Linguistica Silesiana 34, 2013
ISSN 0208-4228

ŁUKASZ STOLARSKI
Jan Kochanowski University in Kielce

TAP AS THE BASIC ALLOPHONE OF THE POLISH RHOTIC

The research reported in this paper is a continuation of the experimentation on the articulation of the Polish /r/ in the intervocalic and postconsonantal positions (cf. Stolarski 2013a and 2013b, respectively). According to Biedrzycki (1978: 83-84), in these two phonetic contexts the rhotic happens to be articulated as a tap. Such an assumption stands in contrast to the widely accepted view that the Polish rhotic is generally realised as a trill. The results reported in Stolarski (2013a) and (2013b) amply prove that in these two environments tapping of the Polish /r/ is extremely frequent.

In this article the articulation of the Polish rhotic is examined in the preconsonantal and word-final phonetic contexts. Biedrzycki's account suggests that in these environments /r/ should be realised as a trill. The results obtained in the current research, however, indicate that even in such contexts the rhotic is mostly tapped. The conclusion which must be drawn from these findings is that the basic allophone of the Polish /r/ is the tap, and not the commonly assumed trill.

1. Introduction

1.1. Note on the abbreviations used in the paper

It is significant to note that later in this article the experiments described in Stolarski (2013a) and Stolarski (2013b), which are summarised in Section 1.3, will be referred to as Experiment 1 and Experiment 2, respectively. Furthermore, the current research on the articulation of /r/ in the preconsonantal position will be called Experiment 3, and in the word-final position Experiment 4.

In Section 1.4 the observed phonetic realisations of /r/ are categorised as Type 1, Type 2, Type 3, Type 4 and Type 5. Similar classifications were also used in Experiments 1 and 2, but it must be underlined that in the present work the "Types" are assigned to various allophones of the rhotic in a notably different way.

1.2. Descriptions of /r/ in the literature on Polish phonetics

In terms of articulatory and acoustic characteristics, rhotics constitute a remarkably diverse group. According to Ladefoged and Maddieson (1996), the group comprises dental or alveolar trills, taps, approximants and lateral flaps. Additionally, it includes post-alveolar flaps and approximants and also uvular trills and approximants. Because of such a diversity of phonetic realisations it is sometimes claimed that the only reason for classifying rhotics as a separate group of sounds is that they are represented by the letter "r" in spelling (Łobacz 2000: 85).

The basic allophone of the Polish phoneme /r/ is typically referred to as an alveolar trill. However, in the literature on Polish phonetics one may encounter suggestions of numerous other ways of articulating of the consonant. As summarised in Stolarski (2013a) and (2013b), many authors mention the palatalised [rʲ] when the segment precedes the high front vowel /i/ or the palatal approximant /j/ (cf. Benni 1959: 28, Wierzchowska 1967: 157, 1971: 138, 1980: 119, Dłuska 1983: 122, Strutyński 1987: 21, Dukiewicz 1995: 40, Wiśniewski 1997: 63, Gussmann 2007: 4). Additionally, Stieber (1966: 111) suggests that palatalisation of the Polish /r/ may also take place when the segment is positioned before another palatal (or palatalised) consonant, but other authors claim that such a process in this phonetic environment is only optional (cf. Steffen-Batogowa 1975: 20, Sawicka 1995: 149). Finally, Rocławski (1976: 132) assumes that the palatalisation of /r/ is never really possible because the palatal element is always realised as a separate segment following the articulation of /r/.

Other allophones of the Polish /r/ include the voiceless [r̥], which is realised between voiceless consonants and in the word-final position when preceded by a voiceless segment (cf. Benni 1959: 29, Wierzchowska 1967: 105, 1971: 122, Rocławski 1976: 132, Strutyński 1987: 24, Dukiewicz 1995: 40), the uvular [ʀ] encountered in deviant speech (cf. Wierzchowska 1971: 122, Pilich 1975: 51, Rocławski 1976: 132, Dukiewicz 1995: 40, Gussmann 2007: 27), the devoiced and palatalised [r̥ʲ] (cf. Benni 1959: 29), the dental approximant [ɹ] and the uvular fricative [ʁ] (cf. Gussmann 2007: 27).

The aspect of articulation which was pivotal for Experiments 1 and 2, and which is also central to the present research, is the manner of articulation of the Polish /r/. Namely, the consonant is fairly consistently classified as a trill. All other types of phonetic realisation are frequently interpreted to be the result of an articulatory undershoot. Nevertheless, the possibility of a tapped realisation of the segment is also mentioned in various publications (cf. Jassem 1973: 246-248, Wierzchowska 1971: 122, 1980: 73, Dłuska 1983: 119, Rocławski 1976: 132 and Dukiewicz 1995: 40).

Even if one assumes that the rhotic, at least underlyingly, is a trill, phonetic realisation of the consonant through other manners of articulation seems natural. First of all, tapping does not contrast with trilling in Polish. Such a situation is rather typical in various languages of the world. Maddieson (1984), for example, reports that as many as 75% of all languages have rhotic phonemes, but phonological contrasts between these phonemes are found in only 18% of these languages. Additionally, Ladefoged et al. claim that "very few languages have any trills at all and even fewer contrast trills of two different kinds" (1977: 49). Although Biedrzycki (1978: 83-84) provides an example of a minimal pair of Polish words in which trilling contrasts with tapping (*mara – Marra*, pronounced [maɾa] and [mara], respectively), the second word is an exceedingly rare foreign proper name. Consequently, the example cannot be regarded as a proof of the phonological distinction between [ɾ] and [r] in Polish. If there is no underlying contrast, there is really no need to articulate the rhotic as a trill. It potentially could be realised as a tap or in any other "easier" way and it would still be correctly classified. Similarly to the way in which children replace the articulation of the Polish rhotic with other types of articulation, such as [l] or [j] (Jaworski and Gillian 2011: 382), adults also tend to substitute the trill with articulatorily easier phonetic realisations. Lindau supports such a claim by mentioning that in languages in which /r/ is thought to be realised as a trill, not all speakers pronounce the segment in this way and even those that do, tend to articulate it in alternative ways as well (1985: 161). Indeed, such weakening of trills has been attested in many languages of the world (cf. Żygis 2005, Colantoni 2005, 2006, Recasens and Espinosa 2007).

It is also worth adding that Jaworski and Gillian (2011), whose results are reported below, assume that the Polish /r/ may be underlyingly a tap. They interpret other realisations of the segment as examples of an articulatory undershoot of [ɾ] rather than [r]. Still, such an approach is exceptional and, generally, the consonant is classified as a trill even by those authors who admit that in some contexts it may be articulated as a tap.

As described in Stolarski (2013a), various factors influencing the phonetic weakening of the consonant have been proposed. For instance, Rocławski (1976: 132) and Jassem (1981: 260) speculate that the way in which /r/ is phonetically realised may depend on the tempo of speech. The faster the tempo, the more likely it becomes for the phoneme not to be articulated as a trill, but as a tap. This assumption may be confirmed by comparing the results of Experiments 1 and 2 and the experiment described in Jaworski and Gillian (2011). In the two former cases which concern careful articulation of /r/ in separate words, trilling was rare, but it was still noticeable. In the experiment reported in Jaworski and Gillian, on the other hand, the production of the rhotic was examined in sentences. This time trilling was not encountered even once. The tempo of speech must, therefore, play a crucial role in the weakening process.

