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Further Analysis of the Articulation of /r/ in Polish – the Postconsonantal Position

Abstract

The present paper constitutes an extension of the research presented in Stolarski (2013), where the articulation of the Polish /r/ was tested in the intervocalic position. It investigates the postconsonantal articulation of the rhotic, the second context in which, according to Biedrzycki (1978: 83–84), the segment may be articulated as a tap instead of the trill. In order to accomplish this task, 10 respondents from different parts of Poland were instructed to read into a microphone 26 natural Polish words in which /r/ was located after consonants. All these articulations were analysed acoustically in terms of the number of constricted intervals in the pronunciation of the consonant under discussion and the data obtained were assessed statistically. In addition, some other measurements, such as the length and relative strength of the intervals, were taken. They provide further information on the nature of the articulation of /r/ in Polish.

1. Introduction

This section briefly summarises the universal characteristics of rhotics and common assumptions regarding the articulation of the Polish /r/. Moreover, the results of the articulation of the rhotic in the intervocalic position presented in Stolarski (2013) are summarised and the aims of the present study are clearly defined.

1.1 Rhotics as a diverse group

Rhotics, or "r-sounds", as they are referred to by Maddieson (1984), constitute a highly diverse group of sounds. The International Phonetic

Alphabet[1] lists at least 8 symbols which belong to this class, but the possible phonetic realisations of rhotics lie on a phonetic continuum involving many manners and places of articulation. Ladefoged and Maddieson (1996: 217) mention that rhotics are realised as trills, taps, fricatives, approximants or even “r-coloured” vowels. Additionally, their articulation may combine features of several of these groups. Nevertheless, Maddieson (1984) observes that in the descriptions of rhotics in various languages the category which is most frequently used is “trill” (47.5%), followed by “tap” or “flap” (38.3%). Other realisations involving approximants or fricatives constitute only 13.5% of the cases.

As far as the place of articulation is concerned, Maddieson (1984) claims that in the descriptions of rhotics the dental/alveolar region is mentioned most frequently; however, it is rarely defined precisely. He additionally suggests that other phonetic realisations involve retroflexes (12%), dentals (3.2%), uvulars (0.9%) and palatao-alveolars (0.6%).

These general statistics should be treated with caution. Reports on the phonetic realisation of rhotics in various languages differ in their level of detail and, in some cases, the assumption that a segment is realised in a given way does not fully correspond to the actual articulation. A good example of this is the extensive discussion on the production of the Spanish phonemic trill. Standard descriptions indicate that the segment is realised with two to five constricted intervals (Recasens & Pallarès 1999). Nonetheless, the rhotic has been reported not to be articulated in the “intended” way which involves two or more closures in a number of dialects (Rissel 1989; Diez-Canseco 1997; Hammond 1999; Adams 2002; Hualde 2005; Bradley, Colantoni & Willis 2006; Díaz-Campos 2008). In fact, production of the phoneme has been used in the categorisation of Spanish dialects (Resnick 1975; Lipski 1994).

A possible common acoustic feature present in all rhotic articulations was proposed by Ladefoged (1975) and Lindau (1978). They suggested that in approximant realisations, as well as in vowel-like segments separating strictures in trills, the third formant is lowered. A similar tendency can also be observed in transitions to and from rhotic consonants. Nevertheless, Ladefoged and Maddieson also provide many counterexamples and conclude that “the overall unity of the group seems to rest mostly on the

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[1] <http://www.internationalphoneticalphabet.org/ipa-charts/ipa-symbols-chart-complete/>

historical connections between these subgroups, and on the choice of the letter ‘r’ to represent them all” (Ladefoged & Maddieson 1996: 245).

Since trilling and tapping are assumed to be the two major phonetic realisations of rhotics, it is worth mentioning that there is an important inconsistency in the way the two manners of articulation are defined. On the one hand, a clear distinction is made by the number of the constricted intervals: one in the case of taps and more than one in trills (Lindau 1985; Gimson & Cruttenden 2001; Dhananjaya, Yegnanarayana & Bhaskararao 2012). On the other hand, authors such as Ladefoged and Maddieson (1996) and Laver (1994) propose an alternative interpretation, according to which trilling does not necessarily have to involve actual constrictions. In the production of these sounds it is the position of the articulators in a configuration which potentially allows vibrations which is crucial, rather than the actual presence of the vibrations. Ladefoged and Maddieson (1996: 217–218) refer to this interpretation as “an articulatory definition”, in contrast to “an acoustic definition” which takes into account the actual realisation of a sound. In the current paper, Ladefoged and Maddieson’s interpretation is accepted. Nevertheless, an additional discussion on the problems resulting from such disparate definitions will be presented in Section 4.

1.2 Assumptions about the articulation of the Polish /r/

In the literature on Polish phonetics the consonant /r/ is consistently referred to as an alveolar trill. As summarised in Stolarski (2013), its other allophones include the palatalised [rʲ] (Benni 1959: 28; Wierzchowska 1967: 157, 1971: 138, 1980: 119; Dłuska 1983: 122; Strutyński 1987: 21; Dukiewicz 1995: 40; Wiśniewski 1997: 63; Gussman 2007: 4), the voiceless [r̥] (Benni 1959: 29; Wierzchowska 1971: 122, 1967: 105; Rocławski 1976: 132; Strutyński 1987: 24; Dukiewicz 1995: 40), the uvular /ʀ/ (Wierzchowska 1971: 122; Pilich 1975: 51; Rocławski 1976: 132; Dukiewicz 1995: 40; Gussman 2007: 27), the devoiced and palatalised [r̥ʲ] (Benni 1959: 29), and also the uvular fricative [ʁ], or even the dental approximant [ɹ] (Gussman 2007: 27). Additionally, some authors mention a possible tapped realisation of the consonant (Wierzchowka 1967: 122, 1980: 73; Jassem 1973: 246–248; Rocławski 1976: 132; Dłuska 1983: 119; Szczepankowski 1985: 47; Dukiewicz 1995: 40), but such an articulation is supposed to be less typical than trilling.

Among the factors which may lead to a tapped pronunciation of the Polish /r/, some authors propose the tempo of speech (Rocławski 1976; Jassem 1981). It is presumed that in slow speech the consonant tends to be articulated as a trill; however, the faster the speech becomes, the more likely it is for the phoneme to be realised as a tap. Moreover, Wierzchowska (1967: 122) and Dłuska (1983: 122) suggest that the tapping is frequently encountered when /r/ follows /i/ or /j/ and the consonant is palatalised (although full palatalisation of the rhotic is, generally, a questionable claim and slight palatalisation of the Polish /r/ is more realistic). Dukiewicz (1995: 40) and Jassem (1974: 60), on the other hand, contend that in casual, non-emphatic speech the tapped [ɾ] may be encountered in any phonetic context. Finally, Biedrzycki (1978: 83–84) suggests that even though the Polish /r/ is basically a trill, especially before consonants and in the coda position, as in *kartka* (‘sheet of paper’) and *dar* (‘gift’), the tapped articulation may be encountered between vowels and after consonants, e.g. in *zaraz* (‘in a moment’) and *strój* (‘outfit’) (Biedrzycki 1978: 83).[2] The experiment described in Stolarski (2013) was based on Biedrzycki’s assumptions and it explored the articulation of the consonant in the intervocalic position as one of the contexts in which tapping could be expected. This paper is an extension of the previous analysis and focuses on the second context suggested by Biedrzycki – the postconsonantal position. Here, again, some articulations of /r/ may involve tapping rather than trilling, but no research has ever been done to verify this assumption.

