Syllabic Rhotics or Vowel-Rhotic Sequences? An Acoustic Study of Czech, Slovak and Croatian Syllabic Rhotics

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ABSTRACT

The present article reports the results of an acoustic analysis of Czech, Slovak and Croatian words containing a syllabic rhotic, with a view to determining whether rhotics of this type should be regarded as syllabic consonants or rather as vowel-rhotic sequences, due to being preceded by an intrusive vocalic element. The primary objective of the study was to describe the temporal and spectral properties of intrusive vocalic elements that precede and sometimes follow the rhotic segment in order to define the extent to which they vary in the three languages. To achieve the aim, an acoustic analysis of samples of read speech was performed. The recordings were obtained from native speakers of Croatian, Czech and Slovak who read a list of words embedded in a carrier phrase. The analysis of the temporal data was meant to reveal whether the syllabic rhotics of the three languages are developing towards becoming vowel-rhotic sequences, which has recently occurred in Slovene. Syllabic rhotics, usually realised as taps, are normally flanked by vocalic segments that not only have a distinct formant structure, but also appear to be sufficiently long to determine their quality. The analysis points to the conclusion that intrusive vocalic elements are schwa-like segments in the sense that the values of their formants (F1 and F2) tend to be similar to those of the schwa vowel. Also, the findings reveal that the average duration of the intrusive segments is considerably longer in Croatian than in Czech and Slovak. Thus, the results indicate that a sound change might be taking place in Croatian.

Keywords: rhotics; intrusive vocalic elements; Slavic languages; acoustic analysis; sound change

INTRODUCTION

The sound systems of the world's languages consist of consonants and vowels. Consonants are usually found at the margins of syllables, whereas vowels occupy the central position. Schematically, the structure of the syllable can be presented as a (C)V(C) sound sequence, where the symbols (C) on both sides of the vowel stand for optional onsets and codas that may consist of a number of consonants. However, there are also languages, e.g. American English, Berber, Czech, Slovak, Croatian, that allow for syllables without a phonological vowel, i.e. one that exists in the speaker's mental representation. In such cases, the central position is occupied by the most sonorous consonant. A consonant sound which functions as a syllabic nucleus in a particular phonological environment is said to be syllabic (Trask, 1996: 344). It has been established that fricatives (see Faytak et al. 2019) or even plosives can serve the function of a syllabic nucleus, e.g.

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in Tashlhitic Berber (Coleman, 1999).[1] It must be emphasised at this point that syllabic consonants normally include a vocalic intrusive element which, de facto, constitutes the syllabic nucleus (Colemann, 1999, Jaworski, 2015, 2018, Wang 2019). In this paper, the term *intrusive vocalic elements* refers to "phonetic transitions between consonants" (Hall, 2006: 387). It logically follows that intrusive vocalic elements do not constitute phonological units and; therefore, they cannot be found in the speaker's mental representation of a word. However, such segments are susceptible to phonetic lengthening that, in the course of time, may result in their acquiring a different phonological status or, in other words, in becoming phonological vowels.

With respect to Slavic languages, the liquids /r/ and /l/ have syllabic variants, which are reflexes of the syllabic sonorants of Proto-Slavic (e.g. Moszyński, 1984; Carlton, 1990; Sussex and Cubberley, 2006). When Proto-Slavic evolved into distinct dialects, the syllabic liquids were affected to a great extent. Both syllabic liquids are still present in the sound inventories of Czech and Slovak, while syllabic rhotics are found in the sound inventories of Croatian, Serbian and Macedonian (Sussex and Cubberley, 2006: 147). It should also be stressed that syllabic rhotics have short and long variants in Serbo-Croatian (Browne 1993) and Slovak (Short 1993b). In Slovene, on the other hand, the non-vowel-adjacent grapheme <r> no longer stands for a syllabic rhotic.[2] Sussex and Cubberley (2006) claim that the grapheme represents the vowel-rhotic sequence [ər]. The authors further argue that, at least for some speakers of Slovene, the intrusive vocalic element has acquired a phonological status and is perceived as a fully-fledged vowel (see also Priestly 1996).

As regards their position within the syllable, syllabic rhotics can either be adjacent to a consonant or flanked by two consonants. Thus, they occur in one of the three contexts presented in (1). Context (1a) includes word-initial rhotics, typically followed by an obstruent. In (1b), syllabic rhotics find themselves in interconsonantal position. Finally, context (1c) includes word-final syllabic rhotics, e.g. in Cz. *vítr* 'wind' or in the very common first name *Petr*.

(1)
a. #_C, e.g. Cr. *rt* 'cape'
b. C_C, e.g. Cr. *krk* 'neck'
c. C_#, e.g. Cz. *bratr* 'brother'

The primary objective of this paper is to provide a comprehensive description of the temporal and spectral properties of intrusive vocalic elements that precede, and sometimes follow, syllabic rhotics in three Slavic languages; namely, Czech, Slovak and Croatian. The study also aims at determining whether or not intrusive vocalic elements occurring in the three languages vary significantly with respect to their quality and duration. In addition to that, the analysis of the temporal data is expected to reveal whether the syllabic rhotics of the three languages show signs of becoming vowel-rhotic sequences, like they did in Slovene (Sussex and Cubberley, 2006; Priestly, 1993).

