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Synchronised and non-synchronised articulation of Polish nasals *ą* and *ę* in child and adult speech

Summary

Nasals are highly frequent sounds in the Polish language. It is believed that their articulation is mainly dependent on surrounding segments. The standard register of Polish language contains two different patterns of articulation of nasalised sounds, so called: synchronised and non-synchronised. This study attempts to show that surrounding consonants have different impact on the way of nasals articulation among adults and children. The acoustic methodology was applied in order to verify the hypothesis about differences in asynchronous articulation of nasals *ą*, *ę* in CVC and CV clusters in front of stops and affricatives; and synchronic articulation before fricatives among children and adults. Nasalised sounds were investigated on the basis of utterances of two children (3;9, 10;1) and compared with similar segments of adult speech excerpted from SpokesWeb CLARIN database.

Key words: language acquisition, acoustic phonetics, nasals *ą* and *ę*, Polish

1. INTRODUCTION

The perception of Polish spoken language from a side of non-Slavic languages speakers might often bring the sensation of highly palatalised and nasalised speech. Even though research on nasalisation could cause certain difficulties in finding acoustically relevant measurements of degree of nasalisation and nasals segmentation, the present paper approaches the phenomenon of the articulation of nasal segments from the perspective of acoustic phonetics and language development.

The first part of present study briefly introduces the acoustic characteristics of nasalisation and describes the position of nasals *ą*, *ę* in Polish vowel system. The following sections discuss the methodology of nasality measurements and introduce the conventions of audio data transcription, created for the need of presented research. Then, criteria for nasals acoustic classification are described in comparison with recorded voice samples. The final part contains the transcripts of recordings from which relevant clusters with nasals *ą* and *ę* were excerpted.

Nasalisation is one of the twelve phonological distinctive features in standard Polish language and applies to bilabial /m/, alveoral /n/, retroflex /ŋ/, palatal /ɲ/, glides: /r/, /l/ and investigated nasals *ą*, *ę* referring to /ɔ̃/[1], /ɛ̃/ or /ɔN/, /ɛN/. Different interpretations of nasals were presented in Polish phonetic literature (Bethin, 1987; Dłuska, 1981; Jassem, 1974; Laskowski, 2010; Zagórska-Brooks, 1968). Even though differences in terminology among researchers are still evident, the common consensus was reached and two general patterns of nasalisation in Polish were distinguished. Depending on the character of sounds following nasals – synchronised and non-synchronised (pol. *synchroniczna*, *niesynchroniczna*), sometimes also called biphonematic and monophonematic (pol. *bifonematyczna*, *monofonematyczna*), articulation types were defined. Investigated nasals in the Polish language are orthographically represented as *ą*[2] and *ę*, which might cause confusion, because in case of the first one, the cardinal /o/ not /a/ is nasalised. This orthographic tradition was established back in the 16th century where the pronunciation of *ą* was closer to /a/. Though the evolution in diachronic phonetics changed the character of nasalised *ą*, the outdated orthographic norm is still valid.

[1] In IPA convention, nasal symbol /ɔ̃/ differs from the one used in phonetic transcriptions of Slavic languages (AS: Alphabet Slavic), where /õ/ character is more common.

[2] The '˛' diacritic (Unicode: U+02DB, HTML: &#260 and U+0104; &#1041 for capitals) as an indicator of nasalisation is used in Polish, Old Church Slavonic and some Athabaskan languages. In Lithuanian though the same symbol indicates the length of sound.

As mentioned before, the differences in articulation of nasals are predominantly dependent on their surroundings. The adjacent sounds are not the only factor influencing synchronised and non-synchronised articulation and, as presented in this study, the age of a speaker can be a modifier of the articulation type. Two aforementioned patterns will be investigated from the perspective of different age of language users. Therefore, the articulation types of nasalised sounds uttered by children will be compared with similar adults' utterances excerpted from SpokesWeb CLARIN database (Pęzik, 2015).

The purpose of this work required establishing new transcribing conventions. Unfortunately, Polish chapter of CHILDES database is not unified. Authors tend to follow various strategies in transcription of audio material and those datasets could not be taken as an example for this study. The transcription conventions applied here contain three obligatory paths: %pho – with information about phonetic layer according to IPA standards; %mor – containing the morphosyntactic relations and %eng – with Polish to English translation. Path %com – provides additional comments on the utterances or subjects' behaviour. Errors were tagged with asterisk and explained in following lines starting with: %err according to Tools for Analyzing Talk (MacWhinney, 2017, pp. 105–112). The intonation contour of utterances was tagged as well as primary and secondary stress. CLAN special characters were used to indicate laughing. The additional comments (see Appendix: line 193) were introduced for possible explanation of target phrases when an utterance was marked as mistaken. The lines with subjects' speech were written, with several exceptions, according to Polish orthographic norm – which makes the data searchable if specific phrase is of an interest to a researcher. The phonetic features with coarticulation diacritic were added in the %pho line. The accentual tagging allows to investigate the alternations of stress patterns in child speech, which might be interesting for some future research comparing the fixed place of paroxytonic accent in Polish orthoepic norm with accentual tendencies discovered among children. The phenomena of palatalization can be traced by following the '%com: palat' tag. Paralinguistic information without linguistically relevant articulation, but possibly important for conversation analysis, was described with '&=' and '!=' (e.g. &=laughs). The syllable prolongation was noted.

The information about morphosyntactic relations was introduced manually. Tags specify: part of speech, tense, aspect, voice, grammatical person, mood, and case. The Latin case abbreviations were used. Some additional lexical and stylistic information was mentioned with DEM and AUG indexes for diminutive and

augmentative forms respectively. When change of speech act occurs, the comment is given in '%add' row (e.g. line 16). Observations on the communicative intention were rarely noted (line 21) to prevent the subjectivity of transcriber's interpretation.

