FIELD PROJECT REPORT 1

Cassie Maz

1. POLISH LANGUAGE OVERVIEW

Though Polish is spoken by small minorities in several countries, it is primarily spoken in Poland. Polish is the official language of Poland, spoken by 98.2% of the country's population of approximately 38 million people [2]. Despite its usage being focused in just one country, the language is not endangered, and despite several political events throughout history that have threatened to eliminate Polish before, the language has remained largely resilient against unwelcomed change.

1.1 Language Family

Polish belongs to the Lechitic branch of Western Slavic languages, a branch of the broader group of Slavic languages belonging to the even broader Indo-European language family [4]. Polish is believed to be descended from Common Slavic, also known as Proto-Slavic, a language that has been artificially reconstructed based on similarities found between the Slavic languages. Many linguists also speculate the existence of a Proto-Balto-Slavic language, an ancestor to the two branches, Baltic and Slavic, of the Indo-European language family [1].

1.1.1 Sprachbund neighbors

Early on, Czech and German contributed heavily to Polish. Czech strongly influenced Polish during the 10th century, during which time Christianity was brought up to Poland, as did Latin, the language of the Catholic Church. Additionally, since the 16th century, Polish has interacted more with Romance languages, most notably French [3].

Russian and German influence presented conflict with the Polish language following the 18th century partition of Poland between Prussia, Russia, and Austria. However,Polish speakers largely resisted the linguistic assimilation pressures presented by their new political authorities, and so despite heavy foreign political influence, influence on their language was minimal [3].

Since WWII, Polish, has been in increased contact with English and Russian, from which it has borrowed words to create neologisms [3].

1.2 Writing

Polish utilizes the Roman alphabet (due to the Catholic influence dating back to the 10th century). It also makes use of diacritics to indicate certain pronunciations [1]. Standard Polish is most closely related to the Wielkopolska dialect [3].

1.3 Dialects

Poland has four dialect regions. Linguists debate whether Kaszuby, spoken north of Wielkopolska, is a dialect of Polish or its own language [5].

1) Malopolska, spoken in the south-east
2) Wielkopolska, spoken in the west
3) Mazowsze, spoken in north-east
4) Slask, spoken in the south-west

2. MY LANGUAGE CONSULTANT

Joanna Gorka is a female sophomore undergraduate student at the University of Pittsburgh. She speaks Polish and English fluently, and has spoken both languages since infancy. She grew up in New Jersey, speaking Polish both at home with her parents and during trips abroad with her extended family. Her family visits Poland each summer, specifically cities in western Poland that belong to the Wielkopolska dialect region. She is literate in Polish, but admits that she rarely writes in Polish and uses it mainly in conversation [6].

3. REFERENCES

[1] Asher, R. E., & Simpson, J. M. Y. (1994). *The encyclopedia of language and linguistics* (1st ed.). Oxford;New York;: Pergamon Press. 3205-6, 3964-6

[2] Central Intelligence Agency. (2017). Poland. *The World Factbook*. Retrieved from https://www.cia.gov/library/publications/the-world-factbook/index.html

[3] Comrie, B., & Corbett, G. G. (1993). *The slavonic languages*. New York;London;: Routledge. 686-7

[4] Gordon, R. G., Grimes, B. F., & Summer Institute of Linguistics. (2005). *Ethnologue: Languages of the world* (15th ed.). Dallas, Tex: SIL International. 550

[5] Sussex, R., & Cubberley, P. V. (2006). *The slavic languages*. Cambridge, UK;New York;: Cambridge University Press. 528-532

[6] Gorka, J. (2017, September 20). Personal interview

FIELD REPORT 2: STOP CONSONANTS

Cassie Maz

1. OBSERVED STOP CONSONANTS

During the previous elicitation sessions, nine different stop consonants were observed in Polish.

Figure 1. Stop consonants observed in Polish, listed in an IPA chart.

	Bilabial	L-D	Alveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b		t d			k g			
Nasal	m		n			ŋ			

All voiced and voiceless plosives that have the same place of articulation are found in contrast with one another, as demonstrated by the minimal pairs below.

Figure 2. Plosive stops of same POA in contrast in Polish

		POA		
		Bilabial	Alveolar	Velar
Plosives	Voiceless	[pas] ‘belt’	[tanjə] ‘cheap’	[bug] ‘god’
	Voiced	[bas] ‘bass’	[danjə] ‘meal’	[buk] ‘beech tree’
Nasals		[mots] ‘strength’	[nots] ‘night’	----

Note that while the velar nasal stop [ŋ] was not observed in contrast with [m] and [n], a sound resembling this nasal stop was observed during the elicitation sessions, but in the middle of words, as in [reŋka] ‘arm’, spelled ręka, and [beŋʒa] ‘will be’, spelled będzie. The language consultant noted that the vowel ‘ę’ creates a nasal-like sound. This environmental influence, as well as possible contrastive instances of [ŋ], will be explored more in the field report concerning nasals.