Among other factors affecting the production of /r/, Wierzchowska (1967: 122) and Dłuska (1983: 122) suggest the process of palatalisation. They claim that the tapped variant is frequently encountered in the production of the palatalised version of the rhotic. Additionally, authors such as Dukiewicz (1995: 40) and Jassem (1974: 60) maintain that articulations of /r/ which do not involve trilling may be produced in any phonetic context, especially in casual, non-emphatic speech.

Finally, a very interesting proposal has been put forward by Biedrzycki (1978: 83-84). He maintains that the Polish /r/ is realised as a trill before consonants and in the word-final position. Nonetheless, he suggests the tapped allophone may appear in the intervocalic position and after consonants. These assumptions were the basis of Experiments 1 and 2. The former explored the articulation of /r/ between vowels; the latter studied the post-consonantal position as a possible contexts in which the rhotic may not be articulated as a trill. The results of the two experiments are described in the section below.

1.3. Former experiments in the articulation of /r/ in Polish

Experiment 1, which dealt with the articulation of /r/ in the intervocalic position, yielded surprising results. While the tapped articulation was expected in that phonetic environment, the frequency of its occurrence was truly astonishing. The rhotic was realised as a trill in less than 3% of the cases. Moreover, about 2% of the articulations involved one constriction with accompanying friction suggesting either a slower release stage or a weaker closure. All other cases were classified as typical taps. The natural conclusion reached in that study was that trilling was almost never encountered in the intervocalic position in Polish. It must be stressed that the examples used in the experiment were separate words, so the phonetic reduction could not be the result of such additional factors as speech tempo.

The results reported in a very similar study by Jaworski (2010) support the view that the rhotic is almost never realised as a trill in the intervocalic position. In that project the articulation of the consonant was investigated in the context of full sentences. Jaworski asked his respondents to alter the tempo of their speech. The data he obtained indicate that the level of the phonetic reduction of /r/ is higher the faster someone speaks. This observation is in agreement with the aforementioned suggestions by Rocławski (1976: 132) and Jassem (1981: 260) and also the general assumption concerning phonetic reduction expressed in *The handbook of the International Phonetic Association* (2003: 36). Additionally, Jaworski observed that the amount of phonetic weakening is dependent on whether the consonant is located in a stressed or an unstressed syllable. The reduction was visibly stronger in unstressed positions than in stressed ones. The same conclusions were reached in Jaworski and Gillian (2011). The experiment summarised there involved a considerably larger sample and the authors took into consideration additional parameters such as the articulatory characteristics of the vowels surrounding the rhotic. The data obtained indicated that the level of phonetic reduction of /r/ depended on the vertical articulatory scale of the flanking segments – the higher the vowels, the more the weakening of the rhotic was observed. The horizontal scale of the vowels also seemed to play a role and phonetic reduction was observed to be slightly stronger between front vowels than between back vowels, but this time the tendency was not marked. Still, one of the most interesting observations in Jaworski and Gillian (2011) concerns the articulation of /r/ in the two groups of respondents divided according to age. Namely, the phonetic reduction of the rhotic was relatively stronger among younger participants than among older ones. Jaworski and Gillian summarised their description by proposing that “the data presented in the article indicate that the lenition phenomenon affecting the Polish rhotic phoneme represents a certain tendency which, if maintained, may lead to a dramatic change in the articulation of the Polish rhotic, and consequently, to a sound change” (2011: 395).

Experiment 2, whose methods were similar to the ones applied in Experiment 1, aimed at examining the way that /r/ is realised in the postconsonantal position. The choice of this phonetic context was based on a suggestion in Biedrzycki (1978: 83-84) who assumes that the consonant may be realised in other ways than a trill not only when it is pronounced between vowels, but also when it follows another consonant. The results obtained were, again, surprising. Trilling was encountered only in 1.48% ± 1.44% of the cases. Moreover, tapped stops were identified in 79.63% ± 4.8% of the cases. If we compare these figures to the ones obtained in Stolarski (2013a), it becomes clear that this allophone is the most basic in both the postconsonantal and intervocalic positions. Other types of articulation observed in Experiment 2, a closure with an immediate intensification in higher frequencies and various types of (trilled) fricatives and approximants, occurred in around 18% of the cases.

1.4. Acoustic characteristics of the possible phonetic realisations of the Polish /r/ observed in the current data

Jaworski (2010), in his studies on the articulation of the Polish rhotic in the intervocalic position, describes in detail the acoustic characteristics of trills, taps, approximants and fricatives, as the articulations actually observed in his experiments. Moreover, he suggests that the phonetic reduction of the consonant may be associated with the consonant strength hierarchy proposed by Hyman (1975: 164). The hierarchy involves such consecutive processes as intervocalic degemination, intervocalic voicing, intervocalic spirantisation, intervocalic sonorisation, intervocalic sonorant deletion and vowel coalescence. This order approximately corresponds to the lenition scale proposed by Lass (1993: 177-180), who specifies that weakening of linguistic sounds may be caused by opening the articulation (stop > fricative > approximant > zero) and by sonorisation (voiceless > voiced). Jaworski (2010: 138) summarises his discussion by proposing the following “rhotic strength hierarchy”: trill > voiceless tap > voiced tap > voiceless fricative > voiced fricative > approximant.

The two publications of which this paper is a direct continuation also characterise the acoustic properties of the observed phonetic realisations of /r/. In Stolarski (2013a) (Experiment 1) the description concerned trilled stops, tapped stops and various “weak closures with an immediate intensification in higher frequencies”. In Stolarski (2013b) (Experiment 2) the same types of phonetic realisations were observed and one more was added to the analysis

– a group of articulations comprising a variety of trilled fricatives, fricatives and approximants. In the present study all of these four categories have been identified in the sample and they are briefly summarised below. In addition, one more has been recognized. It encompasses articulations which could be interpreted either as trilled fricatives or single closures followed by a vocalic element involving friction or approximation.