2. CHARACTERISTICS OF NASAL SEGMENTS

The velum lowering during the articulation process and opening the velopharyngeal port causes the vocal tract extension and direction of an airstream towards nasal cavity. The movement of soft palate leads the airstream to oral and nasal cavities simultaneously. The nasalisation in Polish vowels, occurs more frequently in the second phase of articulation, in contrast to the French language, where the nasalisation is present already in the first segment of vowels (Rochet, 2015). The final segment of nasals *ą*, *ę* has similar spectral characteristics due to fixed volume of nose cavity resonator. Exceptions could be found among patients with changes in anatomy of nasal cavity occurred as a result of endonasal sinus surgery. Nasals are ordinarily voiced and can be phonetically distinguished as sonorants (cf. Kent & Kim, 2011, p. 367). Naturally, during nasals' articulation variations in formant values are visible due to the tongue position, which is: *ą* – mid-back and *ę* – mid-front. As a consequence of the movement of uvula and airstream division, the energy is led to the oral cavity and nasals intensity is slightly lowered compared with intensity of orals. The differences in articulation patterns of Polish nasals might raise the question of their classification. Therefore, *ą* and *ę* cannot be clearly classified as diphthongs, because the elements /o/, /ũ/; /e/, /ũ/ consisting their non-synchronised articulation can be uttered independently, regardless of surroundings. This statement can be easily verified by measuring basic acoustic features of those elements separately and as a part of multisegmental entity. Nasals are typically more voiced than glides and less voiced than fricatives.

The question of nasalisation was raised in the field of language acquisition among the others by Olmsted (1966), Waterson (1971, pp. 195–200), and Macken and Ferguson (1981). The methodology of articulatory phonetics in the nasals investigation was applied by Kurowski and Blumstein (1987, pp. 1917–1927). Before the experimental methods were successfully applied in linguistics, fundamental theories on acquiring the smallest units of language system were stated by Roman Jakobson. The structuralistic approach – typical for the 'Prague Linguistic Circle' – is visible in his early works on language acquisition as well. Jakobson predicted that stops

are acquired before nasals, with fricatives next and liquids late (cf. Macken & Ferguson, 1981, p. 112). Nevertheless, stops, nasals and glides are among the first sound productions. The importance of nasals comprehension could be explained by the high frequency of nasals occurrence and supported by their language-specific discriminations (see Clark, 2016, pp. 69–72). Nasals are considerably frequent sounds in Polish, compared to English – where 18.45% of all consonants produced in initial, medial and final position contain nasal characteristics (Ardussi Mines, Hanson, & Shoup, 1978). Also, language-specific differences in a degree of nasality are noticeable.

Investigated nasals could be problematic for sign language users, because labiograms of both phases of *ą*, *ę* articulation (regardless of synchronised or non-synchronised character) are very similar to /o/ and /e/ (Styczek, 2010, p. 99). Furthermore, deaf subjects significantly differ from non-clinical subjects in velopharyngeal openings during nasals articulation.

Nasalised sounds followed by a vowel, due to inevitable influence of coarticulation, considerably increase their degree of nasalisation (see Nasal assimilation in: Czaykowska-Higgins, 1992, p. 140). However, the degree of nasalisation of surrounding vowels was questioned by Bell-Berti (1993) and interesting conclusions on the anticipatory coarticulation were reached. The extended presence of nasality in orals caused by velopharyngeal dysfunctions (VPD) is defined as hyperrhinolalia. The method of measuring a degree of nasalance, called nasometry, allows to conduct relevant research even with young participants (Whitehill & Lee, 2008, p. 335). Nasometry provides a nasalance score, which is a ratio of nasal acoustic energy to the sum of nasal and oral acoustic energy multiplied by 100. In principle – the higher the nasalance score, the higher the degree of nasality. Other methods in nasalency research, though dependent on signal intensity[3] refer to: nasal pressure, vibration and flow. This investigation is based exclusively on the acoustic methodology, however, it could be easily supported with nasometric method. Interestingly, cinefluorographic methods allow to observe that the degree of nasality of English high vowels /i/, /u/ is greater than low vowels (cf. Chen, 1996, p. 17), which might not necessarily be the case in the Polish language.

Acoustic properties of nasals can be distinguished based on typical low intensity and dense pattern of resonances and anti-resonances (Kent & Kim, 2011, p. 398).

[3] Possible solution to obtain relevant measures of nasality was proposed by Horii (1980). The index HONC (Horii Nasal-Oral Coupling Index) is the ratio of nasal accelerometric amplitude to voice amplitude.

Cross-linguistic spectral analysis of nasalised sounds pointed that F1 is clearly separated from the other formants. The appearance of a pole-zero pair above the first formant is also a vivid effect of nasalisation (Chen, 1996, p. 40). The general tendency of large formant bandwidths is noticeable. High density of formants combined with antiformants and flatter spectrum at low frequencies could be pointed as a general acoustic characteristic of sounds articulated via nasal cavity. The visual recognition of nasalisation on spectrograms should be driven by identifying the blank fields where very little of spectral energy was recorded. The careful following of formant transitions might be helpful in identifying nasality on the spectrographic picture.

3. MATERIAL

The recordings were made in a playtime situation with Tascam DR-05 handheld recorder. Microphones were set in omnidirectional mode. Applied sampling ratio was 44100 Hz. The audio-material was excerpted from two recording sessions which took place in subjects' home environment. Both participants were boys aged 3;9 and 10;1. Researcher's presence and so called Labov's effect had no influence on subjects' behaviour. Subjects' speech was natural and non-stimulated, therefore some overlapping interactions with their parents are noticeable (see Appendix lines: 119, 211, 223, 241, 256, 260, 265, 315, 330). Both children and their parents come from dialectically unmarked region of Poland. Parents of recorded children accomplished university education and a socio-economic status of the family could be estimated as middle-class. The adults' speech samples used for the comparison were downloaded from SpokesWeb – conversation data search database – the spoken part of Polish corpus created as a part of CLARIN-EU infrastructure (Pęzik, 2015). The referential database of SpokesWeb was unfortunately low in metadata. Thus, the information about adults whose voice was analysed in comparison to child speech is highly limited. The policy of CLARIN consortium data protection requires that all files must not contain any personal information. The search options were limited to the speakers' sex, age and education level. Unfortunately, no information about dialectic affiliation or place of birth was enclosed in metadata.