The contrasts in fig. 1 demonstrate that such stop consonants exist as individual phonemes in Polish. However, stop consonants do not necessarily need to be in the same place of articulation to appear in contrast with one another, as illustrated by the minimal pair ‘stary’ and ‘skary’, discussed in section 3.

2. CONTRAST OF [t] AND [d]

Taking a closer look at the alveolar stop consonants, we can observe the similarities between the two words listed in fig. 2 that demonstrate the presence of a minimal pair. [tanjə] ‘tanie’ and [danjə] ‘danie’ differ only in their first phoneme, and these phonemes differ only in their voicing. The parametric representations in fig. 3 help illustrate this.

Figure 3(a). Parametric diagram for ‘tanie’

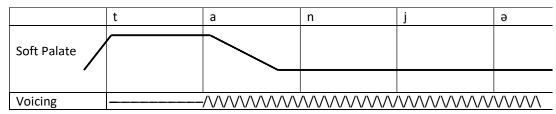
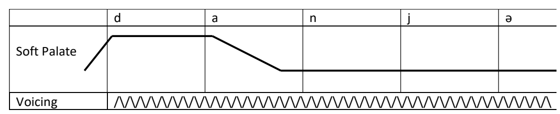


Figure 3(b). Parametric diagram for ‘danie’



As demonstrated in the diagrams above, in terms of the position of the soft palate, the two words do not differ, and voicing only differs between the word initial stop consonants [t] and [d], indicating that some form of contrast occurs at the beginning of the words. Indeed, these two stop consonants are both alveolar plosives, but [t] is voiceless and [d] is voiced.

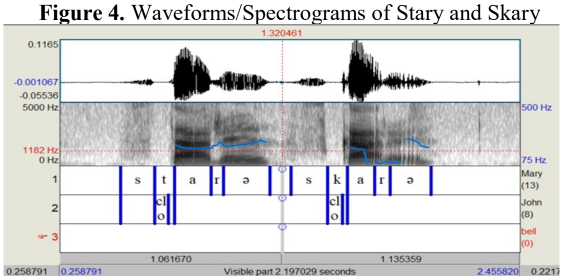
3. PRAAT ANALYSIS OF [k] AND [t]

The stop consonants [k] and [t] were found in frequent contrast with each other during the elicitation sessions. One such example is the minimal pair [starə] ‘old’ and [skarə] ‘complains’ (spelled stary and skary, respectively).

3.1. Characterizing a stop

Stops are characterized by a closure of the vocal tract followed by a burst that releases the sound. This is illustrated in the waveforms of stary and skary. In both words, as shown in fig. 4&5, the waveform is flat directly following the [s], indicating that no sound is being released from the vocal tract. Thus, the requirement for closure is met. The short aperiodic waveform following the closure and immediately preceding the onset of [a] indicates the burst release of the stop, during which the voiceless sound can be heard.

Figure 4. Waveforms/Spectrograms of Stary and Skary



3.2. Differentiating [t] and [k]

To differentiate these voiceless stops from one another, one needs to observe each stop's formant frequencies, or where their spectrograms are most shaded. Alveolar consonants will have a higher frequency relative to velar consonants. Generally, alveolars will have approximant frequencies of over 4000 Hz, while velars will have approximant frequencies between 1500 and 4000 Hz.

Fig 5(a). Spectrogram of [t] in stary

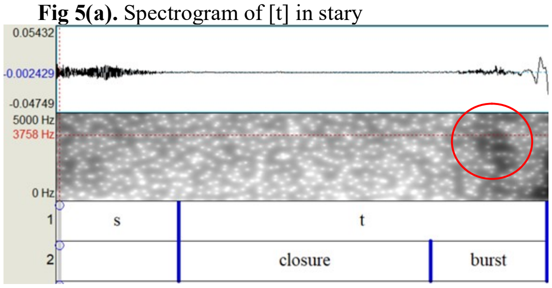
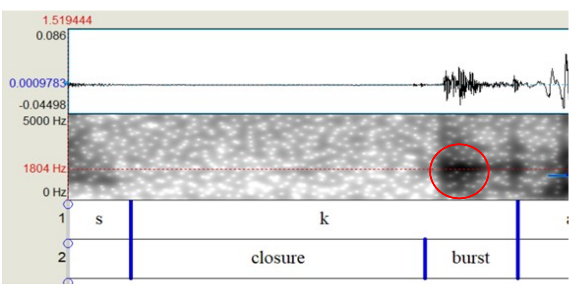


Figure 5(b). Spectrogram of [k] in skary



As shown in fig. 5, [t]'s spectrogram is thickest at just below 4000 Hz and also shows activity closer to 5000 Hz, while [k]'s spectrogram is thickest around 1800 Hz.