The paper is structured as follows. Section 1 explains how syllabic rhotics arose in the Slavic languages. Section 2 is concerned with allophonic variation of the syllabic /r/ in Czech, Slovak and Croatian. Despite being referred to as a trill, the sound has several different articulatory

[1] Ladefoged and Maddieson (1996: 281) claim that "[t]here is no phonetic parameter that can be used to define syllabicity in articulatory, or physiological terms". Rather, syllabicity should be regarded as a phonological concept that refers to the most sonorous segment of a syllable, irrespective of its manner of articulation.

[2] By contrast, in Polish and East Slavic words, e.g. Polish *rtęć*, Russian and Ukrainian *ртуть*, Belorussian *ртуць*, all of which translate into English as *mercury*, the initial rhotics are never regarded as syllabic and, due to being placed in slots normally occupied by obstruents, they are referred to as obstruentised rhotics (Gussmann, 2007; see also Jaworski 2021a). The primary reason for distinguishing between syllabic and obstruentised rhotics lies in the fact that the former, unlike the latter, may occur in vowelless words such as the cognate *krk* 'neck'.

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variants. Section 3 is entirely devoted to the study conducted for the purposes of the paper. It specifies the objectives, describes the methodology, as well as presents and interprets the data. The final section makes several conclusions.

THE RISE OF SYLLABIC RHOTICS IN SLAVIC

All the currently spoken Slavic languages evolved from Proto-Slavic. The Proto-Slavic period extended from ca. 1,500 BC to the 10th century AD (Moszyński, 1984). During that period, the Slavs are said to have spoken one language, although a considerable amount of dialectal variation must have been present over the vast territory (Moszyński, 1984). For practical purposes, linguists divide the Proto-Slavic period into Early Proto-Slavic (EPSl), also referred to as Common Slavic (CS), and Late Proto-Slavic (LPSl).

With respect to EPSl, its phonology was greatly affected by two phenomena, referred to as the tendency for intrasyllabic harmony and the tendency for rising sonority (Moszyński, 1984; Carlton, 1990; Townsend and Janda, 1996). The former triggered palatalisation of consonants before front vowels,[3] whereas the latter changed the structure of the syllable such that the sonority of the constituent sounds increased while moving from the first to the last segment. Since only open syllables meet this requirement, all coda consonants were eliminated. Importantly, the law of rising sonority also affected diphthongs that consisted of a vowel and a sonorant, found in the **tъrt* and **trъt* sound patterns (Moszyński, 1984; Carlton, 1990; Townsend and Janda, 1996).

Some of the processes that affected the rhotic segments of EPSl were intimately related to, or conditioned by, certain changes to the vowel inventory of EPSl. According to Carlton (1990: 98), the EPSl vowels were distinctive with respect to the following features: height (high vs. low), advancement (front vs. back) and duration (long vs. short),[4] as presented in (2). In addition to the eight vowel phonemes, EPSl also had vowel-sonorant diphthongs, inherited from Proto-Indo-European (Moszyński, 1984; Carlton, 1990).

(2) ĭ ŭ

ă̆ ă

During the Late Proto-Slavic period, the EPSl short vowels underwent a qualitative change, presented in (3), which brought into existence two mid-open and two mid-close vowels. It is the changes that affected the latter sounds /ь/ and /ъ/, referred to as *jers*, that gave rise to syllabic liquids in Slavic.

The jers /ь/ and /ъ/ had a weak and strong variant. In the course of time, the strong jers developed into full vowels, while the weak jers were eliminated from the system. It is the fall of the weak jers /ь/ and /ъ/, completed by the end of the 12th century (Townsend and Janda, 1996: 73), that had serious consequences for the phonological system of Slavic. Not only did it reduce the number of vowels in the inventory, but it also reintroduced consonant clusters into the system. As a result, various types of consonant clusters arose, including ones containing inter-consonantal

[3] Schwartz (2013: 275-276) lists as many as seven palatalisation processes that have taken place at different times of the phonological history of the Slavic languages. These are, in chronological order, first velar palatalisation, yod palatalisation, second velar palatalisation, third velar palatalisation, fourth velar palatalisation, coronal palatalisation and surface palatalisation.
[4] In Slavic linguistics, the diacritics [˘] and [¯] represent phonologically short and long vowels respectively.

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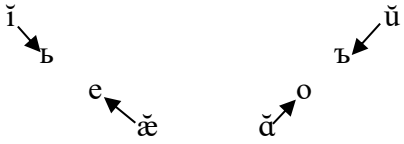
r-sounds which are still retained in several Slavic languages either as syllabic or obstruentised rhotics (Carlton, 1990; Townsend and Janda, 1996).

(3)



Obstruentised and syllabic rhotics were brought into existence as a result of changes that affected the **tъrt* and **trъt* sound patterns. By convention, in these patterns, the grapheme <t> stands for any consonant, <r> for any liquid and <ъ> for any jer (Carlton 1990; Townsend and Janda 1996). Even though **tъrt* and **trъt* were quite different in terms of phonology as **ъr* was a diphthong, while **rъ* was a common consonant-vowel sequence, the changes that affected both sound patterns were closely related (Carlton, 1990; Townsend and Janda, 1996).