3.1. Criteria for sample selection

Firstly, the non-stimulated natural speech of two children (boys aged 3;9 and 10;1) was recorded during their playtime. Secondly, the audio data underwent transcription and annotation process. Nasalised sounds were excerpted from the audio paths and after FFT transformation the spectral analysis of sounds was conducted by the means

of STx package (Balazs, Noll, Deutsch, & Laback, 2000) and Praat 6.0.36 (Boersma & Weenink, 2017) software.

Excerpted samples of nasalised utterances were admitted as synchronic ones if at least two out of five characteristics of nasality applied to the investigated segment: (1) Additional formant (approx. 300 Hz) with relatively high amplitude. Sometimes F1– significantly reduced – could be combined with so called 'nasal formant'; (2) The higher values of F1 and F3[4]; (3) Increased F4; (4) Higher F3 values; (5) Additional formant in one or more of the following ranges: 0.7 kHz, 1.0–1.2 kHz, 1.8–2.25 kHz and 2.7–2.9 kHz. The segmentation should be done with a maximum frame of 45–50 ms after the vowel onset.[5]

The articulation pattern, or more precisely: anticipatory coarticulation effect, suggests that non-synchronised articulation of nasals *ą*, *ę* indicating denasalization of initial segment should be noticeable in front of stops and affricates (e.g. pol. /p/, /b/, /t/, /d/, /tɕ/, /dʑ/, /tʂ/, /dʐ/, /k/, /g/), whereas the synchronised articulation is expected when nasals are followed by fricatives (pol. /v/, /f/, /s/, /z/, /ɕ/, /ʑ/, /ʂ/, /ʐ/, /x/). Two abovementioned assumptions will be verified and compared on the basis of two sets of recordings (children: $index_1$ and adults: $index_2$) within two groups with nasalised vowels in the final and medial position (CV, CVC).

4. RESULTS

Within distinguished categories the following clusters were retrieved: $CV_{ch/a}$ -kę /kɛ̃/, -tą /tɔ̃/, -ię /jɛ̃/, -mą /mɔ̃/, -gę /gɛ̃/, -lę /lɛ̃/, -szę /ʂɛ̃/, -czę /tʂɛ̃/ (lines: 37, 120, 124, 135, 203, 334, 392, 397, 407); $CVC_{ch/a}$ -cząt- /tʂɔ̃t/, -ięć- /jɛ̃tɕ/, -ręk- /rɛ̃k/, -jęd- /jɛ̃d/, -jęk- /jɛ̃k/, -jęci- /jɛ̃tɕ/ (lines: 31, 37, 101, 140, 144, 149, 236, 245, 249, 283, 367). The rest of samples came from untranscribed recordings from which following groups were selected: -pącz- /pɔ̃tʂ/, -kąt- /kɔ̃t/, -wąs- /vɔ̃s/, -węż- /vɛ̃ʐ/, -węch /vɛ̃x/, -wąż- /vɔ̃ʐ/, -męs- /mɛ̃s/, -węsz- /vɛ̃ʂ/, -tęż- /tɛ̃ʐ/, -mąż- /mɔ̃ʐ/.

In total 48 samples belonging to clusters: CV_{ch}, CV_a, $CVC1_{ch}$, $CVC2_{ch}$, $CVC1_a$, $CVC2_a$ were measured. The groups with nasals in the final position (CV_{ch} CV_a) were investigated as independent units with long pause before the next segment or as a final part of a sentence, so the inter-lexical assimilations were not taken into consideration. The results of measurements are given in Table 1. Summarized results for each cluster are presented in Table 2. The second table shows the percentage of samples for which the relevant acoustic feature of initial segment nasality was found.

[4] Higher than oral, cardinal equivalents – /o/, /e/.

[5] The changes are usually noticeable right after 20 ms.

Interestingly, non-synchronic articulation of investigated nasals had some common acoustic characteristics in adult and child speech. The non-synchronic realisation of Polish nasals was relatively often characterised by presence of F2 and F3 in the range between 2300 and 2600 Hz. Considerable differences were noticeable especially in the range of F2, the values of which are highly subject-dependent (as well as F4). The non-vocalic (always second) part of non-synchronised nasals was often accompanied by high amplitude additional formant in utterances of registered in both groups. The non-synchronic realisations had additional formant (around 300 Hz). Even though the nasalised segments are typically longer than oral ones, the tempo of child speech should not be compared with adults' utterances. The second segment of non-synchronised nasals often had two formants very close to each other or even combined.

In the CV_a cluster category, seven utterances were marked as synchronised; whereas among the same type of adults' utterances in group CV_{ch} five productions had clearly synchronised character. Nasals followed by stops or affricates were synchronised in five cases of adult speech but only in three cases in child speech. Third group, consisted of nasals followed by fricatives, was the most frequently synchronised among two groups of subjects. Child speech in CVC_2 was synchronised in five samples and adults' utterances were synchronised in seven cases. No acoustic characteristics of nasalization were found at four child utterances: /jɛ̃/ with nasal in final position; in CVC_1 group: /tɕɔ̃t/ with nasal in medial position followed by stop consonant; /jɛ̃tɕ/ with nasal before affricate and, surprisingly, with nasal in medial position followed by fricative: /vɛ̃zʲ/. Within the set of adults' utterances, the only sample without nasalization features measured was /jɛ̃k/ with nasal followed by stop consonant. Overall, the low degree of nasalization was found among nasals in final position /gɛ̃/ articulated by adults and /mɔ̃/, /lɛ̃/ groups from child samples – all belonging to CV clusters. None of the mentioned utterances from set CVC_1: /jɛ̃tɕ/, /rɛ̃k/, /kɔ̃t/ reached the nasality threshold. Among nasals followed by fricatives (CVC_2), utterances /vɛ̃zʲ/, /mɔ̃zʲ/ and /vɛ̃x/ were not recognised as synchronous and the nasality degree result at /mɔ̃zʲ/ was equal in child and adult pronunciation. The highest score on created nasality scale among children utterances was noted at /jɛ̃d/ and /vɔ̃s/ from CVC_1 and CVC_2 respectively.