3.3. Unaspirated [t] and [k]

In [starə] and [skarə], these two voiceless stops behave similarly as they would after [s] in English, in that they become unaspirated. The vowel [a] comes almost immediately after the burst of the stop consonants, indicating that in this case the stops are unaspirated.

Listening to each word in the sound file without the [s] at the beginning will affect an English speakers percept, since unaspirated [t]'s and [k]'s do not occur in word initial positions in English. (Nor do they seem to appear in Polish, implying a native Polish speaker may perceive it similarly).

Voiced stops tend to show much frequency activity at the very bottom of their spectrograms, often bleeding into the following vowel. From fig. 6, however, the stops in stary and skary do not demonstrate these voiceless characteristics. So though one may hear [d] and [g] when these sounds are segmented, the phonemes [t] and [k] are being produced.

4. SPECULATION ON INSTANCES OF STOPS IN POLISH

Of the Polish words used to find possible minimal pairs, none ended in [b] or [d], as illustrated in fig. 6. Of course, this does not eliminate the possibility of either phoneme from occurring in word final position, considering only a limited pool of about 75 words (many from [1]) was used for observation. However, if a set of words was chosen such that it reflected general stop consonant distributions in Polish, then the absence of [t] and [d] in word final position in said set could imply that such occurrences are rare in the language, if present at all. With such a small pool of words used during the elicitation session, it is difficult to say how accurate the statement, "[t] and [d] never occur in word final position" might be.

Fig. 3: Stop consonants in word initial and final positions

	W.I.	W. F.		W.I.	W.F.
p	[pas]	[pogʒap] 'funeral'	k	[kot] 'cat'	[buk]
b	[bas]	------	g	[gwova]	[bug]
t	[tata] 'dad'	[brat]	m	[mots]	[ʃədʌm] 'seven'
d	[data] 'date'	-------	n	[nots]	[pan] 'man'

5. REFERENCES

[1] Samarin, William T. (1967) Field Linguistics. Holt, Rinehart & Winston.

FIELD REPORT 3: FRICATIVES

Cassie Maz

1. OBSERVED FRICATIVES AND AFFRICATES IN POLISH

During the previous elicitation session, eight fricatives and four affricates were observed, as illustrated in fig. 1.

Figure 1: Observed fricatives and affricates in Polish, in an IPA chart.

	Labiodental	Alveolar	Postalveolar	Velar	Glottal
Fricative	f v	s z	ʃ ʒ	x	h
Affricate		ʦ ʣ	ʧ ʤ		

All of the fricatives and affricates listed above were found in contrast with at least one other fricative or affricate. Table 1 lists several minimal pairs observed during the elicitation session. While this does not demonstrate all possible contrasts in Polish, enough contrasts are shown to demonstrate that the fricatives and affricates listed in fig. 1 are indeed individual phonemes.

Table 1: Some minimal pairs found in Polish during the elicitation session.

Contrast	Transcription	Polish word	Translation
f/v	[frak]/[vrak]	frak/wrak	‘tailcoat’/ ‘wreck’
z/ʒ	[zero]/[ʒero]	zero/ziero	‘zero’/ ‘nook’
s/ʦ	[nos]/[noʦ]	nos/noc	‘nose’/ ‘night’
ʃ/ʧ	[ʃeʃʧ]/[ʧeʃʧ]	szesc/czesc	‘six’/ ‘hello’
s/ʤ	[siki]/[ʤiki]	siki/dziki	‘piss’/ ‘wild’
x/ʧ	[tɪx]/[tɪʧ]	tych/tyć	‘these’/ ‘become fat’
ʣ/z	[viʣa]/[viza]	widza/wiza	‘spectator’ / ‘visas’
h/s	[hala]/[sala]	hala/sala	‘hall’/ ‘room’

2. OBSERVED VERSUS PREVIOUSLY RECORDED FRICATIVES IN POLISH

While the fricatives and affricates shown above accurately demonstrate what was perceived during the elicitation session, they do not embody all possible fricatives and affricates in the Polish language. In fact, Polish has nine simple fricatives and six affricates [1,3]. Ladefoged and Johnson [2] demonstrates some of these contrasts in their text.

During our sessions, my language consultant provided the spellings for different words, and a

Figure 2: Additional fricatives and affricates found in Polish, their POA’s occurring between postalveolar and velar.

	Retroflex	Alveolo-Palatal
Fricative	ʂ ʐ	ɕ ʑ
Affricate	tʂ dʐ	ʨ ʥ

correlation was found between letter combinations and which fricative is being produced. Indeed, in Polish, spelling very accurately reflects which sounds will be producing when pronouncing a specific word (i.e. the combination ‘ch’ in writing consistently represents the phoneme [x]). Such patterns are illustrated in Table 2. However, what I heard during the elicitation session does not include all distinguishable sounds that linguistic authorities have observed in Polish.