In order to facilitate the statistical summary provided in Section 3, the types of articulation observed in the present experiment have been assigned shorter names as listed below:

- trilled stops – Type 1
- tapped stops followed by a vocalic element involving friction or approximation – Type 2
- tapped stops – Type 3
- (weak) closures with an immediate intensification in higher frequencies – Type 4
- trilled fricatives/fricatives/approximants – Type 5

The kind of articulation referred to here (and also in Experiments 1 and 2) as "Type 1" is usually called "a trill". Laver (1994: 128-227, 263-264), however, prefers to name it "a trilled stop". With the use of his terminology it is possible to distinguish it from "a trilled fricative". The former involves a series of contacts between the apex and the alveolar ridge, while the latter concerns cases in which the closures are not complete and there is some audible friction. It is interesting to note that the alternation rate of constricted intervals present in tapped stops, regardless of the place of articulation, is usually in the range of 20 to 30 per second (cf. Pickett 1999: 110, Jassem 1973: 245, Ladefoged et al. 1977: 52). Furthermore, according to Dłuska (1983: 121) these periods of reduced acoustic energy last between 0.1 seconds and 0.3 seconds. Her assumptions have been reliably confirmed in Experiments 1 and 2: the average duration of the closures in the intervocalic position was 0.0219 ± 0.00092 seconds and in the postconsonantal position it measured 0.0207 ± 0.000878 seconds. Finally, it should be stressed than even though authors such as Dłuska (1983: 119) accept the possibility of up to 7 closures in one articulation of /r/ (in hypercorrect pronunciation), the cases observed in Experiments 1, 2 and also 3 almost never exceed two constricted intervals. Indeed, trilling with 3 periods of reduced acoustic energy was only observed once (in Experiment 2). Consequently, it can be said that in normal speech trilled stops are almost never composed of more than two closures.

Another interesting fact about trills (and also taps) is that the constricted intervals are always surrounded by vocalic elements. Jassem (1973: 245-248) refers to them as "vowel-like segments". Most speakers are unaware of their existence (Dłuska 1983: 118-122), but they are inherent in the articulation of /r/ and can always be recognised in spectrograms. They have apparent formant structure. Jassem reports that the first three formants in the articulation of the

Polish /r/ are: F1 = 500 Hz, F2 = 1550 Hz and F3 = 2550 Hz. These values are similar to the ones proposed by Szczepankowski (1985: 47) and also by Wierzchowska (1967: 105) and they resemble the formant structure of the central vowel /ə/.

The articulation classified as “Type 2” was discerned in neither Experiment 1 nor 2. It encompasses tapped stops which are followed by a vocalic element involving friction or approximation. In other words, “Type 2” are the cases in between prototypical trilled stops and tapped stops. In their production, one clear closure can be detected which is followed by a segment which potentially involves some articulatory activity of the apex. Still, the activity resembles friction or approximation rather than trilling and the whole articulation cannot be classified as “Type 1”.

It is worth observing that Łobacz defines the trill as “a relatively long flap followed by a pseudo-vocalic segment of still greater duration, in excess of some 10 ms, with slight traces of one of two weakenings” (2000: 93). Consequently, in her publication “Type 2” would actually be classified as a typical trill and “Type 1” would rather be interpreted as an example of, as she calls it, the “multiple tap”. Nevertheless, we are going to follow the definitions offered by authors such as Gimson who states that the trill is “a series of rapid intermittent closures made by a flexible organ on a firmer surface” (1994: 30) and treat tapped stops which are followed by a vocalic element involving friction or approximation as articulations which are different from prototypical trills. An example of “Type 2” is shown in Figure 1 below.

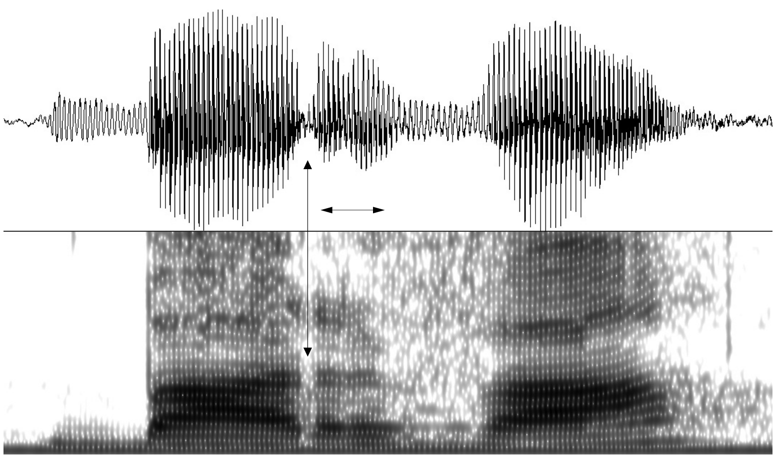

Figure 1: Spectrogram of the articulation of the word “barwa” by Informant 4 as an example of “Type 2” (the closure is marked by a vertical arrow, and the vocalic element involving approximation is marked by a horizontal arrow)

Tapped stops, referred to as "Type 3", are acoustically composed of one constricted interval preceded and followed by the aforementioned "vowel-like elements". It is interesting to observe that alveolar taps are quite similar to alveolar plosives and the main difference between the two kinds of articulation is the duration of the closure. Namely, the constricted interval is extremely brief in the former case and relatively longer in the latter (cf. Kent et al. 1992: 142, Laver 1994 : 224). Example spectrograms of tapped stops were shown in both Stolarski (2013a) and Stolarski (2013b).

In Experiments 1 and 2 the articulation of "Type 4" was interpreted as a special sub-type of the tapped stop, even though it was still classified separately from other allophones of /r/. Indeed, we are dealing here with constricted intervals similar to the ones described above. The difference is that during the closure stage an intensification of acoustic energy in the higher regions of the spectrum can be observed. This additional acoustic activity could be the result of one of two factors. Firstly, the closure itself may not be complete in which case the escaping airstream produces air turbulence. Secondly, the release stage could be relatively slower than in the case of prototypical tapping, which results in friction similar to the one found in affricates. Whatever the cause, the resulting articulation is higher on the lenition scale proposed by Lass (1993: 177-180) than "Type 1" and "Type 2".

Finally, the category named "Type 5" includes a variety of such seemingly dissimilar allophones as trilled fricatives, fricatives and approximants. It was practical to group them together because in none of them could any definite

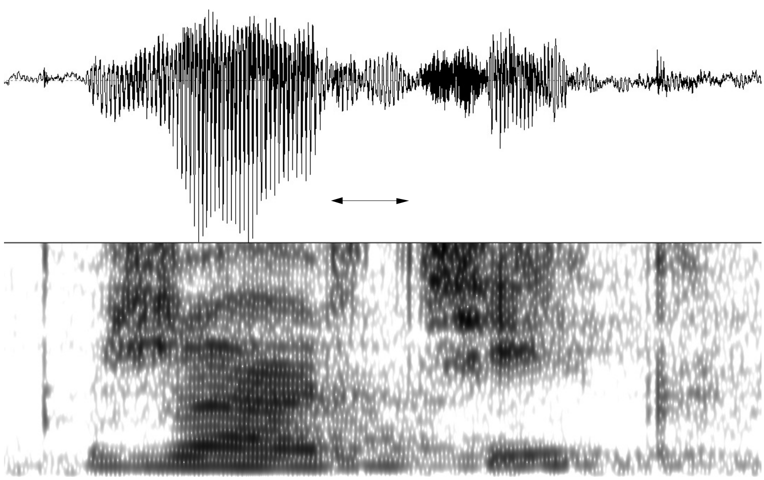

Figure 2: Spectrogram of the articulation of the word "żarcik" by Informant 1 as an example of "Type 5" (the segment which is either a trilled fricative or a "normal" fricative is marked by an arrow)

closure be detected. Moreover, in some of the cases classified as "Type 5" it was difficult to unequivocally determine the exact nature of a given articulation. For instance, it is uncertain whether the pronunciation of /r/ in the word *żarcik* (diminutive of 'joke') by Informant 1 (cf. Figure 2) is an example of a trilled fricative with two minor fluctuations in intensity, suggesting slight movements of the tongue tip, or rather a "normal" fricative.