It is worth mentioning that from the acoustic point of view, /r/, regardless of whether it is realised as a tap or a trill, involves vocoidal elements which are interrupted by one, in the case of tapping, or more, in the case of trilling, constricted intervals. Jassem (1973) calls these vocoidal elements “vowel-like segments” and Ladefoged and Maddieson (1996) refer to them as “open phases”, “vowel-like sounds” or even “approximant phases”. They are inherent in the articulation of tapped and trilled rhotics and they appear before and after each constricted interval (Pilich 1975; Wierzchowska 1980). Dłuska (1983: 118–122) underlines the fact that the “vowel-like segments” are obligatory in the production of the Polish rhotic even though the speaker is usually unaware of their presence during

[2] As far as the posconsonantal position of /r/ is concerned, Biedrzycki (1978) does not specify whether or not the rhotic must be tautosyllabic with the preceding consonant for tapping to occur, but the results presented in Section 3.3 do not indicate that such a condition is necessary.

articulation. One of the reasons why they appear in the production of trills and taps could be that voiceless constrictions may be more effectively distinguished in contrast to these vocoidal elements.

It has been assumed that the “vowel-like segments” last longer than the constricted intervals, but their precise duration may depend on particular characteristics of rhotics in a given language. For example, they are estimated to last approximately 50 milliseconds in Italian (Ladefoged & Maddieson 1996: 219), but only 20–30 milliseconds in Polish (Jassem 1973: 245–246). Furthermore, they have clearly a discernible formant structure which closely resembles the acoustic configuration found in the central vowel /ə/ (Wierzchowska 1967: 105; Jassem 1973: 245–246; Szczepankowski 1985: 47).

It must be stressed that the acoustic characteristics measured in the experiment described in Section 3 concern the nature of constricted intervals. They are central to the current paper because their behaviour is decisive in the classification of rhotics. Nevertheless, a detailed description of the “vowel-like sounds” in the articulation of the Polish /r/ is another important task which could be undertaken in future research.

1.3 Results of the preceding study

The major aim of the experiment reported in Stolarski (2013) was to investigate the most typical phonetic realisation of the Polish /r/ in the intervocalic position in terms of the number of constricted intervals. In order to achieve this goal an acoustic analysis of the articulation of the rhotic was conducted. The test materials involved 18 natural Polish words in which the consonant was pronounced between vowels. The words represented all the possible intervocalic contexts in Polish. The articulation of the consonant was measured between high, low, front, central and back vowels.

There were five men and five women taking part in the experiment. All of them were native speakers of Polish and they came from different parts of Poland. The participants were asked to read into a microphone the 18 words in the most natural way. In order to avoid any possible bias resulting from the conscious articulation of the consonant, the participants were not informed as to what was being investigated and the examples were mixed with random Polish words.

All the recordings were analysed in *Praat* (Boersma & Weenink 2011) and each articulation of /r/ was evaluated in terms of the number of constricted intervals. The final results of the experiment are quoted below:

Table 1. Final results of the experiment reported in Stolarski (2013)

	Trilled stop	**Tapped stop**	**Weak tap with friction**
Sum in all VrV contexts	5	171	4
Percentage	2.8%	95%	2.2%
Margin of error	2.4%	3.2%	2.2%

Surprisingly, trilled articulation was encountered in less than 3% of the cases. The tapped allophone [ɾ] was expected to be found in the intervocalic context, but the frequency of its occurrence was astounding, nevertheless. Indeed, the results of the experiment proved that in the investigated phonetic context the Polish /r/ is realised almost exclusively as a tap. This questioned the predominant opinion expressed in the literature on Polish phonetics that the consonant is basically a trill. Obviously, the conclusion reached in Stolarski (2013) concerns only the intervocalic position and more research needs to be done in order to fully explore the actual nature of the consonant under discussion. The present publication examines the articulation of the Polish /r/ in the postconsonantal position, which is the next necessary step.

Other conclusions reached in Stolarski (2013) include:

1. No relationship between any of the phonetic characteristics of the vowels surrounding the tested consonant and the manner in which it is articulated was observed. Tapping was equally frequent between high, low, front, central and back vowels.

2. The average length of the (first) constricted interval seemed to depend on both the vertical and horizontal articulatory dimensions of the surrounding vowels. It was the longest between front vowels ($\bar{x}$ = 25.9 ms, sd = 7.9 ms, n = 40), shorter between central vowels ($\bar{x}$ = 21.8 ms, sd = 5.5 ms, n = 40) and the shortest between back vowels ($\bar{x}$ = 19.2 ms, sd = 3.7 ms, n = 40). The results for the contrast high versus low were $\bar{x}$ = 23.9 ms, sd = 7.8 ms, n = 50 and $\bar{x}$ = 20.4 ms, sd = 4.6 ms, n = 70, respectively.

3. The vocoidal element preceding the (first) constricted interval was, on average, louder than the one following it. (The vocoidal elements were measured only in terms of voice intensity in order to establish the strength of the (first) stricture; they were distinguished from the preceding and following vowels by transitions in formant structure.)

4. The strength of the closure depended on the horizontal articulatory dimension of the surrounding vowels – it was the weakest between back vowels and the strongest between front vowels.

5. There was a tendency for the tapped articulation to be slightly less frequent among female participants than among male participants. Still, the difference was not large and the sample used in the experiment was too small to prove this observation.

6. Men tended to pronounce /r/ with, relatively speaking, weaker contact between the tongue blade and the alveolar ridge than women.[3] Again, the sample was too small to statistically prove this observation.

1.4 Aims of the present study

This study aims at examining the most typical realisation of the Polish /r/ in the postconsonantal position. The prime objective is to establish the typical number of periods of reduced acoustic energy present in the articulation of the consonant. In other words, this paper aims at answering the question whether the Polish /r/ is realised as a trill or a tap when it is pronounced after other consonants. The choice of this particular phonetic environment is based on Biedrzycki's (1978) suggestions summarised in Section 1.2. Since his claim that the Polish /r/ happens to be realised as a tap in the intervocalic position has been validated in Stolarski (2013), examining the postconsonantal articulation of the consonant is a natural follow-up.

Analogously to the sub-aims pursued in Stolarski (2013), in the present experiment the approximate average length of the constricted intervals will also be estimated. Even though the results obtained in Stolarski (2013) supported the assumption made by Dłuska (1983: 119) that the "consonant-like segments" last between 10 and 30 milliseconds, it is still important to measure the length in another phonetic environment. Additionally, the relative strength with which the contacts between the tongue blade and the alveolar ridge is made will be measured, but the method applied is slightly different from the one used in Stolarski (2013). The new phonetic context examined in this paper necessitates changes in estimating the statistic (see the antepenultimate paragraph in Section 2.3).

[3] The relative strength with which the contact was made was established on the basis of the differences between the maximum intensity in the vocoidal phases surrounding the (first) constriction and the minimum intensity during the (first) constriction.

2. Methods

This section describes the participants and the materials used. Furthermore, the procedures employed in designing and performing the experiment are presented and a detailed discussion on the types of articulation found in the data, as well as the criteria for their differentiation, is provided.

2.1 Participants

The informants taking part in the experiment are the same native speakers of Polish who were selected in Stolarski (2013). Out of the total ten respondents, five are male and five are female and their ages vary from 20 to 33 years old. Three men and three women come from the area around the city of Kielce in central-eastern Poland. Additionally, one female respondent comes from Koszalin, another from Poznań and one male from the eastern part of Poland around Lublin. The only difference between the current group of participants and the one recorded in the previous experiment is that instead of the second person who lives in the Lublin region, a 23-year-old man from Warsaw was asked to take part in the test.

It is worth adding that in Stolarski (2013) no correlation between any measured statistics and the place of origin of individual participants was found. Nevertheless, it is still important to analyse recordings of respondents coming from different regions of Poland in case any differences in their articulation of /r/ happen to emerge in the current experiment.

