught in Standard German and not in Tyrolean. This means that in South Tyrol, Tyrolean can be acquired via spontaneous interactions only, whereas Italian can also be learnt via formal instruction.

By linking the data from the questionnaire and those from the egocentric social network we were able to include into the corpus 8 simultaneous bilinguals, 3 early sequential bilinguals, 4 late sequential bilinguals and 4 very late sequential bilinguals.

In this paper we only focus on the analysis of rhotics as they are articulated by seven speakers out of the nineteen we recorded, namely those belonging to the opposite poles of the discretum (see Table 2): two very late sequential bilinguals (LSB) and five simultaneous bilinguals (SB). Each of the very late sequential bilinguals grew up in strictly monolingual families: an Italian (LSB1, female) and a Tyrolean (LSB2, female) respectively, and according to data from their social network at the time of our recording, had almost no contacts with members of the other language community.

On the other hand the simultaneous bilingual speakers SB1 (male), SB2 (male), SB3 (male), SB4 (female), SB5 (female) came from bilingual families (in the sense that each of their parents was a native speakers of one of the two languages), attended both Italian and German schools, and, according to their egocentric network, kept up relationships equally with members of the two language communities.

Speaker	Age	Gender	Italian	Tyrolean	German	Italian + Tyrolean	Italian + German	Tyrolean + German	Total*
LSB1	23	F	93	0	0	0	0	0	93
LSB2	24	F	7	87	7	0	0	0	101
SB1	31	M	47	13	0	13	13	0	86
SB2	21	M	80	7	0	7	0	7	101
SB3	38	M	40	47	0	7	0	0	94
SB4	41	F	87	0	0	0	0	0	87
SB5	22	F	80	0	0	13	7	0	100

Table 2 – Speakers' rate of interaction (%) in each language or combination of languages for their last 10 encounters during the day of data collection. Information retrieved via the EgoNet software (McCarthy 2011). *Not all logical combinations reported, total might differ from 100%.

2.2 Procedure

For data collection, we used the Articulate Instruments multichannel acquisition system called Articulate Assistant Advanced (AAA) (Articulate Instruments 2011).

Articulatory data was recorded using a portable SonoSite 180 ultrasound machine equipped with a SonoSite ICT intracavitary array transducer operating at 4-7 MHz. The frame rate was automatically and unchangeably set at 15 Hz; the depth was autonomously set at 7 cm; the field of view was 120°. The probe was held by a stabilizing helmet to make sure that it adhered to the speaker's chin and was kept in constant relationship to the speaker's palate.

Acoustic data was recorded at 22,050 Hz using a Marantz PMD660 recorder coupled with a Beyerdynamic MCE86N microphone. The audio signal exiting from the recorder was synchronized to the video signal coming from the ultrasound machine via the SyncSyncBrightUp™ (Articulate Instruments 2011). This device was triggered by an audio beep generated by AAA upon pressing the start recording button. The software then superimposed a white mark on the video signal and generated a sync pulse used to synchronise the audio and video signal during the analysis.

Overall 38 written prompts were presented to each informant via a PC monitor. At first two test words were presented to the speakers to acquaint them with the procedure. Then two word-lists were presented to the participants, one in Italian and one in Tyrolean[7]. Each list contained 18 randomly arranged target words beginning with a CRV sequence of the kind: plosive plus rhotic plus high or low vowel (see Appendix 1). These sequences were chosen to control the high contextual variability of /r/ already observed in Vietti & Spreafico (2008) so to allow a better comparison of static articulations in the two languages; as well as to allow an analysis of coarticulation phenomena in onset clusters[8].

In addition to the target words, each list contained two distractors used to urge informants into swallowing some water or eating some pudding. That was needed to collect palate images of a decent quality that could serve as reference for the subsequent analysis. Each sequence of written prompts was submitted in the same order to the informants three times, so in the end we were able to record 114 words for each speaker. That was needed to ensure that notwithstanding the slow and unalterable scan rate of 15 Hz at least one image of the tongue during the short constriction phase could cleanly be imaged for each of the eighteen CRV sequence in the two languages.