2. Methodology

2.1. Participants

The methodology employed in Experiments 3 and 4 is nearly the same as the one used in Experiments 1 and 2. Five women and five men were asked to take part in the tests. They are all native speakers of Polish and their ages vary from 20 to 33 years old. Three women (Informants 1, 2, 3) and three men (Informants 6, 7, 8) come from the area around the city of Kielce in central-eastern Poland. The other 2 women live in Poznań (Informants 4, 5). Additionally, one male respondent comes from the eastern part of Poland around Lublin (Informant 9) and another from Wrocław (Informant 10). It must be stressed that in Experiments 1 and 2 no correlation between any measured statistics and the place of origin of individual participants was found. All the informants recorded in all of the four experiments speak standard Polish, which is supposed to be the same irrespective of the region in which it is spoken. Nonetheless, in order to avoid any possible bias in the results, participants chosen for Experiments 3 and 4 come from various parts of Poland.

2.2. Selection of materials

The selection of the materials used in the current research was based on the same principle as the one applied in Experiments 1 and 2. Namely, it has been assumed that the articulation of /r/ should be tested in such a way as to measure a possible influence of segments surrounding the rhotic. For Experiment 3 this means that the pronunciation of /r/ should be investigated before every possible consonantal segment. There are around 30 consonants in Polish whose phonemic status is recognised by most linguists. The segments taken into consideration in Experiment 3 include /p, b, t, d, k, g, t͡s, d͡z, t͡ʃ, d͡ʒ, t͡ɕ, d͡ʑ, f, v, s, z, ʃ, ʒ, ɕ, ʑ, x, r, w, j, m, n, ɲ, l/. It is relevant to note that in many studies the velo-palatal stops /c, ɟ/ are also mentioned; however, because of their highly limited distribution (they appear only before /i, j/ and /ɛ/) they will be excluded from the present analysis. Also, the "zero" (or "juncture") /#/ suggested in many publications will not be taken into consideration. Testing the pronunciation of /r/ before such a segment would be equivalent to testing it in the word-final position, which is, in fact, the task of Experiment 4.

All of the examples used in Experiment 3 are listed below:

1. purpura (‘crimson’)
2. karbid (‘carbide’)
3. Marta (‘Martha’)
4. merdać (‘to wag’)
5. latarka (‘torch’)
6. argument (‘argument, reason’)
7. wystarczać (‘to be enough’)
8. tardżuman (‘dragoman’)
9. żarcik (diminutive of ‘joke’)
10. gardzić (‘to despise’)
11. wyborca (‘elector’)
12. zardzewiały (‘rusty’)
13. barman (‘barman’)
14. karny (‘disciplinary’)
15. latarnia (‘lamppost’)
16. parlament (‘parliament’)
17. harfa (‘harp’)
18. barwa (‘colour’)
19. mors (‘walrus’)
20. zmarznąć (‘to freeze’)
21. wiersz (‘poem’)
22. marża (‘mark-up’)
23. gorsi (‘worse’)
24. mierzić (‘to loathe’)
25. monarcha (‘monarch’)
26. berło (‘sceptre’)
27. Daria (a common feminine name)

In the examples selected in Experiment 4 the rhotic is pronounced in the word-final position and directly preceded by one of the six Polish vowels (/i, e, ɨ, a, o, u/). The reason for not using any words ending in /r/ preceded by a consonant was that coda devoicing, which is unwelcome in the current research, is less likely to occur if the rhotic is preceded by a vowel than by a consonant. The words used in Experiment 4 are listed below:

1. Kair (‘Cairo’)
2. skaner (‘scanner’)
3. jasyr (Tatar or Turkish captivity)
4. bar (‘bar’)
5. dyktator (‘dictator’)
6. mur (‘wall’)

It must be noted that in both Experiments 3 and 4 (just as in Experiments 1 and 2) the examples were mixed with other words in order to avoid potential bias resulting from respondents’ conscious articulation of the rhotic. Consequently, the informants were unaware of the purpose of the experiments.

2.3. Procedure

The task given to the participants was to read the lists of words into a microphone in the most natural way possible. All the articulations were recorded and analysed using *Praat* (cf. Boersma et al. 2011).

As in the former experiments, classification of the articulations was largely based on spectrographic analysis. Individual pronunciations were classified by comparing them to the five prototypical “Types” discussed in Section 1.4. In many cases oscillograms in which the constricted intervals were seen as periods of smaller fluctuations of air pressure were also very helpful. Additionally, the decision regarding the actual number of strictures was sometimes influenced by the intensity contour. As described below, the moment of contact between the blade of the tongue and the alveolar ridge results in a drop in intensity.

Each production of /r/ in Experiments 3 and 4 was analysed in terms of the “Type” of articulation, the length of the (first) stricture and the drop in intensity during the (first) stricture. The way in which the last measurement was performed requires explanation. As outlined in Stolarski (2013a) and (2013b), the rate of drop in intensity is a useful indication of the degree of closure. The bigger the measured shift, the stronger the contact between the tongue and the alveolar ridge. In Experiment 1, the value of the drop was calculated as the difference between the average maximum intensity of the vocoidal elements preceding and following the (first) constricted interval and the minimum intensity measured during the closure. In Experiment 2, on the other hand, the vocoidal elements following the (first) stricture were not taken into consideration. The intensity shift was calculated only on the basis of the maximum intensity value in the vocalic component preceding the closure, and the minimum intensity value measured in the closure. The reason for such a change was that in the “consonant + /r/” context the “vowel-like segments” preceding the rhotic are not part of any neighbouring segments. They belong solely to /r/. The decision to disregard the vocoidal elements following the strictures was an optimal solution in Experiment 2. A similar method was not applied in Experiment 1 only because it was impossible to actually measure any vocoidal articulations which would belong exclusively to /r/. They were always merged with the vowels directly preceding and following the rhotic.

In Experiments 3 and 4 the value of the intensity drop will be measured as the difference between the maximum intensity value found in the “vowel-like segment” following the (first) closure and the minimum intensity value measured in the articulation of the (first) closure. This time the vocoidal segments preceding the stricture will not be analysed, because in all the examples used in Experiments 3 and 4 /r/ is preceded by a vowel. Consequently, the vocoidal segment articulated before the (first) closure is merged with the vowel. The “vowel-like element” following the stricture, however, belongs solely to the rhotic.