Table 2: Letter combinations is Polish and their corresponding phonemes according to the elicitation and the IPA, respectively.

Letter Combo	Observed sound	IPA sound	L.C.	O.S.	IPA
s	s	s	c	ʦ	ʦ
sz	ʃ	ʂ	cz	ʧ	tʂ
ś/si		ɕ	ć/ci		ʨ
z	z	z	dz	ʣ	ʣ
ż/rz	ʒ	ʐ	dż	ʤ	dʐ
ź/zi		ʑ	dź/dzi		ʥ
ch	x	x	ch	x	x

Minimal pairs between closely related sounds, such as ʃ and ɕ, were not found during the session. When asked about the contrast examples given by Ladefoged (see fig. 3), the consultant admitted that she could not tell the difference in pronunciation between the last two words presented in each set.

Figure 3: Examples of post-alveolar and alveolo-palatal fricative contrasts in Polish, from Ladefoged [2]

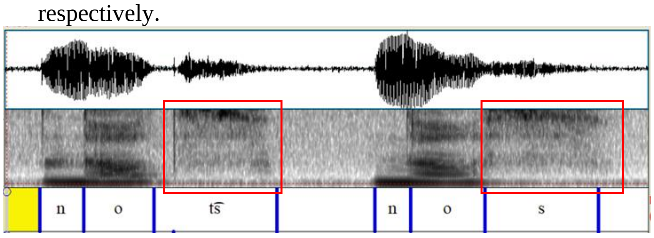
My consultant's percept in this situation could be reflective of how she's interacted with the Polish language throughout her life. She grew up speaking both Polish and English, and besides summer visits to Poland, has lived in the US her entire life. Perhaps her simultaneous acquisition of Polish and English has affected her percept, "Americanizing" it and causing her to find, and maybe produce, contrasts only in those phonemes which are found in English. Other influence of the English language is in the observed [h] phoneme. Though not listed as a possible fricative in Polish [1,3], the consultant differentiates the 'h' and 'ch' sounds in Polish. For instance, she pronounces 'hala' with the glottal [h] used in English, and not the velar [x] used in Polish.

It would be interesting to see how Polish speakers of a different background may perceive these phonemes. While the consultant does not recognize or produce the retroflex and alveolo-palatal fricatives, perhaps her parents, native Polish speakers, do.

3. PRAAT ANALYSIS OF [ʦ] AND [s]

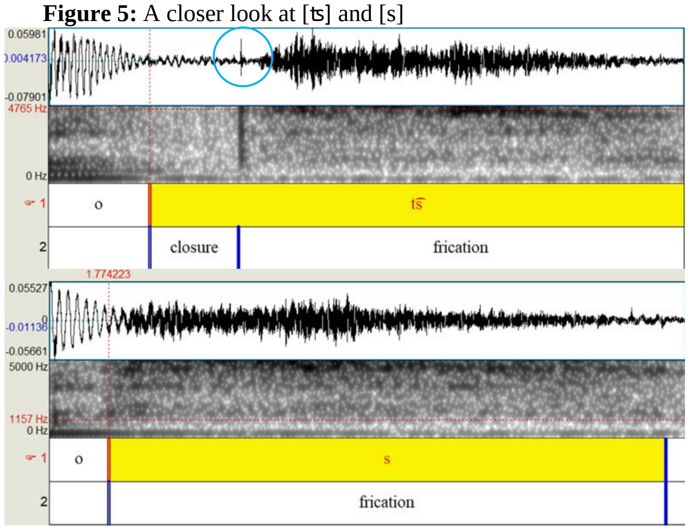
The minimal pair [noʦ] 'night' and [nos] 'nose' illustrates a contrast between an affricate and a fricative that occur at the same place of articulation. Both [ʦ] and [s] are alveolar, but the former features a stop portion prior to frication.

Figure 4: Waveforms and Spectrograms for noʦ and nos, respectively.



Fricatives and affricates are both characterized by aperiodic noise and a lower amplitude than surrounding sounds. Indeed, from fig. 5, the waveforms of both phonemes are irregular (compare to the [o] waveforms) and, from fig. 4, more dampened than the vowel that proceeds them. Notice to that the two phonemes share a similar distribution of intensity on their spectrograms (the darkened portions boxed in red), and neither have a voicing bar at the base of the spectrogram, indicating that they are unvoiced sounds occurring at the same place of articulation.

Figure 5: A closer look at [ʦ] and [s]



Unlike fricatives, affricates are proceeded by a stop gap, and this is the difference between [ʦ] and [s] that classifies them as having different manners of articulation. As indicated in fig. 5, [ʦ] has a closure portion, indicated by minimal waveform activity and a light grey area of the spectrogram. Like a stop consonant, a burst follows (circled in blue), and only then does frication begin.