In Proto-Slavic, vowel-sonorant diphthongs were simplified, or monophthongised, by eliding the vocalic component. The changes were not uniform though. In East Slavic, for instance, instead of deleting the jer segment in **tъrt,* an imitative vowel was epenthesised after the liquid. This phenomenon, also referred to as *pleophony* or *polnoglasie*, transformed **tărt* into **torot*. In the South and West Slavic languages, the strong /ъ/ and /ь/ of **tъrt* developed into full vowels (Moszyński, 1984; Carlton, 1990), whereas weak ones were lost. It is the loss of weak jers that brought into existence **tŗt* sound patterns that included syllabic liquids.

As regards **trъt* patterns, in East Slavic, its reflexes not only maintain the order of the jer and liquid, but they also distinguish between the front and back jer in the case of /r/ (Townsend and Janda, 1996: 65). In other areas, three reflexes of **trъt* are found, depending on the strength of the jer (Carlton, 1990: 153). Deletion of the front jer /ь/ resulted in the palatalised syllabic sonant /ŗʲ/, whereas elision of the back jer /ъ/ brought into existence the plain syllabic rhotic /ŗ/. In LPSl, the two syllabic rhotics remained distinctive in South Slavic and Central Slovak, but eventually they merged as /ŗ/. Another important merger involved the syllabic rhotics arising from **trъt* with those arising from **tъrt* (Carlton, 1990: 153).

Sound sequences of the **tŗt* type, regardless of their origin, were further affected by various changes in different areas. In the currently spoken South Slavic languages, with the exception of Bulgarian and Slovene, non-vowel-adjacent rhotics are regarded as syllabic consonants. As for West Slavic, the rhotic sound retained its syllabicity only in Czech and Slovak.[5] In Polish, Upper Sorbian and Lower Sorbian, **tŗt* sequences were restructured in various ways. Still, their reflexes are relatively frequent, e.g. in the Polish words *brwi* [brvi] 'eyebrows', *trwać* [tr̥fat͡ɕ] 'to last'. Despite not being adjacent to a vowel, in none of the three languages are such rhotics considered to be syllabic (see Gussmann 2007). Finally, in Kashubian, **tŗt* was replaced with syllables containing a vowel whose quality differed from what might be expected from strong [ъ] or [ь] (Moszyński, 1984; Carlton, 1990; Townsend and Janda, 1996).

[5] The phonotactics of the Czech language also allows for sound sequences in which the fricativised trill /ŗ/ occurs in interconsonantal position or in post-consonantal, word-final position, e.g. *pohřbu* 'funeral' (gen.sg.) or *vnitř* 'interior' (archaic). In spite of this, the sound does not have the status of a syllabic rhotic (Bičan, 2013, 2014).

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ALLOPHONES OF SYLLABIC /r̩/

All Slavic rhotics, including the palatalised /rʲ/ of Russian as well as the fricativised /r̝/ of Czech, are said to be trills. However, the study carried out by Jaworski (2018), where samples of read speech were analysed, points to the conclusion that, on the whole, trilled allophones of the sounds constitute a minority variant. Some speakers may still produce trilled allophones, particularly in stressed syllables, but by no means do trilled variants constitute the majority variant in any of the currently spoken Slavic languages. In the vast majority of cases, and in most phonetic contexts, r-sounds are pronounced as taps, represented in the IPA alphabet by the symbol [ɾ]. Other relatively frequent allophones of /r/ include fricativised and approximantised variants, [r̝] and [ɹ] respectively. The allophones appear to be in free variation as they may occur in the same phonological environments, albeit with different frequency.

As for the syllabic rhotics analysed in this paper, the overwhelming majority of the tokens were classified as taps. Only 16 realisations differed from the norm in that they did not have a complete closure and were pronounced either as a spirant [r̝] or an approximant [ɹ].[6] Interestingly, none of the tokens was trilled, which raises the question of why the rhotic sounds are still referred to as trills.

ALLOPHONES OF THE SYLLABIC RHOTIC

A typical realisation of /r̩/ is presented in Figure 1, which depicts the spectrogram of the word *krk* ‘neck’, produced by a native speaker of Czech. Similar realisations of syllabic rhotics of other languages were described in, e.g. Pouplier and Benuš (2011) for Slovene; Jaworski (2014, 2015) for Croatian, Jaworski (2018) for the other Slavic languages. The vocalic elements on both sides of the tap are of similar duration, 35 and 33 ms respectively.[7] What they also have in common is the distinct formant structure, with formant trajectories of one element being a mirror image of the other, which is undoubtedly due to the fact that the rhotic segment is flanked by two velar plosives. What differentiates them is that the formant structure of the vocalic element following the tap is noticeably less intense. Also, the amplitude of vibration, shown in the oscillogram, is considerably lower in the case of the intrusive element following the tap. The slightly different formant values of both vocalic elements indicate that they are similar to those of the neutral vowel schwa, especially with regard to the first formant. More specifically, the F1 values of the preceding and following vocalic elements reached 573 Hz and 557 Hz, while their second formants are 1647 Hz and 1593 Hz respectively. As for the tap closure, it is relatively short, with a duration of 14 ms, followed by a weak release burst.