3. Results and discussion

3.1. Results of Experiment 3

Table 1 summarises the overall results of Experiment 3. As in Experiments 1 and 2, the most frequently encountered articulation is tapping (74.44% ± 5.2%), currently referred to as Type 3 (cf. the description in Section 1.4). It was observed in a relatively smaller number of cases than in the experiment on the intervocalic articulation of /r/, in which taps constituted 95% of all the analysed examples (Experiment 1). In the results of the test on the pronunciation of the rhotic in the postconsonantal position (Experiment 2), tapping was also more predominant. It was articulated in 79.63% of the cases. Consequently, the predictions made by Biedrzycki (1978: 83-84) have been, to a limited extent, confirmed. Indeed, tapping was found to be more frequent in the intervocalic and postconsonantal positions than in the preconsonantal one. Nevertheless, the current experiment reveals that taps are the most popular allophones of the Polish /r/ even before other consonants. Such a conclusion could not be drawn from Biedrzycki's account. Trilling, on the other hand, which is claimed to be the most typical phonetic realisation of the rhotic (cf. the discussion in Section 1.2), was observed in less than 9% of the cases, and the 95% confidence interval for all the trills in the preconsonantal position is 8.52% ± 3.33%. It is visibly more than in the intervocalic position analysed in Experiment 1 (2.8% ± 2.4%) and also in the postconsonantal position examined in Experiment 2 (1.48% ± 1.44%). Nonetheless, the result obtained in the current experiment leaves no doubt that trilling of the Polish rhotic is rare even in the context which is supposed to favour this phonetic realisation.

9 articulations out of the total 270 were classified as Type 2, constituting 3.33% of all the articulations analysed in Experiment 3. As specified in Section 1.4, in these cases the closure stage is followed by a segment which involves some articulatory activity of the apex, but this activity is very weak. Therefore, such articulations could not be classified as trills, but they are also different from prototypical taps. They constitute an intermediate stage along the articulatory continuum between Type 1 and Type 3.

A 95% confidence interval for the articulation of Type 4 in the preconsonantal position in the population of speakers of standard Polish is 8.15% ± 3.26%. It is less than in the postconsonantal position, where it was observed in 12.22 ± 3.91% of the cases (cf. Experiment 2), but this difference is not statistically significant ($p = 0.1176$). It should be emphasized that Type 4 is really a special case of tapping (cf. the definition of Type 4 in Section 1.4) and its high frequency of occurrence only reinforces the claim that the basic allophone of the Polish rhotic is the tap. If Type 3 and Type 4 were calculated together, tapping would constitute over 80% of all the observed articulations.

Type 5 was encountered in 5.56% of the cases. The result is very similar to the one obtained in the postconsonantal position (6.67%) and slightly higher than in the intervocalic position (2.2%), but this difference cannot be treated as highly statistically significant ($p = 0.0849$). The conclusion is that in this study, as well as in Stolarski (2013a) and (2013b), the more reduced realisations of the Polish /r/ such as trilled fricatives, fricatives and approximants are not very common. This observation seems to contradict the results obtained in Jaworski and Gillian (2011), but it needs to be pointed out that the context in which the rhotic was analysed in that publication was different from the one investigated in the present study. As mentioned in Section 1.3, Jaworski and Gillian tested the articulation of the Polish /r/ in sentences, where phonetic undershoot was naturally more likely to occur.

The average duration of the (first) closure in all of the examples analysed in Experiment 3 is 0.0219 ± 0.0067 seconds. This result is identical to that obtained in Experiment 1 (0.0219 ± 0.00092 seconds). In Experiment 2, on the other hand, the average duration was slightly shorter (0.0207 ± 0.000878 seconds) and this difference is statistically significant ($p = 0.0483$). As a consequence, it needs to be recognised that the closures tend to be shorter when /r/ is pronounced in the postconsonantal position than in the contexts investigated in Experiments 1 and 3.

The mean intensity drop during the (first) closure measured in Experiment 3 is 3.1795 dB. This is less than in Experiment 2, in which the average value of the intensity drop was 3.5428 dB. The difference is, however, not statistically significant ($p = 0.0922$). Consequently, it can be assumed that the average strength of the strictures in the articulation of the rhotic in the preconsonantal and postconsonantal positions is similar. It is worth adding that the corresponding result in Stolarski (2013a) is considerably higher (5.9391 dB), but the methods applied in Experiment 1 in calculating these values were dissimilar from the ones adopted in Experiments 2 and 3. Accordingly, it cannot be strictly proven that the constricted intervals are stronger in the intervocalic position than in the preconsonantal or postconsonantal contexts.

Table 1: Overall Experiment 3 results

	Type 1	Type 2	Type 3	Type 4	Type 5		Duration of the (first) closure	Minimum intensity during the (first) closure	Maximum intensity in the vocalic element following the (first) closure	Intensity drop during the (first) closure
Sum in all rC contexts	23	9	201	22	15	Average in all rC contexts	0.0219 secs	71.3793 dB	74.5689 dB	3.1795 dB
Percentage	8.52%	3.33%	74.44%	8.15%	5.56%	Standard deviation	0.0067 secs	3.7751 dB	3.8325 dB	2.1874 dB
Margin of error	3.33%	2.14%	5.20%	3.26%	2.73%	Margin of error	0.000801 secs	0.450302 dB	0.457149 dB	0.260912 dB

Table 2 presents the results of Experiment 3 arranged according to the manner of articulation of the consonants following /r/. It reveals that the rhotic was trilled most frequently before affricates (18.33%). Nevertheless, the difference between this result and the one obtained when the rhotic was articulated before stops (8.33%) is not statistically significant ($p = 0.1072$), so no obvious association between the manner of articulation of consonants following /r/ and the frequency of the occurrence of trilling can be confirmed. The results indicate, however, that the pronunciation of the rhotic before affricates is the most diverse. Instances of Type 4 and 5 are here relatively frequent. What is more, Type 3 was encountered before affricates only in 60% of the cases, which is clearly less frequent than in all other cases in Table 2. It is important to note that a similar diversity of phonetic realisations of the rhotic in the vicinity of affricates was also observed in Experiment 2. Indeed, prototypical tapping was particularly infrequent in this environment and allophones such as trilled fricatives, fricatives and approximants were identified in 18.33% of the cases.

The average duration of the (first) closure in Experiment 3 is relatively longer before laterals and nasals than before any other consonants, but the samples examined in this case are too small to be statistically reliable. The articulation of /r/ in all other instances summarised in Table 2 involves strictures whose duration is similar to the mean result presented in Table 1.

The value of the intensity drop during the (first) closure is relatively higher before sonorants ($\overline{x}$ = 4.2092 dB, s = 2.0978 dB, n = 60) than before obstruents ($\overline{x}$ = 2.8767 dB, s = 2.1246 dB, n = 210) The two tailed p-value for this difference is smaller than 0.0001. This confirms that in the production of /r/ the closures are stronger when the consonant is followed by sonorants than by obstruents. Indeed, the same tendency could be observed in Experiment 2, where the value of the intensity drop was the highest after approximants, nasals and laterals. There must be, therefore, a general tendency for the rhotic to be articulated with a stronger contact between the blade of the tongue and the alveolar ridge in the vicinity of sonorants than in situations in which it is preceded or followed by obstruents.