The aim of this work was to compare the nasality degree of nasalised segments in child and adult speech, although the size of recorded data as well as a number of subjects seems too small to declare some general tendencies in Polish nasals articulations.

Table 1. Nasality in children and adults' speech – individual samples
Tablica 1. Nazalnost u dječjem govoru i govoru odraslih – svi uzorci

		1		2		3		4		5		Nasality degree / Stupanj nazalnosti	
Group / Grupa	Utterance / Izgovoreni segment	CH	A	CH	A	CH	A	CH	A	CH	A	CH	A
CV	/kɛ̃/	+	+	-	+	+	+	-	+	-	-	0.4	0.8
	/tɔ̃/	+	+	-	+	-	-	+	+	-	-	0.4	0.6
	/jɛ̃/	-	+	+	-	-	+	-	-	-	+	**0**	0.6
	/mɔ̃/	-	-	-	+	+	+	+	-	-	+	**0.2**	0.4
	/gɛ̃/	+	-	+	-	-	-	-	-	-	+	0.4	**0.2**
	/lɛ̃/	-	+	+	-	-	+	-	-	-	-	**0.2**	0.4
	/ʂɛ̃/	+	+	-	+	-	-	-	-	+	-	0.4	0.4
	/tʂɛ̃/	-	-	+	+	-	-	+	-	-	+	0.4	0.4
CVC_1	/tʂɔ̃t/	-	+	-	-	-	+	-	-	-	-	**0**	0.4
	/jɛ̃tɛ/	-	-	-	-	-	-	-	+	+	-	**0.2**	**0.2**
	/rɛ̃k/	-	-	-	+	-	-	-	-	+	+	**0.2**	0.4
	/jɛ̃d/	+	-	+	+	-	-	+	-	-	+	0.6	0.4
	/jɛ̃k/	-	-	-	-	-	-	+	-	+	-	0.4	**0**
	/jɛ̃tɛ/	-	+	-	-	-	+	-	-	-	-	**0**	0.4
	/pɔ̃tʂ/	+	+	-	-	+	+	-	-	-	-	0.4	0.4
	/kɔ̃t/	-	-	-	+	-	-	-	-	+	-	**0.2**	**0.2**
CVC_2	/vɔ̃s/	+	+	-	+	+	-	-	+	+	+	0.6	0.8
	/vɛ̃zʲ/	-	-	-	-	-	+	-	-	-	+	**0**	0.4
	/mɔ̃zʲ/	-	-	+	-	-	-	-	-	-	+	**0.2**	**0.2**
	/vɔ̃zʲ/	+	+	+	-	-	+	-	-	-	+	0.4	0.6
	/mɛ̃s/	-	-	-	+	-	+	+	-	+	-	0.4	0.4
	/vɛ̃ʂ/	-	+	-	-	+	-	-	+	+	+	0.4	0.6
	/tɛ̃zʲ/	+	-	-	+	-	+	-	-	+	+	0.4	0.6
	/vɛ̃x/	-	+	-	-	-	+	-	+	+	+	**0.2**	0.8

Legend

Numbers 1–5 refer to acoustic characteristic mentioned above. Index CH – child utterance from recordings; index A – adults' utterances excerpted from SpokesWeb CLARIN database; group CV – consonant + nasal in final position; group CVC_1 – consonant + nasal + stop/affricative; group CVC_2 – consonant + nasal + fricative. Nasality degree index indicates if the utterance character was synchronised ≤ 0.4 or non-synchronised > 0.4.

Legenda

Brojevi 1–5 odnose se na akustičke karakteristike nazalnosti. Oznaka CH odnosi se na dječji govor sa snimaka, a oznaka A na govor odraslih prikupljenih iz baze podataka SpokesWeb CLARIN; skupina CV označava konsonant + nazal u finalnoj poziciji; skupina CVC_1 odnosi se na konsonant + nazal + okluziv/afrikata; skupina CVC_2 odnosi na konsonant + nazal + frikativ. Indeks stupnja nazalnosti govori o pojavnosti sinkronizirane nazalnosti ≤ 0.4 ili nesinkronizirane > 0.4.

Table 2. Nasality in children and adults' speech – segment clusters
Tablica 2. Nazalnost u dječjem govoru i govoru odraslih – skupine glasova

	1	2	3	4	5
CV_{ch}	0.5	0.5	0.25	0.75	0.13
CV_a	0.63	0.63	0.5	0.25	0.5
$CVC1_{ch}$	0.25	0.13	0.13	0.25	0.5
$CVC1_a$	0.38	0.38	0.38	0.13	0.25
$CVC2_{ch}$	0.25	0.25	0.25	0.13	0.63
$CVC2_a$	0.5	0.38	0.63	0.38	0.88

Legend

CV_{ch} – group: consonant + nasal in final position uttered by child; CV_a – group: consonant + nasal in final position uttered by adults; $CVC1_{ch}$ – group: consonant + nasal + stop/affricative uttered by children; $CVC1_a$ – group: consonant + nasal + stop/affricative uttered by adults; $CVC2_{ch}$ – group: consonant + nasal + fricative uttered by children; $CVC2_a$ – group: consonant + nasal + fricative uttered by adults. Numbers 1–5 refer to acoustic features mentioned above.

Legenda

CV_{ch} označava konsonant + nazal u finalnoj poziciji koje izgovara dijete; CV_a označava konsonant + nazal u finalnoj poziciji koje izgovara odrasla osoba; skupina $CVC1_{ch}$ odnosi se na konsonant + nazal + okluziv/afrikata koje izgovara dijete; skupina $CVC1_a$ odnosi se na konsonant + nazal + okluziv/afrikata koje izgovara odrasla osoba; skupina $CVC2_{ch}$ označava konsonant + nazal + frikativ koje izgovara dijete; skupina $CVC2_a$ označava konsonant + nazal + frikativ koje izgovara odrasla osoba. Brojevi 1–5 odnose se na akustičke karakteristike nazalnosti.