2.2 Selection of materials

The selection of materials was based on the principle that the articulation of /r/ should be tested after various consonants. In fact, the most viable solution seemed to be to find examples with /r/ following every single Polish consonant. This would enable the testing of the possible articulatory influence of the place and manner of articulation of neighbouring segments. It is plausible that there may be variations in the phonetic realisation of /r/ within the postconsonantal context itself.

There are many proposals on the exact number of consonantal phonemes in Polish, but entering this considerable debate is beyond the scope of the present article. The set which has finally been chosen is based on Rocławski (1976). It includes the segments which are present in almost all other accounts and their phonemic status is rarely questioned. The inventory is summarised below:

– stops: bilabial /p, b/, post-dental /t, d/, velar /k, g/, velo-palatal /c, ɟ/
– affricates: alveolar /t͡s, d͡z/, post-alveolar /t͡ʃ, d͡ʒ/, alveolo-palatal / t͡ɕ, d͡ʑ/
– fricatives: labio-dental /f, v/, post-dental /s, z/, post-alveolar /ʃ, ʒ/, palatal /ɕ, ʑ/, velar /x/
– trills: alveolar /r/
– approximants: labio-velar /w/, palatal /j/
– nasals: bilabial /m/, post-dental /n/, palatal /ɲ/
– laterals: alveolar /l/

Among the consonants which have been excluded from the analysis are /c, ɟ/. They have highly limited distribution and appear only before /i, j/ and /ɛ/, so the segment under discussion never follows any of them. In addition, the articulation of /r/ will not be tested after another /r/, since trilling in such a context is the only predicted phonetic realisation.

It is worth mentioning that in most studies on the consonant system of Polish the additional “zero” (or “juncture”) /#/ is proposed. Still, from the phonetic point of view, testing the pronunciation of /r/ after such a phoneme would be equivalent to testing it in the word-initial environment, and this is not the aim of the present publication.

All in all, the test materials involved 27 examples (see below). Most of them are common in everyday Polish. In two cases (*Czrezpienianie*, *wadźrajana*) rare proper names were chosen because the intended sound combinations /t͡ʃr/ and /d͡ʑr/ could not be found in any popular words. Moreover, the examples differ in terms of the position of the rhotic within the syllable. According to the criteria for syllable division proposed by Gimson and Cruttenden (2001: 51–52) seventeen involve /r/ which is tautosyllabic with the preceding consonant (examples 1–7, 13 and 17–25) and in the remaining ten cases the rhotic is in a different syllable than the preceding segment (examples 8–12, 14–16, 26–27). One of the possible influences of these differences will be discussed in Section 3.3.

It should be noted that the vowels which follow the rhotic in the examples are random. No particular pattern was chosen because the results of the previous experiment described in Stolarski (2013) indicated that the phonetic characteristics of vowels surrounding /r/ do not affect its articulation type; they only influence additional attributes, such as the relative strength and length of the (first) closure (see Section 1.3), which are of secondary importance to the present study.

The words used in the experiment:

(1) *prawy* (‘right’)
(2) *brat* (‘brother’)
(3) *trawa* (‘grass’)
(4) *drogo* (‘expensively’)
(5) *Kraków* (‘Cracow’)
(6) *grono* (‘circle of people’)
(7) *Czrzepienianie* (the name of a medieval Slavic tribe)
(8) *brydż rodzinny* (‘family bridge’, here the second /r/ was analysed)
(9) *lubić rowery* (‘to like bicycles’)
(10) *wadźrajana* (a Buddhist movement)
(11) *socrealizm* (‘socialist realism’)
(12) *telewidz rozbawiony* (‘amused viewer’)
(13) *mrówka* (‘ant’)
(14) *Konrad* (‘Conrad’)
(15) *koń rasowy* (‘thoroughbred horse’)
(16) *bal roku* (‘ball of the year’)
(17) *fragment* (‘fragment’)
(18) *wrona* (‘crow’)
(19) *srebro* (‘silver’)
(20) *zranić* (‘to hurt’)
(21) *szrama* (‘scar’)
(22) *żrący* (‘caustic’)
(23) *środa* (‘Wednesday’)
(24) *źródło* (‘source’)
(25) *chrapka* (‘willingness’)
(26) *półroczny* (‘half-yearly’)
(27) *chojrak* (ironically about a ‘tough guy’)

As in the experiment described in Stolarski (2013), in order to avoid potential bias resulting from respondents’ conscious articulation of /r/, the examples have been mixed with other words. To be more precise, half of the items on the list presented to the participants were the examples quoted above and the other half were random words used in modern Polish. Consequently, it was very difficult for the informants to guess the aim of the test.

2.3 Procedure

The participants were presented with a list of words. It is important to stress that the words (or, in some cases, pairs of words) were written in isolation. If they were to be produced within a sentence frame, the phonetic processes occurring in connected speech could reduce the chance of the trilled articulation appearing. Producing the forms in isolation was most likely to result in “citation forms”, preferable to various reduced forms typical of connected speech.

The instructions were to read the list into a microphone in the most natural way.

As in the experiment reported in Stolarski (2013), the recordings were analysed in *Praat* (Boersma & Weenink 2011) and the following measurements of /r/ were taken:

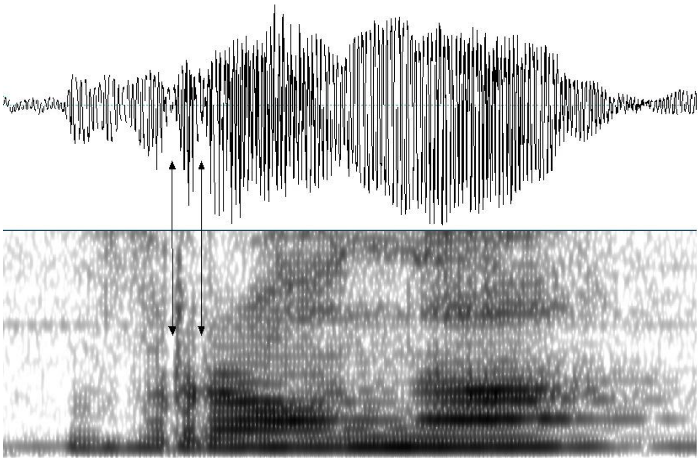
– the type of articulation
– the duration of the (first) closure
– the drop in intensity during the (first) closure

The first property was measured in order to establish the type of articulation of the Polish /r/ in the postconsonantal position (see Section 1.4). The two additional acoustic characteristics were included in this study because they provide supplementary data on the way in which trilling and tapping is realised and allow additional conclusions to be drawn. Moreover, they were also discussed in the previous study on the intervocalic articulation of the Polish /r/ and a comparison between current and the former results referring to the two attributes could help to provide additional explanation regarding the nature of the constrictions in the rhotic.

In the present analysis four types of articulation could be observed. The first three were also encountered in the intervocalic position discussed in Stolarski (2013). Definitions and examples of the four types are provided below:

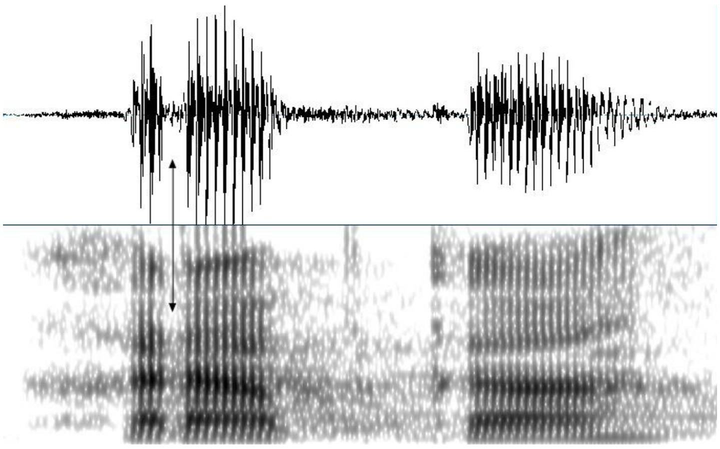
1. A trilled stop – in this case the production of /r/ involves more than one closure, visible as lighter areas in spectrograms and periods of smaller acoustic activity in oscillograms. It is interesting to note that in the present experiment more than two constricted intervals were only observed in one articulation out of 270. Namely, the word *mrówka* (‘ant’) was pronounced with three taps by Informant 3. In all other cases of trilling there were only two closures detected. An example of such an articulation is given in Figure 1.