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7 Since there are no common writing conventions for Tyrolean, which are inherited and customized from Standard German, informants were allowed to examine a printed copy of the word list before the test to be sure they would recognize all forms it contained.

8 We leave this matter for future research.

All speakers were individually recorded in a soundproof room, and whenever possible two researchers at a time attended the data collection session and interacted with the informants. This was arranged to assure that both a native speaker of Italian and a native speaker of Tyrolean were present at the same time so to ensure a truly bilingual environment and have the informant in the bilingual mode (Grosjean 1998).

For data analysis, we ran a parallel auditory[9]/articulatory analysis based on the audio records and on the synchronized mid-sagittal ultrasound images of the tongue. The /r/ tokens were coded for one of seven categories: four dorsals (trill, tap, fricative, approximant); two coronals (trill, tap); and deletion.

Then we semi-automatically fitted mid-sagittal tongue surface using AAA (version 2.13) that also allowed for manual correction of the splines. If we could draw more than one spline traceable back to the same rhotic, we exported only the one corresponding to the closure phase for trills and taps or to the medial one for fricatives and approximants. At last we transferred the curves drawn onto the raw ultrasound image in Cartesian coordinates to a spread sheet as the basis of a qualitative analysis.

3. Data

3.1 Data analysis

Of the 756 rated tokens, only 585 were included in the analysis (Table 3). Problems in tongue imaging common to most UTI research[10], such as discontinuities in the surface contour due to asynchronies between the scan rate and the frame rate as well as to shadows casted by the hyoid bone, the jaw, or ultrasound refraction forced us to discard many tokens. This especially held for SB1, for whom we were only able to extract 22 out of 54 profiles in Tyrolean and 47 in Italian[11].

9 Even if an auditory classification was undertaken, spectrograms were also was used to support the classification.

10 Relevant UTI works on rhotics include, among the many others, Iskarous et al. (2010); Lawson et al. (2008); Proctor (2009); Scobbie & Sebregts (2011).

11 Apparently in Tyrolean the tongue assumed a position that differed from that displayed during the instrumentation set up based on inter-utterance rest positions and henceforth caused the tongue to parallel the beam orientation, thus refracting the ultrasounds. In Italian the phenomenon was rarer, which raises the more general issue of language-specific articulatory settings (Gick et al. 2004).

	Tyrolean	Italian	Total
	Tokens | Coronals % | Allophone	Tokens | Coronals % | Allophone	Tokens | Coronals %
LSB1	42 | 100 | [ɾ]	23 | 100 | [ɾ]	65 | 100
LSB2	41 | 0 | [ʁ]	30 | 0 | [χ]	71 | 0
SB1	22 | 0 | [ʁ̞]	47 | 0 | [ʁ̞]	69 | 0
SB2	51 | 0 | [χ]	53 | 0 | [ʀ]	104 | 0
SB3	51 | 0 | [ʁ̞]	51 | 0 | [ʁ̞]	102 | 0
SB4	49 | 0 | [χ]	49 | 100 | [ɾ]	98 | 50
SB5	48 | 0 | [χ]	28 | 100 | [ɾ]	76 | 50
Total	304	281	585

Table 3 – Analyzed tokens per speaker; percentage of coronal rhotics and major allophone in each language.

3.2 Auditory analysis

Table 3 above contains data on the auditory analysis we ran and reports on the number of tokens, the percentage of coronal rhotics and the most frequent allophone for each speaker in the two languages.

It was evident from our analysis that all speakers but LSB1 resorted to a uvular consonant (mostly [χ]) to read the Tyrolean words. As far as Italian words were concerned, however, both uvular and apical rhotics were attested, since SB4 and SB5 switched between the two places of articulation according to the language the prompts belonged to.

It also emerged from the auditory analysis that none of the speakers we considered alternated between coronal and dorsal variants within the same language, and that in Tyrolean no other allophone beside [χ, ʁ̞, ʁ] was used, while in Italian also [r] occurred.