5. CONCLUSIONS

Polish nasal realisations – synchronised and non-synchronised are mostly dependent on the manner of articulation of adjacent segments. Interestingly, not only articulatory patterns influence the character of nasalization, but it appears that adults' speech, in a few cases among investigated clusters, significantly differed from child's utterances in terms of nasality of initial segment. However, in none of the samples all five characteristics of nasality were found. The highest nasality degree was noted among segments uttered by adults in /vð̃s/ and /vɛ̃x/ CVC_2 clusters and in final /kɛ̃/ segment classified as CV_a. The highest nasality degree among utterances produced by children was noted, surprisingly, in CVC_1 group where theoretically non-synchronic nasals realisation could be expected. Nevertheless, the tendency of non-synchronic articulation of excerpted groups was present within the set $CVC1_{ch}$ where five out of eight samples were pronounced in non-synchronised manner; compared to three samples from $CVC1_a$ cluster. The most frequent acoustic feature among utterances from all groups was (5) – presence of additional formant in abovementioned ranges. Then, the additional so called 'nasal' formant was also observed in a large set of investigated samples. The presence of increased F3 value was less noticeable feature. It is worth to notice that F2 and F4 are the most subject-dependent vowels formants. To obtain results based on different measuring approaches the investigation of nasalisation should be supported with nasometric research. More representative group of participants is also preferable. Additional referential data about adult subjects derived from SpokesWeb CLARIN could be an asset in a future research.

To conclude, this research has shown that non-synchronised as well as synchronised articulation manners can occur in different surroundings in child speech and in adults' utterances. Apart from adjacent segments, the age of language user has a significant influence on the character of nasalisation of Polish *ą*, *ę* nasals.

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APPENDIX / PRILOG

@Begin
@Languages: pol
@Participants: WUJ Adult, MAM Mother, JED Child, BAR Target_Child
@ID: pol|change_corpus_later|WUJ||male||White,MC|Adult|higher||
@ID: pol|change_corpus_later|MAM||female||White,MC|Mother|higher||
@ID: pol|change_corpus_later|JED|10;7.|male|||Child|||
@ID: pol|change_corpus_later|BAR|3;9.|male|||Target_Child|||
@Media: 1, audio
@Location: Wroclaw, Poland
@Situation: Jedrzej i Bartus are playing together
@Interaction Type: family
@Recording Quality: good
@Transcription: detailed
@Transcriber: Jacek
@Date: 27-OCT-2017
%add: Bartus to Jedrej
*BAR: pokāzać ci↑ ?
%pho: pokazatɕ tɕ
%mor: VER|pokaz-ać PRO|ci
%eng: do you want me to show you?
%act: wants attention
*JED: co ?
%mor: PRO|co
%eng: what ?
BAR: ⁇yyy⁇ (1.7) → nājpierw tśēba [p]
%err: trzeba
%com: palat
%pho: najpʲerf tʂeba
%mor: POST|naj-pierw V|trzeba
%eng: first you should
BAR: na te piecą̄tki [p] m [* 0v] tu
%err: c/cz, verb omission
%sit: is instructing how to make a stamp

%pho: na te piecɔ̃tki
%mor: PRO|na PRO|te N:NOM:PL|pieczątk-i
%eng: on this stamps
*BAR: zrōbić jēdną pieczątkę
%pho: pʲetʂɔ̃tkɛ̃
%mor: V|zrobi-ć DET:NUM|jedną N:ACC|pieczątk-ę
%eng: make one stamp
BAR: u ješće [p]
%err: ś/sz ć/cz
%com: palat
%pho: u jeɕt͡ɕe
%mor: PTL|jeszcze
%eng: else
*BAR: o włāśnie ↑tāk to miāło być
%pho: o wu̯aɕɲe ↑tak to mʲau̯o bɨt͡ɕ
%mor: PRT|właśnie tak DET|to V:PAST|miało V:INVbyć
%eng: it was supposed to be like this
*JED: &= laughing
*BAR: o to hop siup
%pho: o to xop ɕup
%com: rythmed phrase
*BAR: ↑&=laughing
*BAR: ciu
%pho: t͡ɕu
BAR: @x hop siup pierwśy [p] raz
%err: metathesis ś/sz
%pho: xop ɕup pʲerfʂɨ ras
%mor: NUM:ORD|pīērwszy raz
%com: palat ryhmed phrase
%eng: first time
*BAR: uwaga↑ →uwaga uwaga bo jedzie rozwaga
%pho: uvaga↑→uvaga uvaga bo jed͡ʑe rosvaga
%mor: CO|uwaga CONJ|bo V:PRES:3SING|jedzie N:NOM|rozwag-a
%eng: watch out the thought is coming

68 %com: rythming wordplay with 'łamaga' and 'rozwaga': clumsy and thought
69 *BAR: ☺łi↑
70 %pho: wi↑
71 %com: happiness interjection
72 *JED: ☺☋ &=laughing
73 *BAR: mama mama mama
74 %pho: mama [x 3]
75 %mor: N:NOM:SING|mam-a
76 %eng: mom [x 3]
77 *BAR: ☋·&=laughing↑
78 *JED: uwaga
79 %pho: uvaga
80 %mor: N:NOM:SING|uwag-a
81 %eng: attention (watch out)
82 *BAR: uwāga
83 %pho: uvaga
84 %mor: N:NOM:SING|uwag-a
85 %eng: attention (watch out)
86 *BAR: uwāga uwāga bo jedzie rolwāga [* n]
87 %pho: uvaga uvaga bo jed͡ʑe rolvaga
88 %mor: N:NOM:SING|uwag-a [x 2] CONJ|bo VERB: 3SING|jedzie N:NOM:SING|rolwag-a
89 %com: wordplay and ryhming
90 %eng: watch out watch out because the [neologism] is coming
91 *BAR: łee ju↑hu☺
92 %pho: we juxu
93 %com: interjections and laughting
94 *JED: hmm☋
95 %pho: xm
96 %com: breathy voice
97 *BAR: &=lauhgting
98 *BAR: hop siup
99 %pho: xop ɕup
100 %com: rythmed wordplay