Figure 1. Articulation of *wrona* (‘crow’) by Informant 3 as an example of the trilled /r/ (the two closures are marked by arrows)



2. A tapped stop – in this case the production of /r/ involves one definite closure. An example is provided in Figure 2.

Figure 2. Articulation of *chrapka* (‘willingness’) by Informant 8 as an example of tapped /r/ (the closure is marked by an arrow)

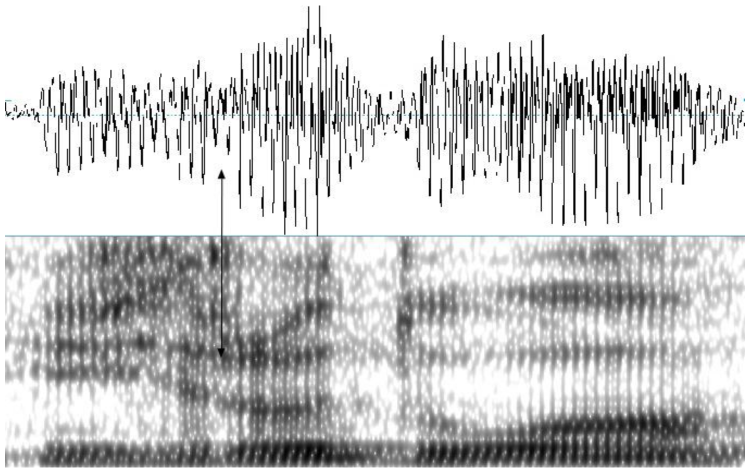


3. One (weak) closure with an immediate intensification in higher frequencies – in Stolarski (2013) such an articulation was treated as a special sub-type of the tapped stop. According to the definition adopted there, simultaneously with the tap is an intensification of acoustic energy in the higher regions of the spectrum. It is useful to treat this type of articulation separate because it is rather different from a prototypical tap and its constricted interval is less distinct (see Figure 3).[4] Consequently,

[4] The interval indicated by the arrow in Figure 3 could also be interpreted as a very short approximant because the formant structure of the surrounding vocoidal elements is partially retained. However, the short length of this approximation and the

measuring the duration of the stricture in such cases involved not only the visual inspection of spectrograms and oscillograms, but also judgements based on auditory information.

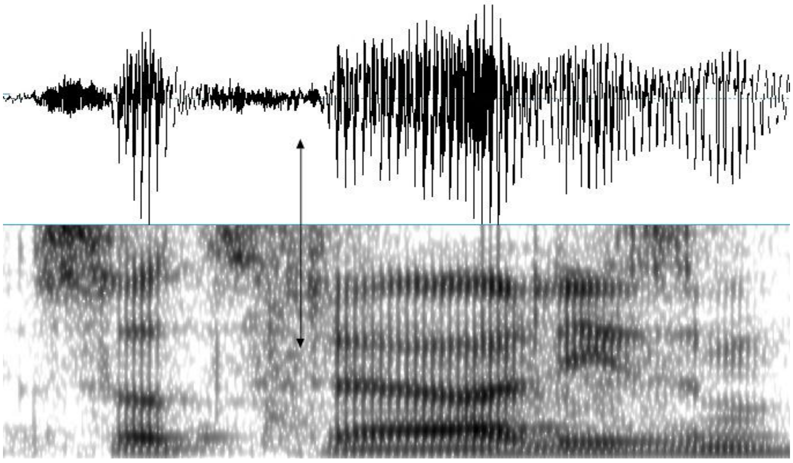
Figure 3. Articulation of *źródło* (‘spring’) by Informant 10 as an example of Type 3. The “weak” closure is indicated by an arrow



4. A trilled fricative / a fricative / an approximant – this type involves various articulations in which no definite closure could be detected. In some cases minor fluctuations in intensity combined with intensification of acoustic energy in higher regions of the spectrum were observed, which suggests slight, rapid movements of the tongue tip combined with friction. Consequently, such phonetic realisation of /r/ may be referred to as a trilled fricative, or a fricative trill (Laver 1994: 264; Trask 1996: 151). In other cases articulation lacking any discernible closure involved only friction. An example of this is presented in Figure 4. Additionally, the constricted interval was occasionally substituted by approximation which was open enough for the friction not to occur. What makes all these articulations distinct from the other categories described above is complete lack of the constricted interval. Consequently, the segmentation of the elements in the articulations which were classified as Type 5 included detailed auditory analysis.

intensification of acoustic energy in higher frequencies make such articulations distinct from prototypical approximants.

Figure 4. Articulation of *socrealizm* (‘socialist realism’) by Informant 6 as an example of Type 4. The “friction” is indicated by an arrow

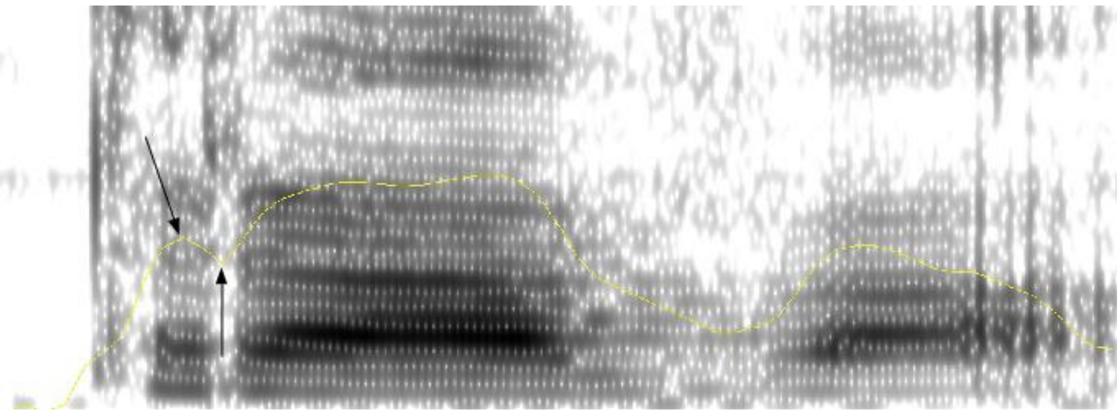


The classification of the recorded articulations of /r/ was primarily based on spectrographic analysis. Each pronunciation was compared with the four prototypical types described above and categorised accordingly. It must be stressed, however, that this classification has been established solely for statistical evaluation. In order to prepare a statistical summary of the problem, the continuum of possible phonetic realisations had to be converted into countable, categorical data. As can easily be predicted, some of the analysed recordings were not easy to classify, as they did not fall neatly into any of the four categories. Problems with the distinction between Type 3 and Type 4 were especially frequent, as the two kinds of articulation are substantially similar. The only essential difference between them is the presence of relatively weak constriction in the former, and lack of any detectable closure in the latter. The decision to classify a given case involved a very detailed analysis of visual data as well as auditory judgements.