[6] It is absolutely certain that the limited amount of allophonic variation found in the speech of the participants resulted from the data collection method. Target words embedded in a carrier phrase are very likely to be hyperarticulated. Samples of spontaneous speech would definitely reveal more allophones and a somewhat lower incidence of taps.

[7] Given that each syllabic rhotic is preceded by a vocalic element, one might argue that, in terms of phonetics, the syllabic sonorants /r̩/ and /l̩/ do not differ significantly from *EPSl diphthongs made up of vowel and a sonorant.

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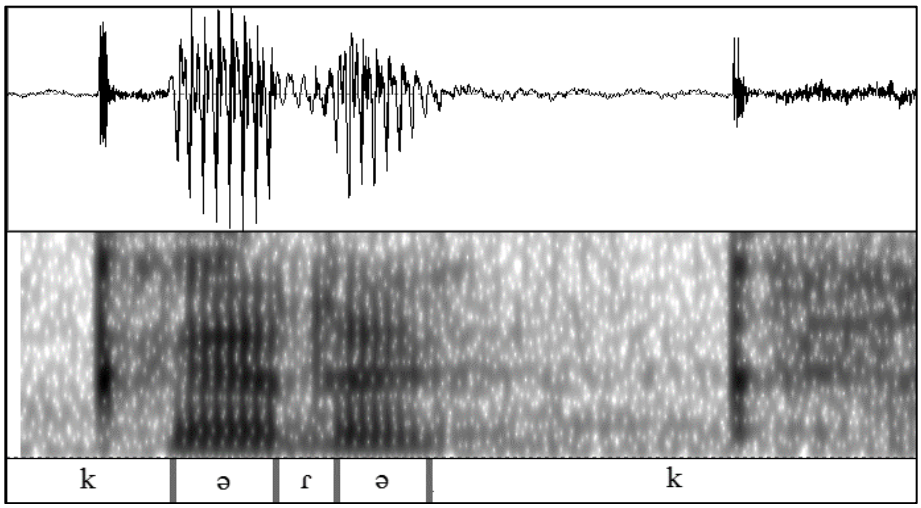

FIGURE 1. Intrusive vocalic elements of the syllabic rhotic of Czech, produced in the word *krk* 'neck'

It is worth emphasising that the presence of two intrusive vocalic elements of almost equal duration is very common in monosyllabic words containing a syllabic rhotic placed between two plosives. If, on the other hand, a syllabic rhotic is found in a polysyllabic word, the duration ratio between the two intrusive elements may differ to a great extent. The manner of articulation of the flanking consonants is another factor that may have an influence on the temporal as well as spectral features of intrusive vocalic elements.

Syllabic rhotics immediately followed by a fricative, especially a sibilant, tend to be realised phonetically as fricated allophones [ɻ̞]. A spirantised realisation of /r̩/ is presented in Figure 2, which shows the spectrogram and oscillogram of the Croatian word *krš* 'rocky terrain', produced by speaker Cr3. The rhotic segment is preceded by a 42-millisecond intrusive vocalic element, whose quality is quite similar to that of the schwa sound, with F1 = 529 Hz and F2 = 1545 Hz. As for the rhotic phoneme, there is no visible closure phase characteristic of tapped realisations. Instead, the vocalic element is immediately followed by a period of voiced friction which is noticeably weaker than that of the sibilant /ʃ/.

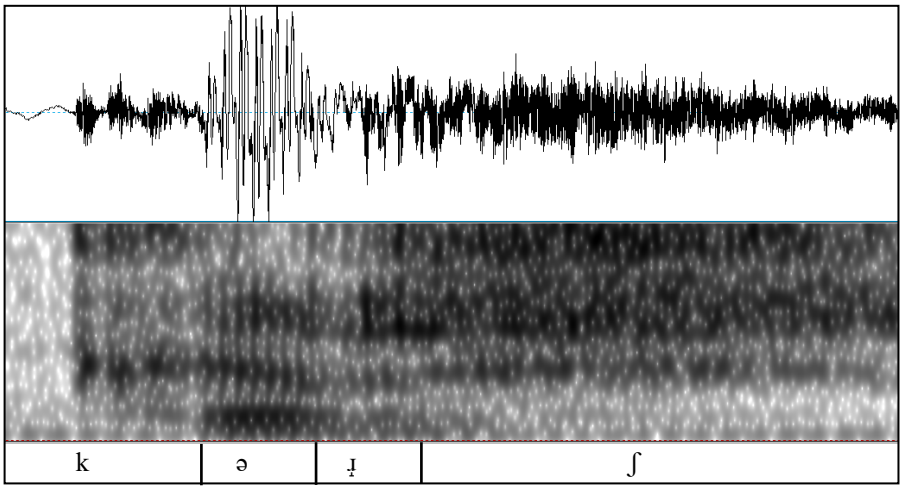

FIGURE 2. A spirantised realisation of the Croatian syllabic rhotic in the word krš 'rocky terrain'.