4. WORD POSITION

During the elicitation session, all observed fricatives besides [ʣ], [ʤ], and [ʒ], were found in word initial, final, and medial positions. (The three listed did not occur in word final position.) Interestingly, affricates can occur in word initial position, a phonetic characteristic not found in English. Additionally, multiple fricatives can occur next to one another, as in the ends of sześć [ʃeʃʧ] and cześć [ʧeʃʧ] (see Table 1). Occasionally, fricatives even occurred after stops, as in [tʒə], trzy 'three,' in which an affricate is not formed, but [t] and [ʒ] remain two distinct sounds.

5. REFERENCES

[1] Jassem, W. (2003). Polish. *Journal of the International Phonetic Association, 33*(1), 103-107.

[2] Ladefoged, Peter & Johnson, Keith. (2010). *A Course in Phonetics*. Thomson/Wadsworth, 163-170.

[3] Żygis, M., & Padgett, J. (2010). A perceptual study of polish fricatives, and its implications for historical sound change. *Journal of Phonetics, 38*(2), 207-226.

FIELD REPORT 4: SONORANTS

Cassie Maz

1. OBSERVED SONORANTS

Eight different sonorants were observed during the elicitation sessions, as listed below in Table 1.

Table 1: Sonorants found in Polish, as listed in an IPA chart.

	Bilabial	Alveolar	Palatal	Velar
Nasal	m	n	ɲ	ŋ
Trill		r		
Approximant			j	w*
Lateral Approximant		l		

*/w/ is considered a labial velar approximant, and is usually listed outside the IPA chart, but has been placed in the velar column for simple representation.

Some examples of these sonorants being found in contrast with one another are listed in Table 2.

Table 2: Minimal pairs of Polish sonorants

Minimal Pair	Example
m/n	[mot͡s]/[not͡s]
r/l	[rɔk]/[lɔk]
j/w	[maja]/[mawa]
n/ŋ	[irenka]/[reŋka]

2. WORD POSITION

The phoneme /j/ was rarely observed in word final position. The closest sound resembling a word final /j/ sound was /ɲ/, which, due to its shared palatal position of articulation with /j/, and its absence from English speech, was initially observed as a palatalized alveolar nasal stop, /nʲ/. The phoneme /w/ was not observed in word final position at all. The phoneme /ŋ/ was never observed in word initial position, but always followed a vowel and preceded a stop or affricate. All other sonorants appeared in word initial, word final, and word mediary positions.

3. APPROXIMANTS CONTRAST

The formant activity for the approximants /j/ and /w/ demonstrate a distinct contrast between the two sounds, as indicated in figures 1 and 2.

Fig. 1: Waveform and Spectrogram for [maja]

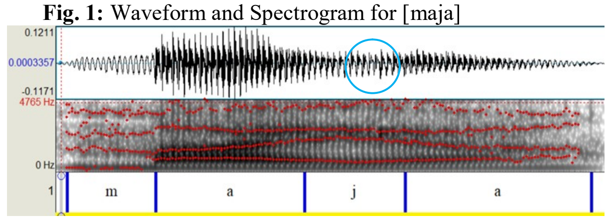
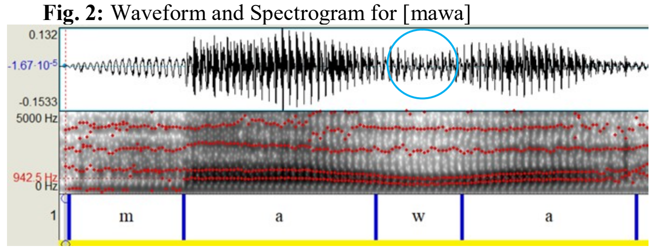


Fig. 2: Waveform and Spectrogram for [mawa]



Notice that these contrasting sounds are indeed sonorants, both demonstrating distinct formant activity and dampened amplitude (clear in the circled sections of the waveforms) compared to their surrounding vowels. As expected, these two demonstrate distinct formant activity, particularly in F2. As indicated by the red lines in fig. 1 and 2, the second formant behave oppositely to each other. While /j/'s formant raises, /w/'s lowers.

This is reflective of their places of articulation. Being a palatal sound, one pronounced further back in the oral cavity, /j/'s formant transitions reflect those of other sounds pronounced further back, like the velar stops /k/ and /g/. Being a velar approximant, one may think that /w/ should demonstrate similar F2 activity. However, /w/'s place of articulation is twofold: it is both labial and velar. The intense lip rounding, elongating the oral cavity further, causes a lowered F2.