It should be noted that in the case of trilled articulation the measurements of the approximate duration of closures concern only the first period of reduced acoustic energy. The second (and third in the pronunciation of *mrówka* by Informant 3) “consonant-like segment” was not analysed, because it was always less distinct and measuring its length would yield inaccurate results. The duration of the first constriction, nonetheless, was relatively easy to establish. As mentioned previously, such constricted intervals are visible as lighter areas in spectrograms and an additional inspection of oscillograms allows relatively precise segmentation.

As far as the relative strength of the closure(s) in individual articulations of /r/ are concerned, they may be estimated on the bases of intensity shifts. The “consonant-like segments” involve reductions of the exhaled volume of air. The firmer the contact between the blade of the tongue and the alveolar ridge, the greater the drop in intensity. This was shown in Stolarski (2013) on the basis of the author’s pronunciation of the sequences [aɾa] and [aɹa]. In the former case, where /r/ was realised as a tap, the drop in intensity was significant, but not in the latter, which involved an approximant articulation. The method which has been adopted in the present paper is similar to the one used previously, but certain changes were necessary. In Stolarski (2013) the intensity shifts were calculated as the difference between the minimum intensity value measured in the articulation of the closures and the maximum value found in the neighbouring vocoidal elements. In the present study, however, the “consonant-like segments” are articulated in a different environment. They are preceded by vocoidal components which belong solely to /r/. These “vowel-like segments” are not associated with any preceding vowels. In the examples used in the present experiment /r/ follows only consonants. Therefore, the drop in intensity will be established on the basis of the difference between the maximum intensity value in the vocoidal component preceding the closure, and the minimum intensity value measured in the closure (see Figure 5). The vocoidal articulation following the “consonant-like segments” will not be taken into consideration, because in this case there is no clear-cut boundary between the vocoidal element typical for the articulation of /r/ and the vowel.

Figure 5. Articulation of *trawa* (‘grass’) by Informant 5. The intensity contour is depicted as a thin line in the middle of the spectrogram. The maximum intensity in the vocoidal component preceding the closure and the minimum intensity in the closure are marked by arrows



It should be pointed out that the intensity shifts which have been measured in this experiment seem to be strongly influenced by the voicing of the preceding consonants (for a detailed explanation, see the penultimate paragraph in Section 3.2). As a result, the shifts are not a good point of reference for comparing the strength of constricted intervals in different groups of examples arranged according to the place and manner of articulation of segments preceding /r/. While in some groups both voiced and voiceless consonants are included, in other cases only voiced segments precede the rhotic. For this reason, direct comparisons are not possible. Nevertheless, the intensity shifts measured in the experiment are useful in the discussion regarding the influence of the informants' gender on the articulation of the consonant (see Section 3.4).

As far as the statistical methods used in Section 3 are concerned, z-tests were applied for the comparisons involving categorical data. In the case of numerical data, t-tests were performed where the sample size was smaller than 30, and z-tests were applied for samples larger than 30.

3. Data analysis

The analysis of the results includes general observations which refer directly to the major aims of the paper (Section 3.1) as well as a detailed discussion on the effects of the place of articulation, manner of articulation, and voicing of the consonants preceding /r/ in the articulation of the rhotic (Section 3.2). Furthermore, in Section 3.3 the problem of a possible influence of the position of /r/ within the syllable is analysed and Section 3.4 examines additional, extralinguistic factors which may have influenced the results.

3.1 Results

The overall results of the present test are reported in Table 2. They show that trilling, referred to as Type 1 (see Section 2.3), is extremely rare in the pronunciation of /r/ in the postconsonantal position in Polish. It was encountered in only 4 out of 270 articulations and the 95% confidence interval for its occurrence in the population of speakers of standard Polish is 1.48% ± 1.44%. It is interesting to note that the four observed cases of trilled /r/ ware pronounced by only one participant. Her articulation of the consonant in the words *wrona* ('crow'), *szrama* ('scar') and *chrapka* ('willingness') involved two constricted intervals and in the example *mrówka* (‘ant’) she articulated /r/ with three closures. On the whole, such a result is very similar to the one obtained in the former experiment designed to study the intervocalic context (see Table 1), where the consonant under discussion was trilled in 2.8% of the cases. As a consequence, the claim made in most studies on Polish phonetics that the typical articulation of the Polish /r/ involves trilling needs to be reconsidered. It has been thoroughly refuted in the present paper as well as in Stolarski (2013). Studying the preconsonantal and word-final articulation of /r/ is the natural next step. As summarised in Section 1.2, Biedrzycki (1978: 83–84) predicted that the consonant may happen to be realised as a tap in both intervocalic and postconsonantal positions, but the fact that trilling was found to be so infrequent is astonishing. His other assumptions suggest that in the preconsonantal and word-final phonetic environments /r/ should be realised as a trill, but in the light of the evidence gathered so far other phonetic realisations seem to be possible even in these contexts.

The present experiment reveals that the most typical articulation of /r/ in Polish in the postconsonantal environment is tapping (Type 2). It was observed in almost 80% of the cases, and the 95% confidence interval for such an articulation among the population of speakers of standard Polish is 79.63% ± 4.8%. A tapped stop may be regarded as the basic allophone of /r/ in the postconsonantal position as well as in the formerly studied intervocalic environment. The corresponding result obtained in Stolarski (2013) revealed that [ɾ] was produced in 95% of the recorded articulations.

Type 3, which involves a single weak closure with an immediate intensification of acoustic energy in higher frequencies, was found in 12.22% of the cases, which is more frequent than in the intervocalic environment investigated in the former experiment. As it was mentioned in Section 2.3, however, this manner of articulation could also be regarded as a special kind of tapping. If its occurrence was calculated together with Type 3, tapped articulation would constitute over 90% of all the cases analysed in the present experiment.

Phonetic realisations which do not involve any definite closure, referred to as Type 4, were observed 18 times, which constitutes 6.67% of the cases. They are less common than the ones grouped under Type 3 (and, obviously, Type 2), but still more frequent than instances of trilling, which are exceedingly rare.

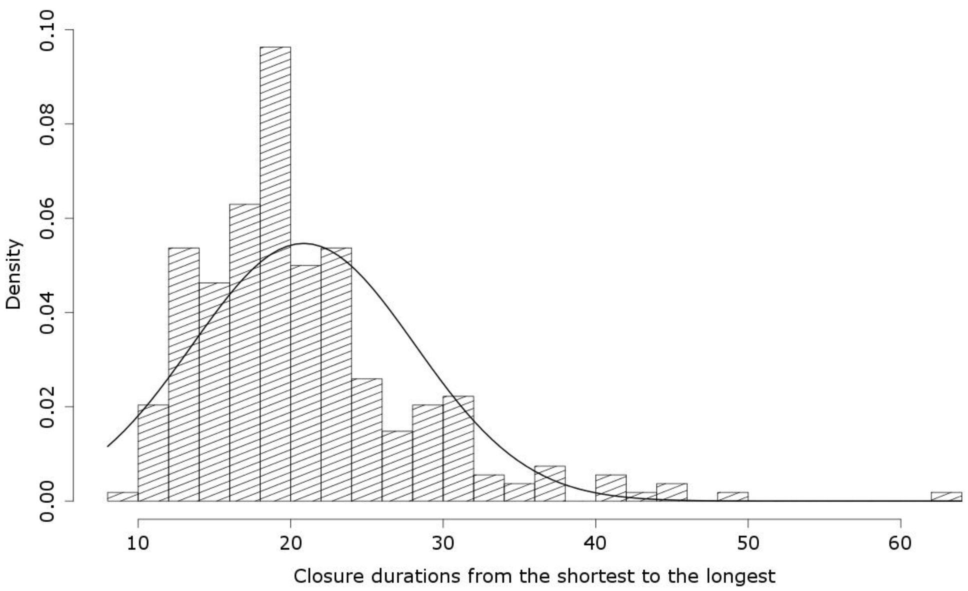
Table 2. General test results

	Type 1	**Type 2**	**Type 3**	**Type 4**
Sum in all Cr contexts	4	215	33	18
Percentage	1.48%	79.63%	12.22%	6.67%
Margin of error	1.44%	4.8%	3.91%	3.03%
	Duration of the (first) closure	Maximum intensity in the vocalic element preceding the (first) closure	Minimum intensity during the (first) closure	Intensity drop during the (first) closure
Average in all Cr contexts	20.7 ms	76.2428 dB	72.6999 dB	3.5428 dB
Standard deviation	7.4 ms	4.1159 dB	4.1201 dB	2.7893 dB
Margin of error	0.878 ms	0.490957 dB	0.491458 dB	0.332716 dB