3.3 Articulatory analysis

3.3.1 Intraspeaker comparison

In order to assess if adult bilinguals display one or two patterns of articulation for rhotics in Italian and Tyrolean respectively, we considered at first the static articulations of the two very late sequential bilinguals LSB1 and LSB2, namely an almost monolingual speaker of Italian and an almost monolingual speaker of Tyrolean, and ran an intraspeaker comparison of their tongue profiles. Our analysis was based on impressionistic observations on the shape and position of the tongue, as well as on the statistic comparison of tongue splines.

The impressionistic, graphic analysis of LSB1's data reported in Fig. 1 shows that in each of the nine CRV sequences we considered ([k, g, t, d, p, b | r | u, a, i]) there is no strong categorical distinction between tongue shape and position in the two languages and that the two splines almost always coincide.

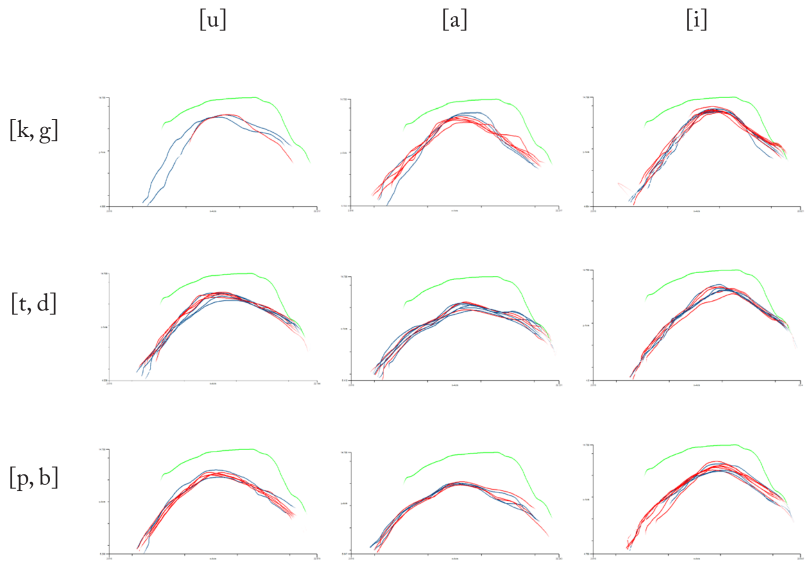

Figure 1 – Tongue shapes for r-sounds in LSB1. See Fig. 2 for the explanation of colors.

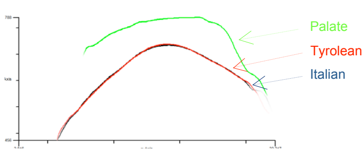

Figure 2a – LSB1, mean tongue shapes for *r*-sounds.

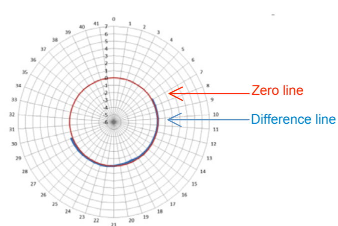

Figure 2b – LSB1, radar chart of the t-test.

The green line at the top of the image always represents the palate, whereas the blue and the red line at the bottom represent shape and position assumed by the tongue in Italian and in the Tyrolean dialect respectively; tongue tip and blade are right, tongue root is left. As a mere means of orientation in the radar chart, groups of spokes can stand for the places of articulation in reference to the upper surface of the vocal tract. In a clockwise direction approximately they are: spokes 7 to 13 alveolar ridge; 14-20 hard palate; 21-25 soft palate (velum); 26-30 uvula; 31-35 pharynx.

Fig. 2a depicts the averaged spline calculated from the subset of splines associated with a rhotic sound in each of the two languages and shows that the main body of the tongue is held convex to the palate, with the antero-dorsum straight and steep raising and the tip down, pointing to the alveolar ridge on the roof of the mouth, thus defining a constriction in the post-alveolar area and producing almost always an alveolar tap in both languages as attested by the auditory analysis.
The initial impression of similarity between the two tongue profiles is confirmed by the statistical analysis, which is based on the calculation of a t-test[12] for each spoke between the two splines via the AAA integrated tool and is rendered here in a radar chart where the higher is the distance among the two lines, the higher is the difference among the two splines (Fig. 2b).