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Spirantised realisations of rhotics result from the speaker exerting an insufficient amount of articulatory effort to produce a complete closure. Sometimes, however, the opening between the tip of the tongue and the alveolar ridge is so wide that an intended tapped rhotic is rendered as an approximant. Figure 3 presents an approximantised syllabic rhotic produced by speaker Cr4 in the word *brvno* 'beam'. The formant structure of the rhotic is virtually the same as that of the preceding and following vocalic elements with respect to the first two formants, while its F3 shows a considerable amount of friction.

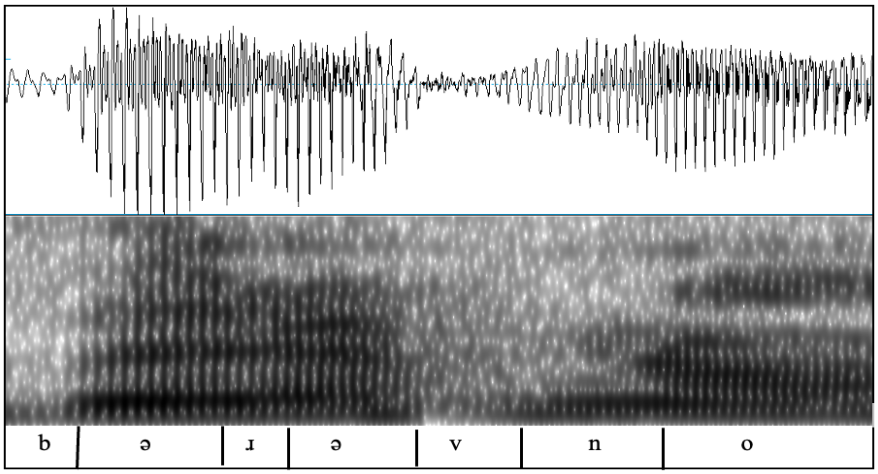

FIGURE 3. An approximantised realisation of a syllabic rhotic in the Croatian word brvno 'beam'.

THE STUDY

The primary objective of this study is to compare the temporal and spectral characteristics of the intrusive vocalic elements flanking the syllabic /r̩/ of Czech, Slovak and Croatian. In order to collect the data for analysis, five native speakers of each of the three languages were asked to read a list of words embedded in a carrier phrase, which translates into English as 'She wrote X on the board', where X represent the slot occupied by the target words. The participants were instructed to read three times a randomised list made up of 20 monosyllabic words containing a syllabic rhotic. Thus, each speaker pronounced 60 target words, which means that the study includes 900 realisations of syllabic rhotics. It needs to be emphasised that, in the case of Slovak and Croatian, which distinguish between long and short syllabic rhotics, only short syllabic rhotics were examined, as in Slovak *vrch* 'hill' or Croatian *vȓt* 'garden'.[8]

With regard to the participants, they were Erasmus students, spending a semester at one of the universities of Szczecin. With respect to the Czech speakers, they come from two cities; namely, Ostrava (3 students) and Prague. They claimed they speak the standard variety of the language in every social context. The average age of the speakers is 22.5 years (± 3 months). Two of the Slovak participants come from the capital city Bratislava, two from Košice and one from Prešov. They also maintain that their native dialect is standard Slovak. The average age of the participants is 21.6 years (± 5 months). Finally, the Croatian speakers come from the north of the

[8] The prosody of Croatian is rather complex in that it involves both length and pitch. For this reason, traditional grammars and dictionaries use four diacritics that represent accent marks. These include: ȁ short and falling, â long and falling, ȁ short rising and á long rising (Browne 1993). As for Slovak, which distinguishes between long and short vowels, long syllabic rhotics are marked as ŕ (Pouplier and Benuš 2011).

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country. Three of them were brought up in Pula and the other two in the city of Rijeka. Their ages range from 22 years to 24.5 years, with the average of 23.2 (± 4 months).

The participants volunteered and they were naïve as to the objectives of the study. During the recording sessions, the informants sat at a table with a Sinn7 mPod USB Studio microphone, connected to a Sony Vaio laptop. The microphone was placed approximately twenty centimetres from the speakers. The Praat software (version 4.2.21) was used to make the recordings, digitise the data and determine the spectral parameters of the intrusive vocalic elements, as well as to produce the spectrograms and oscillograms. As suggested by the authors of Praat (Boersma and Weenink 2022), the original sampling rate was set at 44,110 Hz.

TEMPORAL PROPERTIES OF INTRUSIVE VOCALIC ELEMENTS OF SYLLABIC RHOTICS

The tapped realisation of a syllabic rhotic usually consists of three components; namely, (i) an intrusive vocalic element preceding a tap closure (IVE1), (ii) a closure phase (CP) and (iii) an intrusive vocalic element that follows the tap (IVE2), as presented in Figure 1 above. During the time that passes between the release of a plosive and the completion of the tap closure the vocal tract is open, which gives rise to a vocalic segment. A similar vocalic element may also occur between a tap and a following consonant. The data examined for the purposes of this study confirmed the presence of two intrusive vocalic elements preceding and following the tapped syllabic rhotic. However, it is worth stressing that an intrusive vocalic element following a syllabic rhotic is likely to be less distinct or even deleted in running speech (Jaworski 2018).