The average duration of the closures (or various kinds of approximations in Type 4) amounts to 20.7 milliseconds. It is slightly shorter than the mean length 21.9 milliseconds observed in Stolarski (2013), but on the bases of the samples analysed in the two experiments this difference is statistically non-significant ($p = 0.0651$). It is interesting to note that although the distribution of individual measurements here is approximately normal, it involves some outliers which drive the average upward. This is readily visible in Graph 1 which presents the histogram of individual closure durations with 30 intervals spaced 2 milliseconds apart ranging from 3.2 milliseconds to 62.5 milliseconds. Because the distribution is slightly skewed to the right, the median, which is 19.3 milliseconds, probably better reflects the average duration of the closures.

The average intensity drop in the production of /r/ in the intervocalic position reported in Stolarski (2013) was greater than the one observed in the current experiment. The difference which amounts to 2.3963 ± 0.4414 dB is highly statistically significant ($p < 0.0001$); however, it should be borne in mind that the methods of measuring the intensity shifts in the two experiments differed (see Section 2.3). Therefore, the discrepancy between the two results does not necessarily prove that the contact between the blade of the tongue and the alveolar ridge in the production of /r/ tends to be firmer between vowels than after consonants, although such a tendency is possible.

Graph 1. Histogram of individual closure durations with 30 intervals spaced every 2 milliseconds



3.2 Influence of the place of articulation, manner of articulation and the voicing of the preceding consonants

The summary of the articulation of /r/ after different groups of consonants divided according to the manner of articulation (see Table 3) suggests that trilling is encountered almost exclusively after fricatives, but it must be stressed that the relative frequency of Type 1 is still very low (3.33%). More importantly, the trilled /r/ occurred in the pronunciation of only one participant (see Section 3.1), so the conclusion that trilling is more frequent after fricatives cannot be statistically substantiated by the results of the present experiment. The fact that Types 3 and 4 are more common after fricatives and affricates is, however, evident. The articulatory characteristics of these two groups of consonants cause the following /r/ to frequently be produced with either a weak closure accompanied by immediate intensification in higher frequencies or friction substituting any definite constricted interval. In other phonetic contexts /r/ was produced almost exclusively as a prototypical tap.

Table 3. Articulation of /r/ after different classes of consonants grouped according to the manner of articulation

	Type 1	**Type 2**	**Type 3**	**Type 4**		**Duration of the (first) closure or approximation**	**Intensity drop during the (first) closure**
After stops (on the basis of 60 articulations)							
Sum	0	60	0	0	Average	20 ms	3.6916 dB
Percentage	0%	100%	0%	0%	Standard deviation	5.5 ms	2.3854 dB
Affricates (on the basis of 60 articulations)							
Sum	0	34	15	11	Average	23.3 ms	3.7132 dB
Percentage	0%	56.67%	25%	18.33%	Standard deviation	10.5 ms	3.1940 dB
After nasals (on the basis of 30 articulations)							
Sum	1	27	2	0	Average	20.5 ms	4.1571 dB
Percentage	3.33%	90%	6.67%	0%	Standard deviation	5.4 ms	2.5546 dB
After laterals (on the basis of 10 articulations)							
Sum	0	10	0	0	Average	20.5 ms	3.8419 dB
Percentage	0%	100%	0%	0%	Standard deviation	4.7 ms	2.8634 dB
After fricatives (on the basis of 90 articulations)							
Sum	3	66	15	6	Average	19.5 ms	2.9704 dB
Percentage	3.33%	73.33%	16.67%	6.67%	Standard deviation	5.9 ms	2.7779 dB
After approximants (on the basis of 20 articulations)							
Sum	0	18	1	1	Average	22.8 ms	4.8396 dB
Percentage	0%	90%	5%	5%	Standard deviation	8.4 ms	2.5050 dB

The average duration of the (first) closure was slightly longer after affricates and approximants than in other phonetic contexts and these differences are in most cases statistically significant. For instance, the two-tailed p-value for the difference between 20 milliseconds after stops and 23.3 milliseconds after affricates is 0.031. Nonetheless, it must be pointed out that the articulation of /r/ after affricates was tested on either fairly rare Polish words or on the border between two words. These factors might have had an influence on the prolonged articulation of the "consonant-like element" of /r/ (for a discussion on the role of the position of the rhotic in syllable structure, see Section 3.3).

The differences between the values of intensity drop during the (first) closure summarised in Table 3 are not statistically significant in most cases. The p-values are below 0.05 only when we compare the result obtained after fricatives (2.9704 dB) to the ones after nasals (4.1571 dB) and approximants (4.8396 dB). In these cases the two tailed p-values are 0.0312 and 0.0031, respectively.

Table 4. Articulation of /r/ after different classes of consonants grouped according to the place of articulation

	Type 1	**Type 2**	**Type 3**	**Type 4**		**Duration of the (first) closure**	**Intensity drop during the (first) closure**
After bilabial (on the basis of 40 articulations)							
Sum	1	39	0	0	Average	18.2 ms	3.1222 dB
Percentage	3%	98%	0%	0%	Standard deviation	5.1 ms	2.0719 dB
After labio-dental (on the basis of 20 articulations)							
Sum	1	17	1	1	Average	16.5 ms	1.1549 dB
Percentage	5%	85%	5%	5%	Standard deviation	3.9 ms	2.2007 dB
After post-dental (on the basis of 60 articulations)							
Sum	0	58	2	0	Average	20.4 ms	3.9907 dB
Percentage	0%	97%	3%	0%	Standard deviation	4.7 ms	2.3081 dB
After alveolar (on the basis of 20 articulations)							
Sum	0	11	7	2	Average	21.2 ms	2.7411 dB
Percentage	0%	55%	35%	10%	Standard deviation	11.4 ms	2.7964 dB
After post-alveolar (on the basis of 40 articulations)							
Sum	1	18	9	12	Average	23.6 ms	3.7899 dB
Percentage	3%	45%	23%	30%	Standard deviation	9.1 ms	3.1132 dB
After alveolo-palatal (on the basis of 20 articulations)							
Sum	0	16	3	1	Average	23.1 ms	4.6900 dB
Percentage	0%	80%	15%	5%	Standard deviation	9.4 ms	3.3798 dB
After palatal (on the basis of 40 articulations)							
Sum	0	27	11	2	Average	22.5 ms	4.4900 dB
Percentage	0%	68%	28%	5%	Standard deviation	7.3 ms	3.0441 dB
After velar (on the basis of 30 articulations)							
Sum	1	29	0	0	Average	20.7 ms	3.4770 dB
Percentage	3%	97%	0%	0%	Standard deviation	6.1 ms	2.5967 dB

Table 4 presents the results of the experiment arranged according to the place of articulation of the consonants preceding /r/. It is readily apparent that Types 3 and 4 tend to be more frequent after segments which are alveolar, post-alveolar, alveolo-palatal and palatal. Type 3 and Type 4 were found in 25% and 14.17% of these cases, respectively. Examples in which the rhotic is preceded by consonants with other places of articulation comprise 2% for Type 3 and 0.67% for Type 4. These large differences are highly statistically significant (in both cases the p-values are smaller than 0.0001).