BAR: tely [p] pienć [* p]
%err: cz/t r/l e/ę [cztery pięć]
%pho: tely pʲeɲtɕ͡
%mor: NUM|czter-y NUM|pięć
%eng: four five
BAR: szēś [p] siēdem ōsiem
%err: metathesis ś/ść
%pho: ʂeɕ ɕedem oɕem
%mor: NUM|sześć NUM|siedem NUM|osiem
%eng: six seven eight
*BAR: pien [*] dziesięć
%com: unclassified error utterance close to cardinal numerical '5' without
afticative consonant
%pho: pʲen dʑ͡ɛɕɛ̃tɕ͡
%mor: @x NUM|dziesi-ęć
%eng: @x ten
*JED: &=coughs
*JED: &=lauhgting
*MAM: mhm
*BAR: proszę nagrānie
%pho: proɕɛ̃ nagraɲe
%mor: IMP|prosz-ę N:ACC:SING|nagrani-e
%eng: give me the recording
*BAR: proszę↑
%pho: proɕɛ̃
%mor: IMP|prosz-ę
%eng: please
*JED: &=laughing
*BAR: ee
%com: &=inhaling
*JED: przeprāszam
%pho: pʂepraʂam
%mor: V:1:SING|przeprasza-m
%eng: I am sorry
*BAR: przēcież jā się

136 %pho: pɻetɕ͡ɕeɻ ja ɕɛ̃
137 %mor: CONJ|przecież PRO|ja PRO:REFL|się
138 %eng: but I
139 *JED: &=caugh
140 *BAR: poślizgnąłem tato
141 %pho: poɕlizgɲɔ̃wem tato
142 %mor: V:PAST:1:SING|po-ślizgną-łem N:VOC:SING|tat-o
143 %eng: I have slipped myself dad
144 *BAR: tato poślizgnąłem się tato
145 %pho: tato poɕlizgɲɔ̃wem ɕɛ̃ tato
146 %mor: N:VOC:SING|tat-o V:PAST:1:SING|po-ślizgną-łem
PRO:REFL|się
147 N:VOC:SING|tat-o
148 %eng: dad I slipped myslf dad
149 *BAR: poślizgnąłem się
150 %pho: poɕlizgɲɔ̃wem ɕɛ̃
151 %mor: V:PAST:1:SING|po-ślizgną-łem PART:REFL|się
152 %eng: I slipped myself
153 *BAR: to się poślizgnąłem
154 %pho: to ɕɛ̃ poɕlizgɲɔ̃wem
155 %mor: PRO|to PART:REFL|się V:PAST:1:SING|po-ślizgną-łem
156 %eng: this I slipped myself
157 *WUJ: no to się nīe ślizgaj
158 %add: Uncle - adult to Bartus - direct_child
159 %pho: no to ɕɛ̃ ɲe ɕlizgaj
160 %mor: CONJ|no PRO|to PART:REFL|się V:AUX:NEG|nie
V:IMP:2:SING|ślizgaj
161 %eng: so do not slip
162 *JED: cīcho
163 %pho: tɕ͡ɕxo
164 %mor: V:IMP|cicho
165 %eng: [be] quiet
166 *BAR: nīē↑ nie mam pīcho [* p:m]
167 %err: metathesis p/tɕ͡
168 %com: picho/cicho initial segment changed

%pho: ɲe↑ ɲe mam pʲxo
%mor: AUX:NEG|nie AUX:NEG|nie AUX|mam @x
*JED: &=breathing
BAR: tyl- [0] tak↑ głośno
%err: syllable ommission -ko
%pho: tɨl tak gwoɕno
%mor: @x PRO|tak ADV|głośno
%eng: but that loudly
*BAR: &=hisses
*BAR: &=laughing
BAR: ja piērsy [p] jaˈH↑ piersy [* p]
%err: omission_w metathesis_s/ʂ [x 2]
%pho: ja pʲērsɨ ja pʲersɨ
%mor: PRO:1:SING|ja NUM:ORD:1:SING:MASC|pierwsz-y [x 2]
%eng: me first [x 2]
*JED: @xxx whisper
*BAR: uwāga uwāga↑
%pho: uvaga uvaga
%mor: N:NOM:SING|uwag-a [x 2]
%eng: attention (watch out)
*BAR: @xxx &=squeals
*JED: &=caugh
BAR: @xxx tie [p: m] kōcham
%err: methatesis tʲ/t͡ɕ
%com: target_strasznie
%pho: tʲe koxam
%mor: PRO:REFL:2:SING|cię V:PRES:1:SING|kocha-m
%eng: I love you
*JED: &=giggling
BAR: us [n: uk]
%com: neologism
*BAR: @xxx
%com: sounds like English
*BAR: &=screaming
*BAR: @xxx ↑ tu na chwīlę

%pho: tu na xfilɛ̃
%mor: DET|tu PART|na chwilę
%eng: here for a moment
*JED: o niɛ̄
%pho: o ɲe
%mor: PART|o nie
%eng: oh no
*MAM: ja nie mogę
%pho: ja ɲe mogɛ̃
%mor: PRO:1:SING|ja NEG|nie V:PRES:1:SING|mog-ę
%eng: I cannot
*BAR: &=shouting
*JED: &=giggling
*BAR: zobacz
%pho: zobatʂ
%mor: V:IMP:2:SING|zobacz
%eng: look
*BAR: @xxx
%com: unclear
*MAM: przēstań skākać
%pho: pʐestaɲ skakatɕ
%mor: V:IMP:2:SING|przestań V:INF|skaka-ć
%eng: stop jumping
BAR: trzȳmaj kierōwi [m] bō się nie poprāwi
%com: singing
%err: omission
%pho: tʂɨmaj kʲerovi bo ɕɛ̃ ɲe popravi
%mor: V:IMP:1:SING|trzyma-j target_N:ACC:SING|kierow- CONJ|bo
PART:REFL|się NEG|nie V:FUT:3:SING|popraw-i
%eng: hold the target_wheel* because it will not get better
*BAR: &=screaming
*JED: &=laughing
*BAR: ja miāłem zdjęcie na mōje przygōdy
%pho: ja mʲawem sdjɛ̃tɕe na moje pʂɨgodɨ