With respect to the temporal characteristics of syllabic rhotics, Figure 2 shows the mean values (in ms) of the two intrusive elements preceding and following the tapped allophone of the rhotic as well as the duration of the tap closure. The pattern that emerges from the data is that the vocalic element preceding a tap closure (IVE1) tends to be longer than the other one (IVE2). Only occasionally was the following intrusive element longer than the preceding one. This general tendency was confirmed by a series of statistical tests, which revealed significant differences ($p < .01$) between the duration of IVE 1 and IVE2 for each of the speakers.

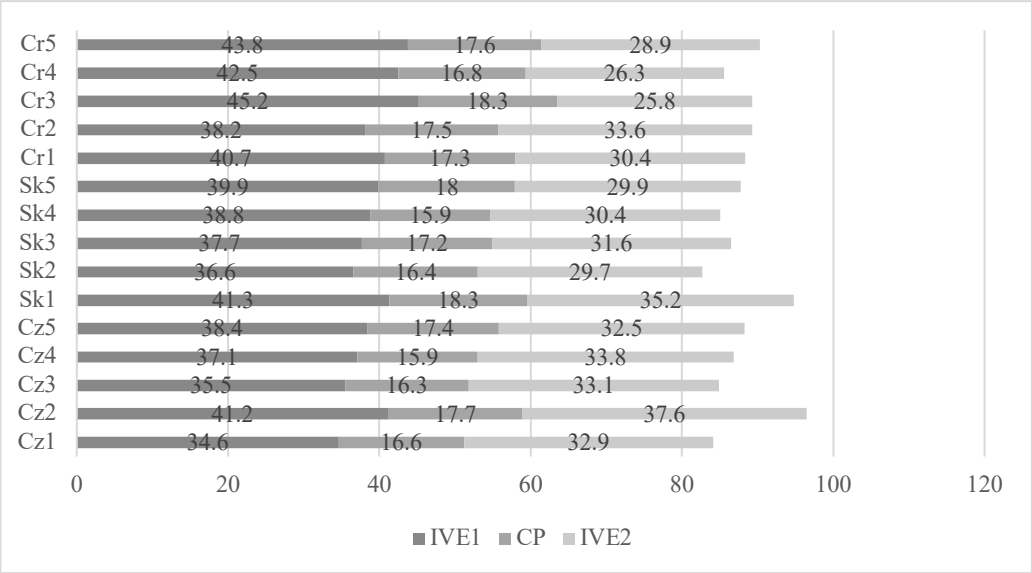

FIGURE 4. Temporal characteristics of intrusive vocalic elements

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Even though the mean values in Figure 4 do not immediately reveal statistically significant differences, an analysis of variance revealed that there is a very high degree of interspeaker variation with respect to the duration of IVE1, IVE2 as well as that of the tap closure. The results of one-way ANOVA test for the three dependent variables are highly significant, with F = 18.319, df = 888, p = 3.05E-32 for IVE1, F = 10.615, df = 888, p = 2.52E-19 in the case of the tap closure, and F = 14.764, df = 888, p = 1.39E-26 for IVE2. Interestingly, the significance level is much lower, yet still highly significant (p > 0.0001), when the data produced by speakers of the same language are compared. This strongly suggests that the values of the parameters should not be solely regarded as speaker-specific, but also as dependent, to a certain extent, on the language of the speaker. This conclusion was confirmed by one-way ANOVA performed on data arranged into three language groups, which also revealed highly significant differences with respect to the three parameters. The significance level is particularly high with respect to IVE1, with F = 40.782, df = 888, p = 2.24E-16, and IVE2, where F = 33.848, df = 888, p = 5.72E-14. On the other hand, the differences between the three languages are much less striking when the durations of closure phases were compared, with F = 4.95, df = 872, p = 0.0076.

The temporal data are of particular interest as far as the objectives of this study are concerned. First of all, in the three languages, intrusive vocalic elements on both sides of the tap are, on average, considerably longer than the 20 ms perception threshold (Weiss et al., 1999, Srebot-Rejec, 1988). This fact suggests that speakers of the three languages should be able to perceive them and determine their quality. The data also indicate that, in the speech of the Croatian participants, the duration of preceding intrusive vocalic elements is significantly longer than in the other two languages. This finding further implies that a change in progress is taking place as at least some speakers of Croatian may be in the process of gradually replacing the syllabic rhotic with a vowel-rhotic sequence. As noted above, a change of this type has recently affected the sound inventory of Slovene (Priestly, 1993; Sussex and Cubberley, 2006). Given that Slovene and Croatian are in close contact due to a combination of circumstances, it is rather inevitable that the two languages influence each other.

SPECTRAL PROPERTIES OF INTRUSIVE VOCALIC ELEMENTS OF SYLLABIC RHOTICS

The spectral properties of intrusive vocalic elements flanking tapped variants of syllabic rhotics are presented in Table 1. Somewhat surprisingly, the F1 and F2 values presented in Table 1 follow a consistent pattern in that, on average, intrusive vocalic elements preceding a tap closure are lower than their counterparts following the closure. In terms of articulatory features, the former intrusive elements are slightly higher and more retracted than the latter, but both preceding and following vocalic elements should definitely be classified as mid central or schwa-like sounds.