There are two possible explanations for such a tendency. Firstly, the Polish /r/ is an alveolar consonant. If it is preceded by a segment which has the same or similar place of articulation, its production will naturally become more strenuous than in cases when it is preceded by consonants articulated at some other location in the mouth. For example, it is obvious that the sequence /t͡ʃr/ is harder to pronounce than /kr/ or /pr/. In the former case the speaker needs to place the tongue on the alveolar ridge and make a complete closure, behind which the air pressure builds up. Then she needs to release the air with an accompanying friction typical for affricates and immediately after that, with the same part of the tongue, perform the action of tapping (or trilling). In the latter cases the blade of the tongue is not involved in the articulation of the preceding consonants and the production of /r/ is easier. The speaker has more control over the movements of the blade of the tongue and the closure stage is performed with more precision. This interpretation is substantiated by the differences in the mean duration of the closures. The constricted intervals were comparatively longer when /r/ was pronounced after alveolar, post-alveolar, alveolo-palatal and palatal consonants than in other cases. It is probably also the result of the articulatory positions allowing less control over the movements of the blade of the tongue. After consonants with a place of articulation around the alveolar region, the constricted intervals are pronounced with less precision.

The second explanation is that it may be not the place but rather the manner of articulation which triggers the phonetic realisations of Type 3 and 4. In fact, all Polish alveolar, post-alveolar and alveolo-palatal consonants are either affricates of fricatives (see Section 2.2). In addition, two out of the four palatal phonemes are fricatives (/ɕ/ and /ʑ/). Such a convergence of phonetic characteristics makes it difficult to decide on the conditioning of the tendency. One possible conclusion would be just to state that /r/ is more frequently articulated with friction or approximation after affricates and fricatives which are pronounced around the area of the alveolar ridge.

Table 4 suggests that intensity drops during the (first) closure may be correlated with the duration of the stricture. The longer the period of reduced acoustic energy, the greater the drop in intensity. Nonetheless, this tendency is much less evident in Table 3. Consequently, in order to establish the strength of the correlation all measurements of the durations of individual closures have been compared with the corresponding drops in intensity and the correlation coefficient obtained is 0.53. This indicates that the positive linear relationship is not very strong. A scatterplot of all the durations of individual closures against the corresponding shifts in intensity is shown in Graph 2.

Graph 2. Scatterplot of the durations of individual closures against the corresponding shifts in intensity (r = 0.53)

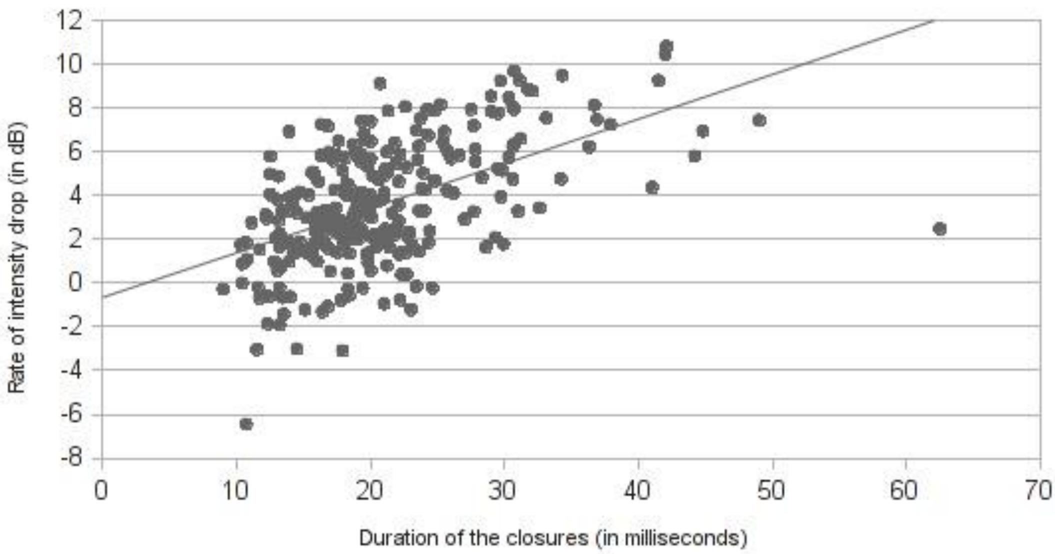


Table 5. Articulation of /r/ after different classes of consonants grouped according to voicing

	Type 1	Type 2	Type 3	Type 4
After voiceless (on the basis of 110 articulations)				
Sum	2	85	10	13
Percentage	1.82%	77.27%	9.09%	11.82%
After voiced (on the basis of 160 articulations)				
Sum	2	130	23	5
Percentage	1.25%	81.25%	14.38%	3.13%

	Duration of the (first) closure	Maximum intensity in the vocalic element preceding the (first) closure	Minimum intensity during the (first) closure	Intensity drop during the (first) closure
After voiceless (on the basis of 110 articulations)				
Average	20.4 ms	74.8133 dB	72.1864 dB	2.6270 dB
Standard deviation	7.9 ms	4.1204 dB	4.0628 dB	2.7317 dB
After voiced (on the basis of 160 articulations)				
Average	21.4 ms	77.0927 dB	72.7794 dB	4.3133 dB
Standard deviation	6.9 ms	3.8375 dB	4.1768 dB	2.5973 dB

Another factor which influences the values of intensity shifts is the voicing of the consonants preceding /r/ (see Table 5). In this context the relationship is rather close. The difference between the mean values of intensity drops after voiceless consonants and after voiced consonants is 1.6863 ± 0.65 dB ($p < 0.0001$). It must be stressed, though, that the mean minimum intensity values during the closure are very similar in the two contexts. The difference results mainly from the dissimilar values of the average maximum intensity in the vocoidal element preceding the constricted interval. They differ by 2.2794 ± 0.9729 dB and the observation is, again, highly statistically significant ($p < 0.0001$). The natural conclusion is that the type of voicing of the preceding consonants has a direct effect on the level of intensity of the vocoidal element articulated before the closure. When /r/ is pronounced after voiced segments, the vocoidal element tends to be louder than when /r/ is articulated after voiceless segments. All this points to the fact mentioned in Section 2.3 that intensity shifts measured in this experiment should not be treated as a reliable point of reference for comparing the strength of constricted intervals in the different groups summarised in Tables 3 and 4. The values which have been obtained are biased by the unequal duration of the closures and by the type of voicing of the preceding consonants.

The data reported in Table 5 do not reveal any important differences in the frequency of occurrence of the types of articulation of /r/ defined in Section 2.3. Trilling is equally rare after voiceless and voiced segments and other kinds of phonetic production do not seem to vary substantially. Only

Type 4 should be treated as slightly more frequent after voiceless consonants than after voiced consonants (p = 0.0049).

3.3 Tautosyllabic versus heterosyllabic /Cr/ sequences

The /Cr/ sequences in seventeen examples analysed in the present experiment are tautosyllabic (examples 1, 2, 3, 4, 5, 6, 7, 13, 17, 18, 19, 20, 21, 22, 23, 24 and 25). In the other ten cases the rhotic and the directly preceding consonant are heterosyllabic. The two groups are compared in Table 6.