4. NASAL CONTRASTS: /n/ AND /ɲ/

A very interesting sonorant found in Polish that is absent from English is the palatal nasal /ɲ/. This sound was most often found in contrast with /n/, and its contrasts in spectrographic form are shown below. Take the two words [baɲka] and [ranka], and notice the second formant transitions in fig. 3 and 4 between the preceding vowel and the nasals.

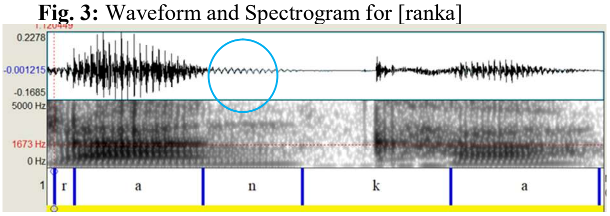


Fig. 3: Waveform and Spectrogram for [ranka]

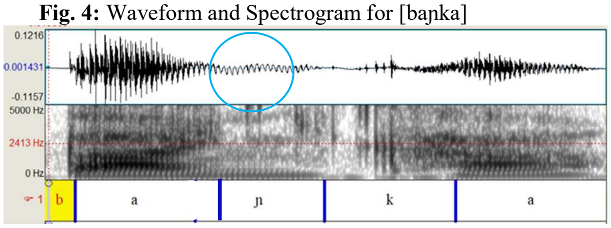


Fig. 4: Waveform and Spectrogram for [baɲka]

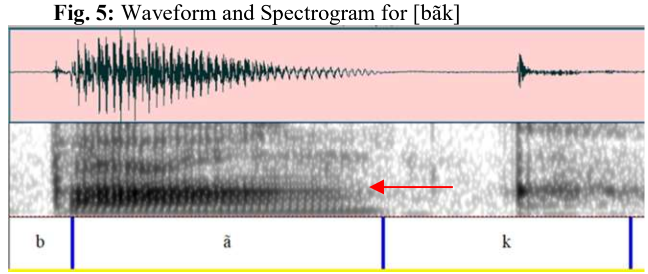
While the second formant of the vowel /a/ transitions flatly into /n/ at about 1673 Hz (indicated by the red lettering to the left of the spectrogram), it raises considerably when transitioning into /ɲ/, at about 2413 Hz. Again, these formant transitions reflect place of articulation. The palatal /j/ in [maja] has a second format around 2337 Hz, which parallels that of the palatal /ɲ/.

Another observation that can be made is the level of dampening occurring in these two sounds. Refer to the circled sections of the waveforms. These nasals are much more damped than the approximants from section 2. The most indicative comparison would be between /j/ and /ɲ/ (fig. 1 and 4), as they only differ in manner. The /j/ has a higher amplitude than /ɲ/, which makes sense considering the cavities these two sounds pass through. While /j/ is only pronounced orally, /ɲ/ goes through both the oral and the nasal cavity. Travelling through two tubes increases the potential for a sound to be absorbed as it passes by both the cheeks and the edges of the nostrils. The resulting sound should be, and indeed is, less intense.

4.1: Nasalized Vowels

Another contrast with [baɲka] was observed, initially perceived to be [bank]. However, upon further observation of the sounds spectrogram, the vowel appears to be nasalized, creating instead [bãk]. Observe the waveform and spectrogram transitions between the vowel and the nasal in fig. 5.

Fig. 5: Waveform and Spectrogram for [bãk]

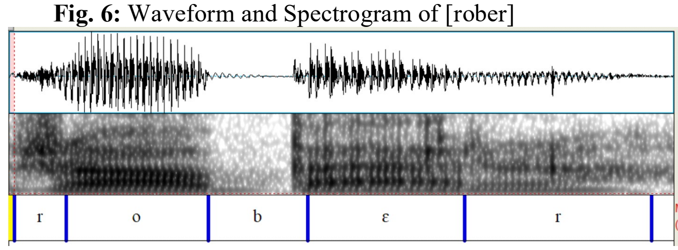


The formant transitions in the above spectrogram do not appear so distinct as those in fig. 3 and 4. In the latter figures, there is a clearer beginning of the nasal sound, indicated by the antiformants. These are portions where the black formants from the preceding vowel are diluted drastically, indicating a sudden change in manner, the lowering of the velum which allows air to pass through the oral cavity. The transition in fig. 5 is not so abrupt, and the formants appear to slowly fade. This is especially evident in the second formant (marked by a red arrow). More vowels like this will be explored in the field report comparing contrasting vowels.

5. TRILL LENGTH IN WORD FINAL AND WORD INITIAL POSITIONS

The trill /r/ found in Polish can occur in word initial, word final, and word mediary positions, but its length varies depending on where it is placed. Take, for instance, the word [rober], its spectrogram and waveform shown in fig. 6.