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TABLE 1. The mean F1 and F2 values of intrusive vocalic elements flanking syllabic rhotics

	IVE 1		IVE 2	
	F1	**F2**	**F1**	**F2**
Cz1	516 (± 54)	1592 (± 91)	562 (± 42)	1648 (± 83)
Cz2	531 (± 57)	1621 (± 83)	571 (± 47)	1702 (± 92)
Cz3	568 (± 49)	1644 (± 69)	590 (± 38)	1657 (± 73)
Cz4	522 (± 47)	1573 (± 76)	558 (± 33)	1721 (± 78)
Cz5	573 (± 57)	1628 (± 86)	601 (± 51)	1634 (± 82)
Sk1	490 (± 49)	1647 (± 81)	508 (± 29)	1688 (± 66)
Sk2	533 (± 46)	1558 (± 73)	541 (± 36)	1606 (± 76)
Sk3	507 (± 38)	1592 (± 69)	563 (± 42)	1648 (± 71)
Sk4	551 (± 52)	1634 (± 76)	539 (± 38)	1613 (± 59)
Sk5	479 (± 33)	1522 (± 63)	511 (± 41)	1594 (± 67)
Cr1	548 (± 49)	1530 (± 74)	568 (± 38)	1553 (± 61)
Cr2	521 (± 46)	1492 (± 85)	519 (± 41)	1517 (± 73)
Cr3	517 (± 33)	1549 (± 67)	546 (± 34)	1579 (± 59)
Cr4	509 (± 58)	1573 (± 70)	532 (± 35)	1611 (± 74)
Cr5	497 (± 41)	1476 (± 68)	509 (± 43)	1500 (± 68)

The spectral properties of intrusive vocalic elements are presented graphically in Figure 5, which is based on the data produced by Cr3. The vocalic segments are shown within a frame of reference formed by the speaker's peripheral vowels [i], [a] and [u]. The scatterplot shows clearly that, in terms of statistics, the intrusive vocalic elements that precede a tap closure do not differ from the ones that follow it as the two sets of data overlap completely. As a matter of fact, the statistical tests conducted for the F1 and F2 data produced by each speaker revealed that the two sets of intrusive vocalic elements are very similar with respect to their spectral properties. In the case of F1, the differences never came close to the level of statistical significance ($p > .05$), nor did they reach the 5% threshold with regard to F2. Speaker Cz4 was the only exception to the general rule as her F2 data of IVE1 and IVE2 reached the level of statistical significance ($p = 0.0272$).

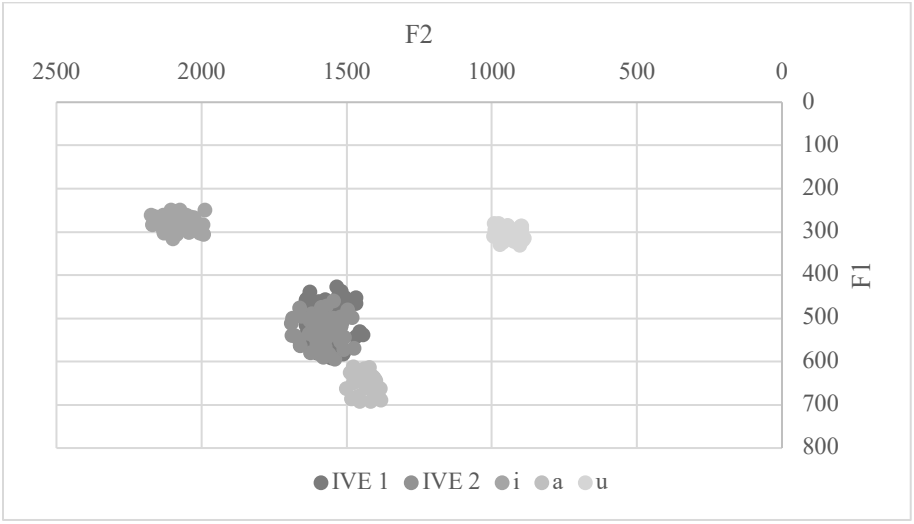

FIGURE 5. The distribution of intrusive vocalic elements preceding (IVE1) and following (IVE2) tap closures, based on the data produced by speaker Cr3

CONCLUSION

The data presented in this contribution demonstrate clearly that, in the vast majority of cases, a syllabic rhotic is articulated as a tap that is preceded and followed by an intrusive vocalic element. The data also revealed a considerable amount of interspeaker variation regarding the temporal characteristics of syllabic rhotics. The vocalic elements examined in this study differ significantly with respect to duration and so do the closure phases, albeit to a lesser extent. The articulatory features of syllabic rhotics thus bear a strong resemblance to EPSl diphthongs including a rhotic component, providing that the r-sound was realised phonetically as a tap. As a matter of fact, there are phonetic arguments strongly suggesting that that was the case. If the EPSl rhotic component of diphthongs had been a glide or a rhoticised vowel, like the American English vowels [ɚ] and [ɝ], then the diphthongs *ir and *ur, inherited from PIE, would not have been affected by metathesis in EPSl due to observing the law of rising sonority. In all likelihood, the rhotic segment was phonetically a tap whose articulation involved making a complete closing gesture and, therefore, the *ir and *ur diphthongs had to be eliminated from the sound system of the language. An analogous change affected the other PIE diphthongs containing sonorant components; namely, the nasals /m/, /n/ and the lateral /l/, as their articulation also required a complete closing gesture.