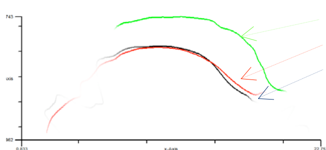

Figure 3a – LSB2, mean tongue shapes.

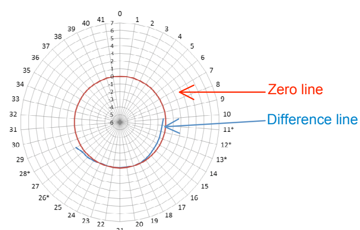

Figure 3b – LSB2, radar chart of the t-test.

The analysis of LSB2's data offers a different image for the tongue shape and position, but a very similar one for the almost coincidence of the profiles in Tyrolean and in Italian. Extracted mean tongue surfaces (Fig. 3a) show a near semi-circular shape especially for Italian, with a retracted root, the dorsum held convex to the palate and the lamina pointing down. The tongue bunching up towards the postvelar zone and the absence of an alveolar constriction point to a dorsal articulation, which fits in with the acoustic analysis that shows a predominance of voiced or voiceless uvular fricatives. The statistical analysis (Fig. 3b) of the difference between the two splines shows that these thicken in the laminal and in the posterodorsal area, apparently because of a slight backwards shifting of the tongue which is still to be seen notwithstanding the poor quality of the images in the hindermost region of the tongue.
The intraspeaker comparison of SB1 shows again almost an overlapping of the two contours (Fig. 4a) that display a near semicircular shape similar to that reported for LSB2: the tongue is mid bunched and the lamina is kept low while the middle of the

12 2-tailed t-test, unequal variances and sample sizes, Welch-Satterwaite equation as performed by AAA. t-test was significant at 5%.

tongue is raised towards the hard palate. This configuration allows the identification of a dorsal articulation, notwithstanding the limit in the size of the depicted palate that makes it difficult to precisely assess the place of articulation. Nevertheless the auditory analysis of this speaker's production by the two evaluators converges on an auditorily identical [ʁ̞] as the most recurrent variant, which is further confirmed by the spectrographic analysis. As for the similarity between the two profiles, the t-test (Fig. 4b) shows that the difference among the two splines almost equals zero, except for two points in the foremost part of the imaged tongue[13] and for a point in the back due to an higher degree of root retraction in Tyrolean.

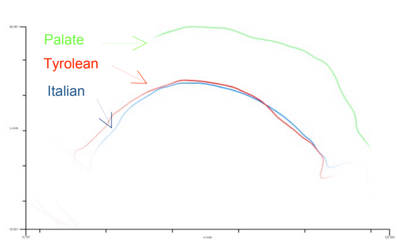

Figure 4a – SB1, mean tongue shapes.

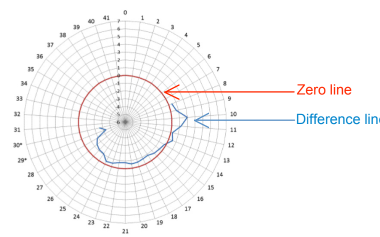

Figure 4b – SB1, radar chart of the t-test.

For speaker SB2 (Fig. 5a) the tongue is held convex to the palate with the anterodorsum raising up and the tongue tip down pointing to the alveolar ridge, thus defining a dorsal articulation. The impressionistic and the statistical (Fig. 5b) analysis on the difference between the two splines show that even if the two profiles are broadly comparable in shape, in Tyrolean the tongue tends to be lower than in Italian, especially in the dorsum. However, the radar chart also depicts how statistically significant differences emerge in the antero-dorsum rather than in the root.

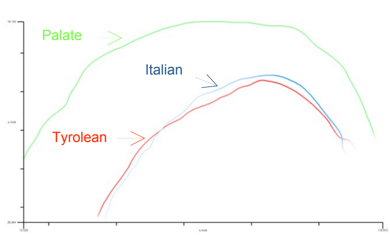

Figure 5a – SB2, mean tongue shapes.