Fig. 6: Waveform and Spectrogram of [rober]



As with the other sonorants, the /r/'s can be distinguished from the surrounding vowels by amplitude dampening, evident in the waveforms. The word initial /r/ only lasts 39 ms, while the word final /r/ is more drawn out, lasting 141 ms. A word mediary /r/ behaves similarly to a word initial /r/.

FIELD REPORT 5: CONSONANT POA

Cassie Maz

1. OBSERVED CONSONANTS

All consonants that have been observed during the elicitation sessions thus far are listed below.

Fig. 1: Complete Consonant IPA chart for Polish

	Bilabial	Labio-dental	Alveolar	Post-Alveolar	Palatal	Velar
Plosive	p b		t d			k g
Nasal	m		n		ɲ	ŋ
Trill			r			
Fricative		v	s z	ʃ ʒ		x
Affricate			ʦ dz	ʧ dʒ		
Approximate					j	
Lateral Approximate			l			

Polish also has the bilabial velar approximate /w/, not listed in the chart above due to its dual place of articulation.

2. PALATAL AND VELAR NASALS

The hardest contrast to locate was between the palatal nasal /ɲ/, not found in English, and the velar nasal /ŋ/, which is found in English. The lack of such contrasting sounds in English made perceiving two different sounds difficult. Analysis of spectrographic activity was necessary to differentiate the two. The presence of a palatal nasal in Polish first became apparent when contrasted with the alveolar nasal /n/, as illustrated in [koɲ] and [ʒona].

Fig. 2: Waveform and Spectrogram for [zona]

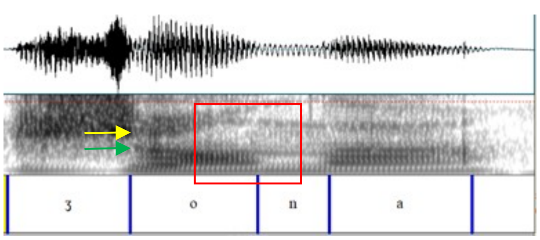
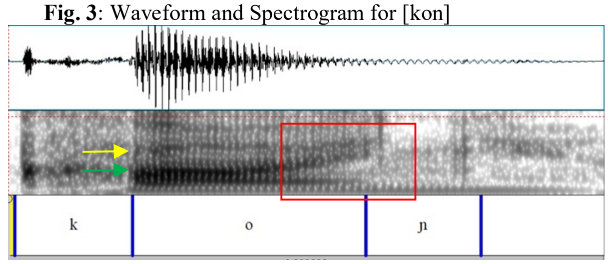


Fig. 3: Waveform and Spectrogram for [kon]



As illustrated by the boxed portions of figures 2 and 3, the formant transitions between the vowel /o/ and the nasal differ. (The green arrow indicates the beginning of formant 2; the yellow arrow indicates the beginning of formant 3.) While formants 2 and 3 remain relatively flat in figure 2, formants 2 and 3 both rise when transitioning into the nasal. This makes sense, considering that a higher F2 is seen in phonemes with a place of articulation farther back in the mouth.

After having observed the palatal nasal in Polish, I tried finding it in contrast with /ŋ/, its neighbor in place of articulation. This proved more difficult to find. However, close examination of formant 2 and 3 activity hinted at slight differences. For example, one word that particularly confused me was [malɛŋka], whose nasal I sometimes perceived as palatal and sometimes perceived as velar. Its spectrogram, figure 5, proved more reliable than my percept.

Fig 4: Waveform and Spectrogram for [irɛŋka]

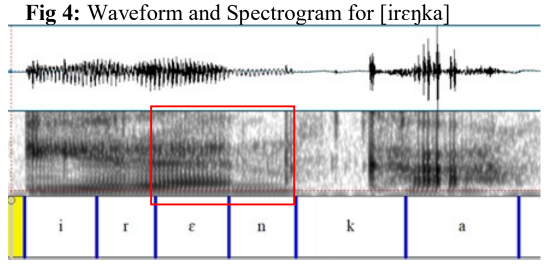
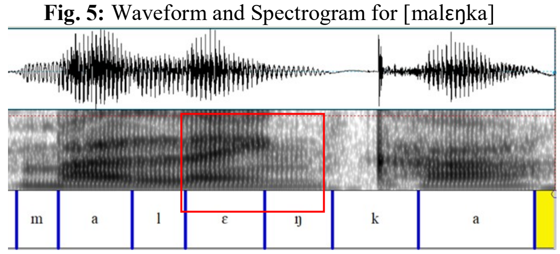


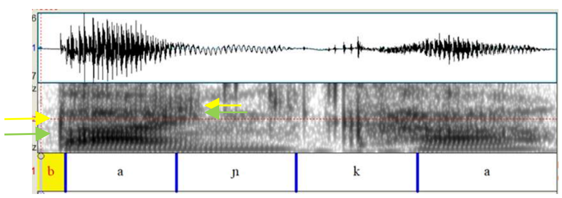
Fig. 5: Waveform and Spectrogram for [malɛŋka]