Following this line of argument, and the fact that an interconsonantal tap must be pronounced with a vocalic onglide, it may be further argued that, phonetically speaking, the syllabic rhotics present in the currently spoken Slavic languages resemble EPSl diphthongs *ir and *ur. This claim can be further supported by the fact that syllabic rhotics serve exactly the same functions as vowels, i.e. they carry the prosodic features of stress, length, intonation and, in Serbo-Croatian (Browne, 1993) and Slovene (Priestly, 1993), also pitch.

A finding that is particularly interesting regards the differences in duration of intrusive vocalic elements between the three languages under investigation. The presented data strongly suggest that, in the Croatian language, they tend to be significantly longer than their counterparts in the speech of the Czech and Slovak participants. Four of the Croatian speakers produced preceding vocalic elements whose mean duration is longer than 40 ms. Vowel discrimination studies have shown that the quality of the [i, e, a, o, u] vowels can be reliably distinguished by the human ear if their duration is 20 ms or longer (Weiss et al., 1999, see also Srebot-Rejec, 1988). If that is the case, this phenomenon can be regarded as a reversal of the sound change that affected PSl diphthongs ending in a sonorant sound. This assumption should not be rejected out of hand, particularly in the light of how the syllabic rhotic of Slovene has changed recently (see Priestly, 1993; Sussex and Cubberley, 2006). It is worth emphasising at this point that reversals of sound changes are nothing unusual in the history of PIE. Nasal vowels constitute a particularly good example of speech sounds that cyclically appear and disappear (Carlton, 1990; Townsend and Janda, 1996; Moszyński, 1984).[9]

As regards their spectral properties, both intrusive vocalic elements should be described as mid-central. With respect to their distribution, in terms of statistics, they are more advanced and considerably higher than the speaker's allophones of [a]. As shown in Figure 3, the distribution of intrusive vocalic elements preceding the tap closure is virtually the same as that of the ones following the tap. This finding is hardly surprising given what has been established for the Croatian language (Jaworski, 2014, 2015) and the other Slavic languages (Jaworski 2018) in similar studies where samples of read speech were analysed. However, it would be interesting to find out whether or not similar distribution patterns occur in polysyllabic words containing both a syllabic rhotic

[9] Polish is the only Slavic language that still has nasal vowels in its sound inventory.

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and a phonological vowel. In other words, it should be determined whether the quality of the preceding or following phonological vowel is positively correlated with the spectral properties of the intrusive vocalic elements flanking a syllabic rhotic.

Another question that arises in this context is whether the lengthening of the intrusive vocalic component of the syllabic rhotic of Slovene, as well as the subsequent change of its phonological status, and a likely development of the same type in Croatian and the other Slavic languages that have syllabic rhotic in their sound inventories, should be regarded as a lenition or fortition. Phonological processes belonging to the former group are usually defined as a "reduction in the degree of articulatory complexity" (Gurevich 2004: 13). With respect to consonants, there seems to be general consensus in the literature that "lenition tends to shorten consonants and render them louder or more vowel-like" (Katz 2016; Katz and Pitzanti, 2019: 1; see also Kirchner, 1998; Kul and Jaworski, 2011; Cohen Priva and Gleason, 2019; Jaworski, 2009, 2021). As for vowels, lenition processes typically result in centralisation or deletion (Dziubalska-Kołaczyk 2002; Jaworski, 2009, 2017).

Seen from the articulatory perspective, replacing an interconsonantal syllabic rhotic with a vowel-rhotic, or even vowel-rhotic-vowel, sequence could be regarded as a lenition in that a sound sequence that constitutes an articulatory difficulty is replaced with the universally preferred CVCVC sound combination. On the other hand, linguists who subscribe to the effort-based approach to lenition would probably claim that a sound change of this type should be classified as a fortition, i.e. a process that enhances the acoustic properties of a speech sound (Dziubalska-Kołaczyk 2002). Also, the addition of one or two vowels can definitely be thought of as a fortition process as it increases the amount of articulatory effort necessary to pronounce such a sound sequence.

Even though the results presented in this paper indicate that the syllabic rhotic of Croatian may be changing into a vowel-rhotic sequence, they do not allow for drawing far-reaching conclusions due to being based on data produced by a small number of speakers. Also, it must be remembered that the results may have been influenced, at least to a certain extent, by the data collection method. Without a doubt, target words embedded in a carrier phrase tend to be pronounced more carefully than the rest of the phrase. In order to be fairly certain that a change in progress is taking place, it would be necessary to conduct a large scale study including many speakers representing different age groups, regions, occupations, levels of education, etc.

Rhotics are not the only syllabic consonants found in the world's languages. Nasals, laterals, fricatives and even plosives can also serve the function (see Faytak et al. 2019; Coleman 1999). It would be interesting to determine whether intrusive vocalic elements associated with syllabic consonants other than rhotics have spectral and temporal characteristics similar to those preceding and following the syllabic rhotics investigated in this study.

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