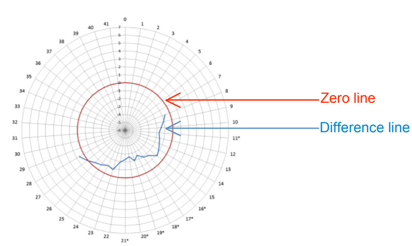

Figure 5b – SB2, radar chart of the t-test.

[13] Even if statistically significant data is not revealing given the poor definition of the tongue profile at the considered point.

The intraspeaker comparison of SB3 profiles (Fig. 6a) shows again two broadly comparable contours similar to those by LSB2 with a clear mid bunching of the tongue: the front, blade and tip are low, while the middle of the tongue is raised towards the palate to articulate even spectrographically similar uvular approximants. The Cartesian space shows that in Italian the tongue is kept lower but, for the foremost portion, which is higher. Nevertheless the radar chart associated with the t-test (Fig. 6b) illustrates that the difference between the two splines is significant but for the anterodorsal and the radical portion. The differentiation thus seems to involve the position of the tongue, rather than its shape.

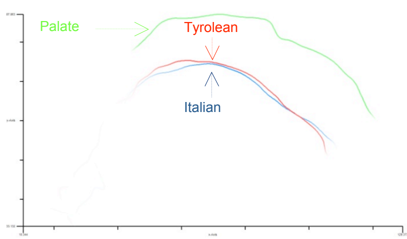

Figure 6a – SB3, mean tongue shapes.

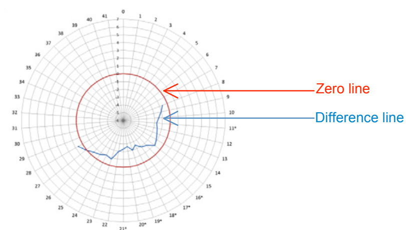

Figure 6b – SB3, radar chart of the t-test.

For speaker SB4, Figure 7a displays that both in Tyrolean and in Italian the tongue is kept smoothly convex to the palate, with no bunching or tip raising. Even if similar in shape, the intra-speaker comparison of tongue profiles via the t-test reports a significant differentiation which affects almost each point and, again, is due to the different position the tongue takes, lowered and retracted in Tyrolean, with respect to the palate. Surprisingly both the auditory and the spectrographic analysis gives different outcomes for the two languages and dorso-uvulars prevails in Tyrolean, while alveo-coronals are predominant in Italian.

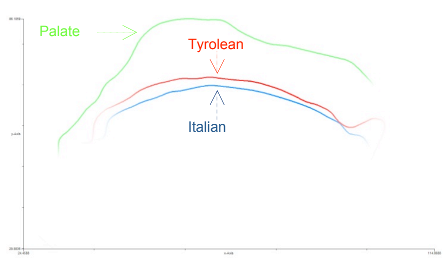

Figure 7a – SB4, mean tongue shapes.

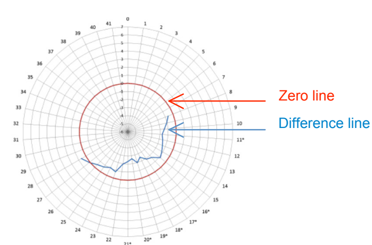

Figure 7b – SB4, radar chart of the t-est.

Examination of tongue curves for speaker SB5 shows (Fig. 8a) that she articulates rhotics in the two languages in different ways: in Tyrolean her tongue forms a smooth convex curve with no distinct bunching; the root is slightly retracted, the body leaned towards the back of the mouth and the tip is far from determine a point of primary constriction next to the alveolar ridge. On the contrary, when articulating a rhotic in Italian, the body of the tongue is more advanced and presents a mid-bunching; the middle is more raised towards the hard palate while the blade and the tip are kept high, at least higher than in Tyrolean. Besides a saddle is to be spotted, which probably coincides with the place where the dorsum and the lamina diverge.
The visual impression of a difference among the two mean splines for the two languages is further confirmed by the statistic and auditory analysis: as reported in the radar chart (Fig. 8b), there are significant differences both in the posterodorsal/radical region and in the laminal area; and as derived from the auditory analysis the speaker goes for apical rhotics ([ɾ]) in Italian and for uvular rhotics ([χ]) in Tyrolean.