Table 2: Articulation of /r/ before different classes of consonants grouped according to the manner of articulation

	Type 1	Type 2	Type 3	Type 4	Type 5		Duration of the (first) closure or approximation	Intensity drop during the (first) closure
Before stops (on the basis of 60 articulations)								
Sum	5	2	46	3	4	Average	0.0218 secs	3.6748 dB
Percentage	8.33%	3.33%	76.67%	5%	6.67%	Standard Deviation	0.0064 secs	2.2310 dB
Before affricates (on the basis of 60 articulations)								
Sum	11	3	36	5	5	Average	0.0207 secs	2.2506 dB
Percentage	18.33%	5%	60%	8.33%	8.33%	Standard Deviation	0.0054 secs	1.9927 dB
Before nasals (on the basis of 30 articulations)								
Sum	2	0	21	5	2	Average	0.0250 secs	4.0510 dB
Percentage	6.67%	0%	70%	16.67%	6.67%	Standard Deviation	0.0101 secs	1.9359 dB
Before laterals (on the basis of 10 articulations)								
Sum	0	1	8	0	1	Average	0.0258 secs	4.1833 dB
Percentage	0%	10%	80%	0%	10%	Standard Deviation	0.0111 secs	2.5656 dB
Before fricatives (on the basis of 90 articulations)								
Sum	5	3	70	9	3	Average	0.0213 secs	2.8652 dB
Percentage	5.56%	3.33%	77.78%	10%	3.33%	Standard Deviation	0.0055 secs	2.0281 dB
Before approximants (on the basis of 20 articulations)								
Sum	0	0	20	0	0	Average	0.0214 secs	4.4596 dB
Percentage	0%	0%	100%	0%	0%	Standard Deviation	0.0058 secs	2.1730 dB

The results of Experiment 3 arranged according to the place of articulation of the consonants following /r/ (cf. Table 3) show that Type 3 is the least frequent before articulations around the alveolar region. The same tendency was found in Experiment 2 and it is apparent that tapping of the rhotic tends to be less regular in the vicinity of post-dental, alveolar, post-alveolar and alveolo-palatal consonants. Trilling, on the other hand, is relatively more frequent in these contexts and other "Types" of articulation also tend to be produced more often. In Stolarski (2013b) such a diversity of phonetic realisations of /r/ in the vicinity of consonants whose articulation involves the alveolar region was explained by referring to the fact that the Polish rhotic is alveolar itself. In its production the blade of the tongue articulates with the alveolar ridge. Any neighbouring consonants with a similar place of articulation make it more difficult for the speaker to control the movements of the tongue and the closure stage is performed with less precision. As a result, the rhotic tends to be frequently realised in ways other than the intended tapped stop.

Table 3: Articulation of /r/ before different classes of consonants grouped according to the place of articulation

	Type 1	Type 2	Type 3	Type 4	Type 5		Duration of the (first) closure	Intensity drop during the (first) closure
Before bilabial (on the basis of 40 articulations)								
Sum	0	0	38	2	0	Average	0.0201 secs	3.6136 dB
Percentage	0%	0%	95%	5%	0%	Standard Deviation	0.0062 secs	2.3065 dB
Before labio-dental (on the basis of 20 articulations)								
Sum	0	1	19	0	0	Average	0.0209 secs	3.2655 dB
Percentage	0%	5%	95%	0%	0%	Standard Deviation	0.0043 secs	2.1016 dB
Before post-dental (on the basis of 60 articulations)								
Sum	8	3	38	6	5	Average	0.0241 secs	3.3500 dB
Percentage	13.3%	5%	63.3%	10%	8.3%	Standard Deviation	0.0087 secs	2.2413 dB
Before alveolar (on the basis of 20 articulations)								
Sum	2	0	14	2	2	Average	0.0207 secs	2.1341 dB
Percentage	10%	0%	70%	10%	10%	Standard Deviation	0.0060 secs	2.7498 dB
Before post-alveolar (on the basis of 40 articulations)								
Sum	6	3	24	7	0	Average	0.0221 secs	2.3528 dB
Percentage	15%	7.5%	60%	17.5%	0%	Standard Deviation	0.0067 secs	2.1341 dB
Before alveolo-palatal (on the basis of 20 articulations)								
Sum	5	1	9	2	3	Average	0.0202 secs	2.2925 dB
Percentage	25%	5%	45%	10%	15%	Standard Deviation	0.0048 secs	1.4243 dB
Before palatal (on the basis of 40 articulations)								
Sum	2	0	33	2	3	Average	0.0227 secs	3.4797 dB
Percentage	5%	0%	82.5%	5%	7.5%	Standard Deviation	0.0069 secs	2.5212 dB
Before velar (on the basis of 30 articulations)								
Sum	0	1	26	1	2	Average	0.0210 secs	3.8484 dB
Percentage	0%	3.3%	86.7%	3.3%	6.7%	Standard Deviation	0.0042 secs	1.5374 dB

It is interesting to note that the mean values of the intensity drop during the closures also seem to be dependent on the place of articulation of the consonants following /r/. Namely, the average result before consonants which are articulated around the alveolar region ($\bar{x}$ = 2.7403 dB, s = 2.2375 dB, n = 140) is visibly lower than the result obtained before consonants articulated in other places ($\bar{x}$ = 3.5730 dB, s = 2.1789 dB, n = 130). The two tailed p-value for this difference is 0.002. This additionally supports the assumption that the closure stage is performed with less precision before post-dental, alveolar, post-alveolar and alveolo-palatal consonants than before bilabial, labio-dental, palatal and velar consonants.

Table 3 does not indicate any clear association between the place of articulation of the consonants following /r/ and the duration of the (first) closure in the production of the rhotic. Although the strictures tend to be the longest before post-dental segments ($\bar{x}$ = 0.0241 seconds) and, when this result is compared to the ones obtained before bilabials, labio-dentals, alveolars, alveolo-palatals and velars, the differences are statistically significant ($p < 0.05$), in all of the other cases summarised in Table 3 the average durations of the strictures do not seem to be influenced by the consonants following /r/.