238 %mor: PRO:PER:1:SING|ja V:PAST:1:SING|miał-em
N:ACC:SING|zdjęci-e PART|na
239 PRO:POS:1:SING|moje N:NOM:SING|przygod-y
240 %eng: I had a photo on my adventures
241 *MAM: Jēzu niē skacz
242 %pho: Jezu ɲe skatʂ
243 %mor: N:VOC:Jezu PART:NEG|nie V:IMP:1:SING|skacz
244 %eng: Jesus do not jump
245 *BAR: @xxx zdjẽcie do naszēgo
246 %pho: zdjɛ̃tɕe do naʂego
247 %mor: N:NOM:SING|zdjęci-e PREP|do
PRO:POS:GEN:SING:2:PLUR|nasz-ego
248 %eng: photo to our
249 *BAR: pilnika piękněgo
250 %pho: pʲiɫɲka pʲɛ̃knego
251 %mor: N:GEN:SING|pilnik-a ADJ:GEN:SING|piękn-ego
252 *BAR: koniec
253 %pho: koɲec
254 %mor: N:NOM:SING|konie-c
255 %eng: the end
256 *MAM: przēstań skakać
257 %pho: pʐestaɲ skakatɕ
258 %mor: V:IMP:2:SING|przestań V:INF|skaka-ć
259 %eng: stop jumping
260 *MAM: rozūmiesz co do ciēbie mõwię
261 %pho: rozumʲeʂ co do tɕbʲe muvie
262 %mor: V:PRES:2:SING|rozumie-sz PART|co do
PRO:PER:REF:1:SING|ciebie
263 V:PRES:1:SING|mówi-ę
264 %eng: do you understand what I am talking to you
265 *MAM: niē skacz
266 %pho: ɲe skatʂ
267 %mor: PART:NEG|nie V:IMP:1:SING|skacz
268 %eng: do not jump
269 *MAM: nīe skacz bo mniē do szału doprowādzisz zāraz

%pho: ɲʲe skatʂ bo mɲe do ʂawu doprowadʑiʂ zaraz
%mor: PART:NEG|nie V:IMP:2:SING|skacz CONJ|bo PRO:PER:REF:1:SING|mnie
PART|do N:GEN:SING|szał-u V:2:SING|do-prowadzi-sz ADV|zaraz
%eng: do not jump it drives me crazy
*BAR: &=screaming
*BAR: māma
%pho: mama
%mor: N:NOM:SING|mam-a
%eng: mom
*BAR: @xxx bą̄dź cīcho bo
%pho: bɔ̃dʑ tɕxo bo
%mor: V:IMP:2:SING|bądź ADV|cicho CONJ|bo
%eng: be quiet because
*BAR: bo Jędruś nagrȳwa filmiki
%pho: bo Jɛ̃druɕ nagrɨva filmiki
%mor: CONJ|bo N:NOM:SING:DEM|Jędruś V:PRES:3:SING|nagrywa N:ACC:PLUR:DEM|filmik-i
%eng: be quiet because Jedrus is recording films
*BAR: &=shouting
*MAM: @xxx
*BAR: &=singing
*BAR: &=singing ↑
*JED: māma
%com: whispering
%pho: mama
%mor: N:NOM:SING|mam-a
%eng: mom
*BAR: &=singing
*JED: māma
%com: whispering
%pho: mama
%mor: N:NOM:SING|mam-a
%eng: mom
BAR: mani [n]

304 %com: neologism
305 %pho: ma:ɲi
306 *BAR: &=shouting
307 *BAR: a:oa [* n]
308 %pho: āaoa
309 *BAR: chȳba @xxx
310 %pho: xɨba
311 %mor: PART|chyba
312 %eng: perhaps
313 *BAR: &=shouting
314 *BAR: &=singing
315 *MAM: nīe skacz
316 %pho: ɲʲe skatʂ
317 %mor: PART:NEG|nie V:IMP:1:SING|skacz
318 %eng: do not jump
319 *BAR: &=singing
320 *BAR: dlaczēgo nie ma głōśni [* 0]
321 %com: omission_głośni-0
322 %pho: dlatʂego ɲʲe ma gwoɕnʲ
323 %mor: AUX:WH|dlaczego PART:NEG|nie V:3:SING|ma target_N:GEN
324 %eng: why there is no [* 0]
325 *BAR: dlaczēgo niē ma głōsnych [* p]
326 %err: s/ś
327 %pho: dlatʂego ɲʲe ma gwosnɨx
328 %mor: AUX:WH|dlaczego PART:NEG|nie V:3:SING|ma
ADJ:GEN:PLUR|głośny-ch
329 %eng: why there is no loud
330 *MAM: bo mȭwisz
331 %pho: bo muviʂ
332 %mor: CONJ|bo V:PRES:2:SING|mówi-sz
333 %eng: because you are speaking
334 *BAR: nie mȭwię
335 %pho: ɲʲe muvie
336 %mor: PART:NEG|nie V:PRES:1:SING|mówi-ę
337 %eng: I am not speaking