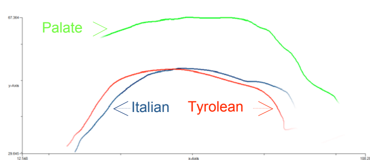

Figure 8a – SB5, mean tongue shapes.

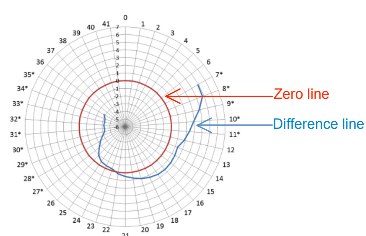

Figure 8b – SB5, radar chart of the t-test.

Data presented so far allow us to answer the first question on whether adult bilinguals display different patterns of articulation for rhotics in the two languages they speak and to affirm that apparently no space for differentiation is left for very late bilinguals. In fact they tend to almost completely transfer the shape and position of articulation from one language to the other and to articulate rhotics in the second language they learnt as if that were instances of the first language they learnt.
On the other hand, simultaneous bilinguals tend to differentiate among articulation patterns in the two languages, even if with varying degrees: indeed as reported in Table 4 while in the case of SB1 the two splines significantly differ in only two points, for the rest of informants the number of points

increases up to more than half of the traceable profile as it is in the cases of SB3 and SB4.

	SB1	SB2	SB3	SB4	SB5
N. of points	2	7	17	17	14

Table 4 – Number of significantly different points among the two splines.

As already mentioned before, intraspeaker differences in tongue splines might refer to a change in the position of the tongue or to modifications in the shape of the tongue. Changes in the position of portions of the tongue seems to affect SB1, SB2, SB3, SB4 especially and to ensue from the placement of the post-dorsum that in Tyrolean tends to be moved towards the uvula and the pharynx. Minor changes in the position affect also the lamina that in Italian (in all but one case, SB4) is shifted upwards, which is sometimes unexpected as in the case when uvular rhotics are produced.

Changes in the shape of the tongue are rarer if considered from the intra-speaker comparison perspective, and are actually limited to SB5 who in Italian keeps the antero-dorsum and the lamina are high towards the hard palate and the alveoli. This modification is in keeping with the different acoustic outputs in the two languages (coronal and dorsal), but counter-intuitively is not to be found in SB4 despite a similar front-back alternation in her auditory productions.

These results on intraspeaker changes in tongue position and shape are relevant to the phonetic characterization of simultaneous bilingual speakers because they point to possible space for differentiation in the articulation of rhotics in the two languages notwithstanding the absence of overt auditory differentiation for the two languages and, *de facto*, the transfer of a phone from one system to the other. This is of importance because it shows how articulatory data can add to the study of acoustically based theories of bilingual phonology, introducing previously unattested considerations such as auditory invariance coupled with articulatory differentiation[14]. It also allows modeling of the effects of language contact within adult simultaneous bilinguals that as individual speech producers may serve as precursors for language change.

14 Please refer to Vietti (2012) for an account on acoustic invariance coupled with articulatory differentiation in the uvular fricatives of a simultaneous Italian/Tyrolean bilingual.

3.3.2 Interspeaker comparison

In order to address the second question as to whether the patterns of articulation of adult bilinguals resemble those of monolinguals, we ran an interspeaker comparison between the simultaneous bilinguals SB1-5 and the very late sequential bilingual LSB1 and LSB2 speakers, who acted as control subjects: indeed in a region characterized by societal multilingualism such as South Tyrol, it is almost impossible to find truly monolingual speakers.
Our comparison is impressionistic and based on the superimposition of the different speakers' palates based on translations and rotations (but not on rescalings) aimed at identifying the points of maximum coincidence in the areas of the alveolar ridge and the hard palate as shown in Fig. 9.

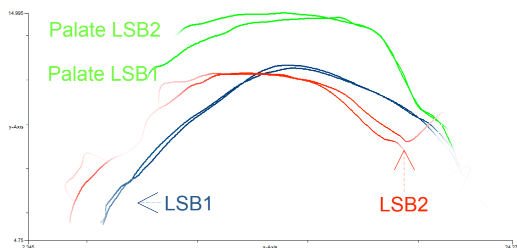

Figure 9 – Interspeaker comparison: LSB1 (blue), LSB2 (red) mean tongue shapes.