Table 4 summarises the results of Experiment 3 according to the type of voicing of the consonants following /r/. It reveals the same tendencies that were discovered in Experiment 2. The frequency of occurrence of the five "Types" defined in Section 1.4 does not depend on the voicing of the consonants articulated after the rhotic. Even though Type 1 was encountered slightly more often before voiceless segments than before voiced ones and an opposite tendency is observable in the case of Type 3, these differences are not statistically significant ($p > 0.05$). Also, the fact that the average duration of the (first) closure is longer before voiced consonants ($\bar{x}$ = 0.0224 seconds) than before voiceless consonants (0.0210 seconds) is not statistically meaningful ($p = 0.082$). There is, however, a statistically significant difference between the mean values of the intensity drop during the (first) closure ($p > 0.0001$). In Experiment 2 this observation was interpreted as a direct result of the dissimilar values of the average maximum intensity in the vocalic elements preceding the constricted interval. In the current

Table 4: Articulation of /r/ before different classes of consonants grouped according to voicing

	Type 1	Type 2	Type 3	Type 4	Type 5		Duration of the (first) closure	Maximum intensity in the vocalic element following the (first) closure	Intensity drop during the (first) closure
Before voiceless (on the basis of 110 articulations)									
Sum	13	4	79	9	5	Average	0.0210 secs	73.0092 dB	2.5589 dB
Percentage	11.82%	3.64%	71.82%	8%	4.55%	Standard Deviation	0.0058 secs	7.9910 dB	2.0898 dB
Before voiced (on the basis of 160 articulations)									
Sum	10	5	122	13	10	Average	0.0224 secs	75.1851 dB	3.5913 dB
Percentage	6.25%	3%	76%	8.13%	6.25%	Standard Deviation	0.0074 secs	3.7381 dB	2.1643 dB

study a similar phenomenon may be observed. The mean minimum intensity values during the closure are, indeed, very similar and the difference between them (1.1397 dB) is statistically insignificant (p = 0.1499). Nevertheless, the difference between the values of the average maximum intensity in the vocalic element following the constricted interval, which amounts to 2.1769 dB, must be interpreted as statistically important (p = 0.0077). All of this points to the conclusion that the type of voicing of the consonants flanking the rhotic influences the relative loudness of the "vowel-like segments" in the articulation of the rhotic rather than the strength of its strictures.

3.2. Results of Experiment 4

The results of Experiment 4 (cf. Table 5) are similar to the ones obtained in Experiment 3. Again, Biedrzycki's (1978: 83-84) assumptions have been partially confirmed. Clearly, trilling is relatively more frequent in the word-final position than in the contexts investigated in Experiments 1 and 2. However, the results indicate that the most frequent realisation of /r/ is tapping (80%) and the cases of trilling are still fairly rare (10%). The inescapable conclusion that the basic allophone of the Polish /r/ is the alveolar tap and not the trill has been confirmed once again.

Type 2 has not been encountered in Experiment 4 at all. Types 4 and 5 are also less frequent than in Experiment 3, but these differences are not statistically significant (p > 0.05). On the whole, the frequency of occurrence of the five "Types" in Experiments 4 is very similar to that obtained in Experiment 3.

Likewise, the difference between the value of the average intensity drop during the (first) closure in Experiment 3 (3.1795 dB) and the corresponding result in Experiment 4 (2.8452 dB) is statistically insignificant (p = 0.2396). This shows that the relative strength of the strictures in both experiments is the same. Nonetheless, it is readily observable that the level of intensity in both measured points (during the closure and in the vocalic element following the closure) is, on average, higher in the preconsonantal phonetic context than in the word-final position. Such a result is in accordance with the intuitive assumption that voice loudness should decrease in the final stage of an articulation.

Table 5: Overall Experiment 4 results

	Type 1	Type 2	Type 3	Type 4	Type 5		Duration of the (first) closure	Minimum intensity during the (first) closure	Maximum intensity in the vocalic element following the (first) closure	Intensity drop during the (first) closure
Sum in all examples	6	0	48	4	2	Average in all examples	0.0253 secs	69.0874 dB	71.9326 dB	2.8452 dB
Percentage	10%	0%	80%	6.67%	3.33%	Standard deviation	0.0048 secs	4.4876 dB	4.5783 dB	1.9646 dB

The average duration of the (first) closure of /r/ in the word-final position (0.0253 seconds) is longer than in any of the previous Experiments, but the sample used in Experiment 4 is too small to confirm such an observation. In all cases the p-values are much larger than 0.05.

3.3. Role of the respondents' place of origin and gender

It is worth adding that in none of the four experiments did the place of origin of the participants have any influence on any of the collected statistics. The summaries provided in Stolarski (2013a) and (2013b) reveal, however, that the gender of the informants affects a number of articulatory characteristics of the rhotic. First of all, women tend to articulate the Polish /r/ more clearly. The frequency of trilling was slightly higher in this group, but the samples in Experiments 1 and 2 were too small to prove such an observation. The number of articulations analysed in Experiments 3 and 4 is also too small to validate this tendency statistically. Nevertheless, the data gathered in Table 6, which are based on all the four experiments, allow conclusions to be drawn which are statistically relevant. The two-tailed p-value for the difference between the frequency of Type 1 articulation among women (7.18%) and men (2.56%) is 0.0028. It conclusively demonstrates that the female participants pronounced the trilled allophone of the rhotic more frequently than men. It is also curious to note that Type 2, which is just one level further away from Type 1 on the scale of phonetic reduction, was produced solely by women. In contrast, Types 3, 4 and 5, which encompass gradually more reduced articulations of /r/, were articulated more frequently by men.

Table 6: Results of all the four tests arranged according to the gender of the participants

	Type 1	Type 2	Type 3	Type 4	Type 5
Results for female participants (on the basis of 390 articulations)					
Sum	28	9	307	28	18
Percentage	7,18%	2,31%	78,72%	7,18%	4,62%
Results for male participants (on the basis of 390 articulations)					
Sum	10	0	328	35	17
Percentage	2,56%	0%	84,1%	8,97%	4,36%

4. Final conclusion

The major observations made in the present study are summarised below.

1. The basic allophone of the Polish /r/ is the tapped alveolar stop in all of the environments analysed in Experiments 1, 2, 3 and 4. Trilling has been encountered much less frequently and should be treated as a secondary pho-

netic variant. Its frequency of occurrence is similar to that of the reduced production of /r/ involving friction of approximation. Biedrzycki's assumptions (1978: 83-84), however, cannot be entirely denied. It is evident that trilling is relatively more frequent in the preconsonantal and word-final phonetic environments than in the intervocalic and postconsonantal contexts.

2. The average duration of the (first) closure in Experiments 1, 3 and 4 is around 0.022 seconds. The average obtained in Experiment 2 is slightly shorter (0.0207 seconds).
3. There are no significant differences between the average strength of the closures in the phonetic environments examined in Experiments 2 (postconsonantal), 3 (preconsonantal) and 4 (word-final). In Experiment 1 the mean value of the drop in intensity was visibly higher, but the dissimilar methods applied in that case do not allow for the formation of an objective judgement.
4. The relative strength of the closures depends on whether the rhotic is articulated in the vicinity of sonorants or obstruents. In the former case the strictures tend to be stronger than in the latter.
5. The phonetic realisations of the rhotic are more diverse in the vicinity of consonants articulated around the alveolar region. Tapping in such contexts is relatively less frequent. It has also been established that the relative strength of the strictures is smaller when /r/ is followed by consonants involving the alveolar region.
6. Men tend to pronounce the rhotic less "clearly" than women. Firstly, in the male respondents' articulation Types 3, 4 and 5 are relatively more frequent than in the female respondents' articulation. Types 1 and 2, on the other hand, are articulated more often by women. Secondly, the relative strength of the closures is, on average, higher in women's pronunciation than in men's pronunciation.

In conclusion, the data obtained in the four experiments referred to in this publication indicate that the commonly accepted view on the articulation of the Polish rhotic is incorrect. The trilled articulation of the consonant is rare and should be treated only as one of the secondary realisations of the consonant.