*BAR: ja przēcież niē mówiłem
%pho: ja pɛ̨etɕeɛ̨ ɲʲe muviwem
%mor: PRO:PER:1:SING|ja PART|przecież PART:NEG|nie V:PAST:1:SING|mówił-em
%eng: but I was not speaking
*JED: &=giggling
*BAR: māma @xxx głōs
%pho: mama gwos
%mor: N:NOM:SING|mam-a N:NOM:SING|głos
%eng: mom sound
*JED: &=whispering @xxx
*BAR: tu jēst szlāban nīe można przejēchać
%pho: tu jes ʂlaban ɲʲe moʐna pʂejexat͡ɕ
%mor: PRO|tu V:3:SING|jest N:NOM:SING|szlaban PART:NEG|nie V:INF|można
V:INF|prze-jech-ać
%eng: here is the bar cannot go
*BAR: cō mam zrōbić
%pho: co mam zrobitɕ
%mor: AUX:WH|co V:PRES:1:SING|mam V:INF|zrobi-ć
%eng: what should I do
BAR: uwaga intaka [n]
%com: ryhming
%pho: uvaga intaka
%mor: N:NOM:SING|uwag-a
%eng: watch out
*BAR: &=yells
*BAR: o niē chȳba
%pho: o ɲʲe xɨba
%mor: PART:NEG|o nie PART|chyba
%eng: oh no perhaps
BAR: krętka nie ma taka para [n]
%com: neologisms, unclear
%pho: krɛ̃tka ɲʲe ma taka para
*BAR: mi (...) mi mi mi mi

%com: vocalizes: mi [x 5]
*BAR: mi mim mi mim mi mim
%com: pitch shifting: rise-fall-rise
*BAR: tā:k
%pho: tak
%mor: AUX:AFF|tak
%eng: yes
*BAR: &=mumbles
*BAR: oō ja upādłem na podłōgę
%pho: o:o ja upadwem na podwoge
%mor: INT|oo PRO:PER:1:SING|ja V:PAST:1:SING|upadł-em ADV|na
N:ACC:SING|podłog-ę
%eng: oh I fell on the floor
*BAR: ale zīmno mi
%pho: ale ʑimno mi
%mor: CONJ|ale ADV|zimno PRO:PER:REF|mi
%eng: but I am cold
*BAR: tāk to mi jēst zīmno
%pho: tak to mi jes ʑimno
%mor: AUX:AFF|tak PRO:DEM|to PRO:PER:REF|mi
V:PRES:3:SING|jest ADV|zimno
%eng: this way I am cold
*BAR: chōdź na chwīlę
%pho: xotɕ na xfile
%mor: V:IMP:2:SING|chodź PART|na ADJ|chwilę
%eng: come here for a moment
*JED: &=whispering @xxx
*BAR: &=singing
*BAR: &=yells
*BAR: ɬīi jūhu
%com: wordplay
*BAR: dlaczēgo dzīś nie ma głōsu
%pho: dlatʂego dʑɕ ɲʲe ma gwosu
%mor: AUX:WH|dlaczego ADV|dziś AUX:NEG|nie V:PRES:3:SING|ma
N:GEN:SING|głos-u

405 %eng: why today there is no sound
406 *BAR: &=screaming
407 *BAR: ja właśnie skaczę
408 %pho: ja vwaɛɲʲe skatɕɛ̃
409 %mor: PRO:PER:1:SING|ja PART|właśnie V:PRES:1:SING|skacz-ę
410 %eng: I am just jumping
411 @End

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Sinkroniziran i nesinkroniziran izgovor poljskih nazala *ą* i *ę* u govoru djece i odraslih

Sažetak

Nazali *ą* i *ę* u poljskom jeziku artikuliraju se na dva načina – sinkronijski i asinkronijski, a nazalnost je jedno od dvanaest distinktivnih obilježja poljskih fonema. Smatra se da način artikulacije nazaliziranih segmenata uglavnom ovisi o njihovu okruženju. U ovome je članku pažnja usmjerena na usvajanje jezika te je pretpostavljeno da se način artikulacije *ą* i *ę* značajnije razlikuje kod djece i odraslih govornika.

Spontani govor dvoje djece snimljen je i transkribiran uz pomoć programa CLAN. U radu su primijenjena vlastita pravila transkripcije u koju su uključeni podaci o fonetskoj realizaciji u standardu IPA s primarnim i sekundarnim naglaskom, morfosintaktičkom strukturom rečenice, posebnim komentarima o koartikulaciji ili pogreškama te niz paralingvističkih podataka o izgovoru. Krajnji redovi namijenjeni su engleskom prijevodu. Govor odraslih govornika poljskog jezika preuzet je iz korpusa SpokesWeb CLARIN.

Polazi se od pretpostavke da je asinkronična artikulacija nazala tipična za *ą* i *ę*, koji se nalaze ispred afrikativnih suglasnika, ali da je sinkronički način artikulacije ispred frikativa, jer su izmjereni segmenti nazalizirani u sredini slogovne jezgre konsonant-vokal-konsonant (CVC). Dodatno su istraženi nazali u krajnjem položaju konsonant-vokal (CV). Sinkronizacija segmenata bila je označena ako su se na spektru pojavile barem dvije od pet navedenih karakteristika: (1) dodatni formant (oko 300 Hz) s relativno visokom amplitudom – ponekad redukcijom F1, sažimanje prvog maksimuma s takozvanim nazalnim formantom; (2) povećane vrijednosti F1 i F3; (3) veći F4 u odnosu na nenazalni segment; (4) veće vrijednosti F3 te (5) prisutan dodatni maksimum u okviru 0,7 kHz, 1,0–1,2 kHz, 1,8–2,25 kHz i 2,7–2,9 kHz. Na osnovu tih kriterija napravljena je skala nazalnosti.

Spektrogramska analiza materijala pokazala je sličnosti u nazalima u govoru djece i odraslih, kao što su F2 i F3 u dometu 2 300 i 2 600 Hz, iako neka obilježja nazalnosti nisu bila zabilježena niti u jednom dječjem izgovoru grupe CVC /vɛ̃ʐ̨/. Najveći stupanj nazalnosti dječjeg izgovora bio je zabilježen u grupama CVC /jɛ̃d/ i /vɔ̃s/. Detaljni prikaz nazalnosti u okviru 24 konsonantske skupine s nosnim segmentom sadrži Tablica 1. U budućim

istraživanjima pojavnosti nosne artikulacije poželjno je ponoviti postupak na većem broju ispitanika da bi se mogao donijeti zaključak o općenitim tendencijama nazalne artikulacije segmenata *ą* i *ę*.

Ključne riječi: usvajanje jezika, akustička fonetika, nazali *ą* i *ę*, poljski