Fig. 9 depicts the static articulation for mean rhotics in the two very late bilinguals LSB1 (the Italian dominat, in blue) and LSB2 (the Tyrolean dominant, in red). This qualitative analysis clearly illustrates that sequential bilinguals use two radically different tongue configurations and allows us to spot the two different places of articulation, the coronal (alveolar) and the dorsal (uvular), which is not unexpected at all given that according to previous research (see also Romano 2013) coronal articulation are quasi-standard in Italian while uvular articulations are quasi-standard in the Tyrolean dialect.
In order to answer our second research question, the comparison between LSB1, LSB2 on the one hand and SB4 and SB5 on the other is, however, of higher relevance than that of LSB1 and LSB2 or that of SB1-SB3 because the two simultaneous bilinguals SB4 and SB5 are the only speakers to modify, in an auditorily perceptible manner, the place of articulation of rhotics in the two languages.

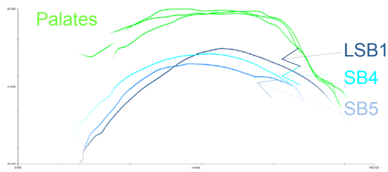

Figure 10a – LSB1, SB4, SB5 Italian.

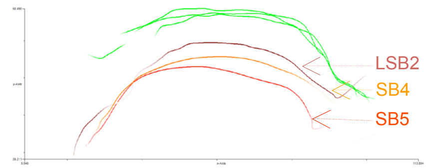

Figure 10b – LSB2, SB4, SB5 Tyrolean.

Figures 10a and 10b report the graphical comparisons of tongue profiles in Italian and Tyrolean respectively for LSB1, LSB2, SB4, SB5, and show that for both languages the mean tongue profiles of the simultaneous bilingual diverge from the averaged profiles of the Italian dominant and of the Tyrolean dominant sequential bilinguals.

As regards Italian, the tongue profile of the simultaneous bilinguals SB4 and SB5 differs from that of LSB1. In the case of SB4 there is no steep raising of the postero-dorsum but a higher rate of root retraction and a moderate lowering of the lamina instead. On the other hand SB5 displays a higher rate of root retraction and a significant lowering of the middorsum.

As regards Tyrolean, the picture is similar and tongue profiles for SB4 and SB5 differ from that of LSB2. Indeed even if SB4's tongue shape is similar to that of LSB2 and even if posterodorsum and root almost coincide, the anterodorsum is kept significantly lower by the simultaneous bilingual. On the other hand, regarding SB5, she converges towards the root retraction typical also for the Tyrolean-dominant speaker, but still shows a significant lowering of the middorsum.

The interspeaker comparison of tongue profiles thus shows that the patterns of articulation for rhotics by simultaneous bilinguals are different from those used by almost monolingual speakers. This result is of relevance because it shows that simultaneous bilinguals might differ in the articulatory implementation of the same rhotic phonetic segments from very late sequential bilingual not only in the sense that, at least articulatorily, they maintain cross-language phonetic differences, but also that they develop new, third articulatory patterns that diverge from those of native speakers.

4. Discussion

The collected data, and especially the intraspeaker comparison, show that very late sequential bilinguals do not present distinct articulatory patterns for rhotics in the two languages, while the simultaneous bilingual do, even if at varying degrees. Besides interspeaker comparison shows that articulatory patterns for rhotics used by simultaneous monolinguals differ from those used by the very late sequential bilingual speakers who acted as control subjects. Differentiation of patterns might occur as a consequence of articulatory, acquisitional or sociophonetic factors.