It would be interesting to investigate possible reasons for the mistake made by the authors who refer to the Polish rhotic as a trill. It is fairly obvious that their descriptions are based on either intuitive auditory evaluations or the opinions expressed in other publications. In order to shed more light on this problem an auditive experiment could be designed in which single elements in the articulation of the consonants are removed. The results of such an enquiry could help to establish the way in which the rhotic is perceived by the listener and, consequently, explain why it has been incorrectly classified.

References

Benni, T. 1959. *Fonetyka opisowa języka polskiego.* Wrocław: Zakład Narodowy Imienia Ossolińskich.

Biedrzycki, L. 1978. *Fonologia angielskich i polskich rezonantów.* Warszawa: Państwowe Wydawnictwo Naukowe.

Boersma, P., D. Weenink 2011. *Praat: doing phonetics by computer* [Computer program]. Version 5.2.03, retrieved 22 April 2011 from http://www.praat.org/.

Colantoni, L. 2005. Increasing periodicity to reduce similarity: an acoustic account of deassibilation in rhotics. In M. Díaz-Campos (ed.). *Selected proceedings of the 2nd Conference on Laboratory Approaches to Spanish Phonetics and Phonology*, 22-34. Somerville, MA: Cascadilla Proceedings Project.

Colantoni, L. 2006. Micro and macro sound variation and change in Argentine Spanish. In N. Sagarra and A. Toribio (eds.) *Selected proceedings of the 9th Hispanic Linguistics Symposium*, 91-102. Somerville, MA: Cascadilla Proceedings Project.

Dłuska, M. 1983. *Fonetyka polska.* Warszawa and Kraków: Państwowe Wydawnictwo Naukowe.

Dukiewicz, L. 1995. Fonetyka. In H. Wróbel (ed.) *Gramatyka współczesnego języka polskiego, fonetyka i fonologia*, 9-103. Kraków: Wydawnictwo Instytutu Języka Polskiego PAN.

Gimson, A.C. 1994. *Gimson's pronunciation of English.* London and New York: Arnold.

Gussmann, E. 2007. *The phonology of Polish*. Oxford: Oxford University Press.

Hyman, L. 1975. *Phonology: Theory and analysis.* New York: Holt Rinehart and Winston.

Jaworski, S. 2010. Phonetic realisations of the Polish rhotic in intervocalic position: a pilot study. *Annales neophilologiarum* 4: 125-140.

Jaworski, S., E. Gillian 2011. On the phonetic instability of the Polish rhotic /r/. *Poznań studies in contemporary linguistics* 47(2): 380-398.

Jassem, W. 1973. *Podstawy fonetyki akustycznej.* Warszawa: Państwowe Wydawnictwo Naukowe.

Jassem, W. 1974. *Mowa a nauka o łączności.* Warszawa: Państwowe Wydawnictwo Naukowe.

Jassem, W. 1981. *Podręcznik wymowy angielskiej*. Warszawa: Państwowe Wydawnictwo Naukowe.

Kent, R.D., Ch. Read 1992. *The acoustic analysis of speech.* San Diego and California: Singular Publishing Group, Inc.

Ladefoged, P. and I. Maddieson 1996. *The sounds of the world's languages.* Oxford: Blackwell.

Ladefoged P., A. Cochran and S. Disner 1977. Laterals and trills. *Journal of the International Phonetic Association* 7: 46-54.

Lass, R. 1993. *Phonology: an introduction to basic concepts.* Cambridge: Cambridge University Press.

Laver, J. 1994. *Principles of phonetics.* Cambridge: Cambridge University Press.

Lindau, M. 1985. The story of /r/. In V. Fromkin (ed.). *Phonetic linguistics: Essays in honour of Peter Ladefoged*, 157-168. Orlando: Academic Press.

Łobacz, P. 2000. The Polish rhotic. A preliminary study in acoustic variability and invariance. *Speech and language technology* 4: 85–101.

Maddieson, I. 1984. *Patterns of sounds.* Cambridge: Cambridge University Press.

Pickett, J.M. 1999. *The acoustics of speech communication*. Boston, London, Toronto, Sydney, Tokyo, Singapore: Allyn and Bacon.

Pilich, J. 1975. *Fonetyka opisowa języka polskiego.* Siedlce: Wydawnictwo Wyższej Szkoły Pedagogicznej w Siedlcach.

Recasens, D. and A. Espinosa 2007. Phonetic typology and positional allophones for alveolar rhotics in Catalan. *Phonetica* 63: 1-28.

Rocławski, B. 1976. *Zarys fonologii, fonetyki, fonotaktyki i fonostatystyki współczesnego języka polskiego*. Gdańsk: Wydawnictwo Uczelniane Uniwersytetu Gdańskiego.

Sawicka, I. 1995. Fonologia. In H. Wróbel (ed.) *Gramatyka współczesnego języka polskiego, fonetyka i fonologia*, 107-198. Kraków: Wydawnictwo Instytutu Języka Polskiego PAN.

Steffen-Batogowa, M. 1975. *Automatyzacja transkrypcji fonematycznej tekstów polskich.* Warszawa: Państwowe Wydawnictwo Naukowe.

Stieber, Z. 1966. *Historyczna i współczesna fonologia języka polskiego.* Warszawa: Państwowe Wydawnictwo Naukowe.

Stolarski, Ł. 2013a. Articulation of the Polish /r/ in the intervocalic position. In: M. Kuczyński and L. Szymański (eds) *Language, thought and education: Across systems.* Oficyna Wydawnicza Uniwersytetu Zielonogórskiego, Zielona Góra (in print).

Stolarski, Ł. 2013b. Further analysis of the articulation of /r/ in Polish – the postconsonantal position. In *Radomskie studia humanistyczne.* Radom: Wydawnictwo Politechniki. Radomskiej (in print).

Strutyński, J. 1987. *Zarys fonetyki i fonologii języka polskiego.* Kraków: Skrypty Uczelniane Uniwersytetu Jagiellońskiego Nr 546.

Szczepankowski, B. 1985. *Fonetyka akustyczna, audytywna i wizualna.* Warszawa: Wydawnictwo Uniwersytetu Warszawskiego.

The International Phonetic Association 2003 *Handbook of the International Phonetic Association (IPA)* Cambridge: Cambridge University Press.

Wierzchowska, B. 1967. *Opis fonetyczny języka polskiego.* Warszawa: Państwowe Wydawnictwo Naukowe.

Wierzchowska, B. 1971. *Wymowa polska.* Warszawa: Państwowe Zakłady Wydawnictw Szkolnych.

Wierzchowska, B. 1980. *Fonetyka i fonologia języka polskiego.* Wrocław: Zakład Narodowy im. Ossolińskich.

Wiśniewski, M. 1997. *Zarys fonetyki i fonologii współczesnego języka polskiego*. Toruń: Wydawnictwo Uniwersytetu Mikołaja Kopernika.

Żygis, M. 2005. (Un)markedness of trills: the case of Slavic r-palatalisation. *Zeitschrift für Slawistik* 50: 383-407.