The differences in the type of realisation of the rhotic in the two groups are very small. Type 2 and Type 4 are distributed in an almost identical manner. The largest difference concerns Type 3, but even in this case it is too small to be statistically relevant (4.4% ± 8.39%, p = 0.2846). These results suggest that the type of articulation of the rhotic does not depend on whether or not the consonant preceding /r/ and /r/ are tautosyllabic. Consequently, Biedrzycki's (1978) assumption that the tapped realisation of the rhotic may be encoutered in the postconsonantal position (see Section 1.2) may be extended to heterosyllabic sequences.

As far as the length of the stricture is concerned, it tends to be longer in heterosyllabic sequences. The average difference between the two groups amounts to 2.6 ms ± 1.74 ms and should be treated as statistically significant (p = 0.0035). Additionally, in heterosyllabic clusters the mean intensity drop during the (first) closure is larger than in tautosyllabic ones. Again, this difference is statistically significant (0.9276 dB ± 0.6352 dB, p = 0.0042).

Table 6. Articulation of /r/ according to whether or not the preceding consonant belongs to the same syllable as the rhotic

	Type 1	**Type 2**	**Type 3**
Tautosyllabic (on the basis of 170 articulations)			
Sum	4	136	18
Percentage	2.35%	80%	10.59%
Heterosyllabic (on the basis of 100 articulations)			
Sum	0	79	15
Percentage	0.00%	79.00%9	15.00%

	Duration of the (first) closure	**Maximum intensity in the vocalic element preceding the (first) closure**	**Minimum intensity during the (first) closure**
Tautosyllabic (on the basis of 170 articulations)			
Average	19.9 ms	76.2459 dB	72.9911 dB
Standard deviation	5.8 ms	3.6096 dB	3.8946 dB
Heterosyllabic (on the basis of 100 articulations)			
Average	22.5 ms	76.2394 dB	72.0570 dB
Standard deviation	7.7 ms	3.9694 dB	4.1624 dB

3.4 Influence of the informants' characteristics: gender and place of origin

The statistical summary of the results arranged according to the gender of the respondents (see Table 7) suggests that men tend to articulate the Polish /r/ slightly less clearly. In their pronunciation, Types 3 and 4 occur more frequently, although on the basis of the sample used in the current experiment these differences cannot be proven statistically. It is also noticeable that the average duration of the (first) closure is somewhat longer in male pronunciation. Even though the difference is statistically significant ($p = 0.0174$), the corresponding result in Stolarski (2013) casts doubt on its relevance. Namely, in the preceding experiment the average duration of the closure was longer in women's pronunciation.

In the case of the results concerning shifts in intensity the tendency is the same as in Stolarski (2013). The drop is greater in female speech. Again, the sample is too small to prove that the difference is statistically significant ($p = 0.0912$). Nonetheless, when we calculate the two-tailed p-value on the basis of the data from both experiments the difference becomes relevant ($p = 0.0297$). Therefore, it may be concluded that women tend to articulate /r/ with stronger contact between the tongue blade and the alveolar ridge than men.

The results of the present study do not reveal any crucial differences which would depend on the place of origin of the participants. The same observation was reported in Stolarski (2013).

Table 7. Results of the test arranged according to the gender of the participants

	Type 1	**Type 2**	**Type 3**	**Type 4**
Results for female participants (on the basis of 135 articulations)				
Sum	4	112	13	6
Percentage	2.96%	82.96%	9.63%	4.44%
Results for male participants (on the basis of 135 articulations)				
Sum	0	103	20	12
Percentage	0.00%	76.30%	14.81%	8.89%
	Duration of the (first) closure	**Maximum intensity in the vocalic element preceding the (first) closure**	**Minimum intensity during the (first) closure**	**Intensity drop during the (first) closure**
Results for female participants (on the basis of 135 articulations)				
Average	19.8 ms	75.3541 dB	71.4706 dB	3.8835 dB
Standard deviation	7.4 ms	3.7660 dB	3.6178 dB	2.8374 dB
Results for male participants (on the basis of 135 articulations)				
Average	21.9 ms	77.1328 dB	73.8196 dB	3.3132 dB
Standard deviation	7.1 ms	4.2930 dB	4.3015 dB	2.7092 dB

4. Discussion and conclusions

The overall results of the experiment (see Section 3.1) indicate that the trilling of /r/ is extremely uncommon in Polish. Amongst the 270 analysed articulations trilling was observed no more than 4 times and only in the pronunciation of one informant. The most typical phonetic realisation of the consonant is a tapped stop, which was articulated in 79.6% of the cases. Such a result is similar to the one reported in Stolarski (2013), where the production of /r/ was examined in the intervocalic context. All this data leads to the conclusion that the widely accepted view that the consonant is a trill needs a fundamental revision.

It is useful to focus at this point on the two definitions of trilling mentioned in Section 1.1. If the problem is considered from the “acoustic definition” point of view, the common view on the articulation of the Polish rhotic is most probably incorrect. Its basic allophone in the two analysed phonetic environments is a tap and trilled articulation in these contexts is extremely rare. However, the final answer is less straightforward if we consider the "phonetic definition", according to which trills are "sounds made with an articulatory configuration appropriate for vibration, regardless of whether vibration actually occurs" (Ladefoged & Maddieson 1996: 217–218). In such a case the claim that the Polish rhotic is actually a trill is harder to dismiss. Nevertheless, the data obtained in the experiment suggest that even according to the gestural account the realisation of this consonant does not normally involve trilling. Namely, the average duration of the closures reported in Table 2 (20.7 ms) is shorter than the duration of trills in other languages. Taking into account the statistics mentioned in Dhananjaya et al. (2012), Ladefoged and Maddieson (1996) or Lever (1994), for the lingual gesture to be trill-like in a one contact rhotic, the duration of the closed phase should be about 50 ms or more.

A possible reason for the rhotic rarely being trilled might be a narrow range of allowable variation of the aerodynamic conditions suitable for trills (Ladefoged & Maddieson 1996; Solé, Ohala & Ying 1998; Solé 2002). If such small variations occur, the resulting articulation involves various kinds of fricatives, approximants and, possibly, taps. In the discussion on the production of the Spanish rhotics, briefly summarised in Section 1.1, this factor is frequently quoted as an explanation for a number of common deviations from trilling in numerous dialects.

Another aspect which is worth mentioning in the current discussion is a frequent lack of phonemic contrasts between rhotics in a given language. Maddieson (1984) suggests that the most typical distribution of liquids in languages of the world involves one lateral and one r-sound. In the case of languages with a larger number of liquids than two, there are usually more laterals than r-sounds. This relatively small diversity of rhotics in a single language has also been observed by Ladefoged and Maddieson (1996: 239) who discuss Australian languages which usually have only two rhotics, even though the contrasts among stops, nasals, and laterals involves four members. Moreover, they claim that "the great majority of the world's languages have only a single type of rhotic sound in their inventory" (1996: 237). All this suggests that any claims that a rhotic in a given language is realised as a trill should be interpreted with caution, especially if a language involves only one phonemic r-sound. If there is no contrast between trilling and tapping then the very force of "ease of articulation" makes trilling very unlikely, as seems to be the case in Polish. Saleh et al. (2015) reach a similar conclusion in their analysis of the Egyptian Cairene

/r/: although it may be realised either as a trill or a tap, the latter articulation is more frequent. Finally, it must be stressed that even a phonemic contrast between trilling and tapping in a language does not guarantee that trilling will actually be phonetically realised, as has been found in many dialects of Spanish (see the discussion in Section 1.1).

Examining the other contexts mentioned by Biedrzycki (1978: 83–84) – the preconsonantal and word-final positions – is the next step. Even though Biedrzycki states that in these two environments the Polish /r/ should be trilled, in the light of the current findings there is reason to suspect that tapping will be observed in these contexts as well.

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