In articulatory terms, marked intraspeaker differentiation as exploited by simultaneous bilinguals SB4 and SB5 is used effectively to reach different articulatory targets in the two languages and make the speaker sound like a native monolingual in each of the two codes. Marked intraspeaker differentiation of the kind however seems to be counter-economical: rhotics are indeed known not only for their interchangeability, the coronal/dorsal opposition is indeed non-pathological in both Italian and Tyrolean, but also for the high constellations of gestures that are required to articulate them (Proctor 2009). This might be the reason for developing third articulatory patterns that apparently allow for an economic reuse of most of the articulatory program, except for fine tunings of tongue root and tip positions, which seems comparable to those attested in speakers SB1 and SB3. Indeed these speakers, who resort to an at least auditorily identical [ʁ̞] in both languages, build the auditorily undetectable[15] but articulatory visible opposition between rhotics in the two languages on just one parameter, namely a change in the tongue position, and specifically raising vs. lowering or advancing vs. retracting of the whole tongue in Italian and Tyrolean respectively.

From the acquisitional perspective, intraspeaker differentiation of patterns as reported for simultaneous bilinguals could occur as a consequence of the particular organization of bilingual speakers phonetic system. In this sense a proposal such as the one put forward by Flege (1995) on the basis of perceptual and acoustic data in the Speech Learning Model (SLM) is of interest, even if it only partially suits our records. If the transfer of articulatory patterns from the first to the second learnt language attested for LSB1 and LSB2 is compatible with the mechanism of phonetic category assimilation that according to the SLM should affect speakers with limited exposure to the second language (both in qualitative and quantitative terms, namely Age of Arrival and especially Length of Residence), the elaboration of third, merged patterns of articulation that apparently draws on L1 and L2 input should not be a characteristic of

[15] To further prove this statement a broader auditory analysis and/or a rigorous perceptual study is necessary.

speakers exposed to the two languages for a long time. On the contrary, those speakers should rather operate a phonetic category dissimilation so as to increase the phonetic difference between the realizations in the two languages.
Probably the SLM fails to account for data such as those presented here not only because the theory has not been elaborated to explain articulatory data, but also because of the special nature of rhotics with respect to their perceptibility. For example, see the research by Engstrand et al. (2007) on the perceptual bridge in rhotics that showed how coronal and dorsal rhotics may occasionally be confused in perception so that “intended coronals could be interpreted as dorsals or viceversa” (2007:176). And, most of all, because data compared here refer to simultaneous and not to (very late) sequential bilinguals.
Moreover our data pertain to simultaneous bilinguals raised in a societal bilingualism situation. As this difference is of sociophonetic relevance, it should not be disregarded; indeed it should be stressed here that attitudinal factors might also play a role. In particular, the decision of simultaneous bilinguals to characterize themselves as members of one of the two established linguistic communities or as members of the a truly bilingual community might favor the use of two separate patterns of articulation (as in SB4 and SB5) or the development of a third system of articulation (as for SB1, SB2 and SB3) to index respectively their identities. In this sense rhotics would prove once more to be the preferred markers of local identity and/or of social variation selection.

5. Conclusion

This study aimed to add new data and details to previous work on the phonetics of rhotics in Italian and Tyrolean, and showed how variable this class of sounds proves to be if considered from an articulatory perspective. In addition, it aimed to offer new data for the study of the phonological systems of bilingual speakers and showed how previous proposals such as SLM can be put to the test simply through the adoption of articulatory data.
However, the authors of this paper are well aware that the results are preliminary, and therefore not conclusive. First of all, there were limitations in the size of the dataset used to derive their observations, and especially the representativeness of those observations. Secondly, the image quality was sometimes poor, and in particular the image resolution was poor enough to sometimes distort the derived representation of the tongue shape. Lastly, the authors recognize the limitations of the impressionistic technique used to evaluate the data, especially in comparison to quantitative analysis as permitted by techniques such as

SS-Anova (Davidson 2006); or the nearest neighbor distance (Zharkova & Hewlett 2009).
This, togheter with interspeaker normalization, will be addressed in future research.

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Appendix 1

Italian target words

privo, prato, prude, triste, trave, truce, cricca, crampo, crudo, briga, bravo, bruco, dritto, drago, druso, grave; grido, gruppo.

Tyrolean target words

prigl, pratzl, prunzen, trichtor, traktor, truhe, krischtn, kravall, krustn, brikett, brathiandl, bruscht, driber, dran di, druckn, grint, graf, gruslig.