The true indicator for a velar nasal in figure 5 word lies in the spectrogram's "velar pinch" as the vowel /ɛ/ transitions into the nasal. As observed in other consonants articulated at the velum, when the consonant occurs after a vowel, the vowel's third formant will lower and its second formant will rise, coming together in what is known as a velar pinch. In figures 4 and 5, the /ɛ/'s formant activity is boxed in red. Notice that, in figure 5, formant 3 ends at a slightly lower frequency than when it began. Formant 2's rise is much more obvious. In contrast, in figure 4, the third formant remains fairly flat, and the second formant lowers, only slightly.

From the spectrogram for [baɲka], also shown in field report 4, one can see the minute differences in the formant transitions between palatal and velar consonants. In [baɲka], like in [malɛŋka], the two formants grow closer to each other, but in the former's case, they both rise together into the nasal.

Fig. 6: Waveform and spectrogram of [baɲka]



Note that these two sounds are not entirely in contrast with one another. They are preceded by different vowels, which affects the positions of the vowel's formants, and therefore may affect the formant transitions which are crucial for identifying the nasals' places of articulation. One might hypothesize that with a shorter back cavity, the velar nasal will have a higher F2 locus than a palatal nasal. During previous elicitations, while several contrasts between the palatal and velar nasal were perceived, the recordings did not back these contrasts up with spectrographic evidence, and so such a theory is difficult to accurately apply. (This is discussed further in section 3.) In future elicitation sessions, I hope to find more substantial evidence for my claims. While the velar and palatal nasal have been found in contrast with the alveolar nasal by themselves, a stronger argument for their being distinct phonemes in Polish would be if they were found in the same vowel environment.

3. NASAL WORD POSITIONS

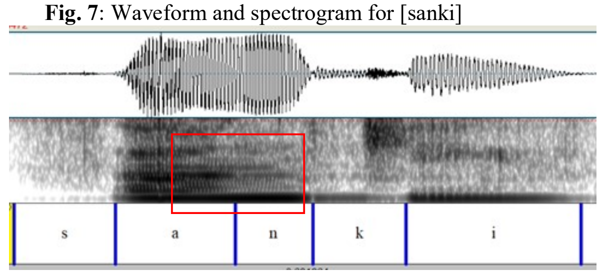
While the bilabial and alveolar nasals were found in word initial, medial, and final position, the velar nasal was found to only occur in word medial position, and only when immediately followed by a velar stop. Also, the palatal nasal was not found in word initial position See Table 1 for examples.

Table 1: Word Positions of Nasals in Polish

Nasal	Word Initial	Word Medial	Word Final
bilabial	mnjɛ	zɛmnom	dzɛm
alveolar	nos	ɔna	jɛdɛn
palatal	N/A	baɲka	dzɛɲ
velar	N/A	malɛŋka	N/A

This is an interesting distinction from English, which has words that can end with a velar nasal (for example, rang, transcribed [raŋ]). Another interesting note is that while the presence of a velar nasal guarantees a velar stop to follow directly afterwards, the converse is not true. The presence of a velar stop after a nasal does not guarantee that the nasal will be velar. For two obvious examples, refer to figures 4 and 6. Less readily perceivable examples of this were found when trying to find contrasts between /ɲ/ and /ŋ/. The word [sanki] was originally perceived as [saŋki], but observe the spectrogram below.

Fig. 7: Waveform and spectrogram for [sanki]



The flat formant transitions indicate the alveolar nasal, not a velar one. In this, and several other cases, I expected to hear /ŋ/, probably because the sequence 'nk' in English is almost always [ŋk].
Also, the palatal nasal did not occur in word initial position. While the sequence [nj] is possible, as in [njɛ], the first two consonants are distinct sounds.

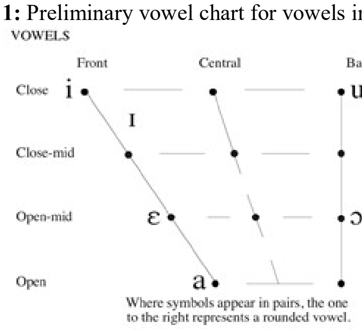
FIELD REPORT 6: SIMPLE VOWELS

Cassie Maz

1. POLISH VOWEL CHART

A total of six simple vowels, presented in the preliminary vowel chart below, were perceived during the elicitation sessions.

Figure 1: Preliminary vowel chart for vowels in Polish



In addition to these six simple vowels, Polish has two nasalized vowels, /ɔ̃/ and /ɛ̃/.

2. VOWELS IN CONTRAST

Not all vowels were found in contrast with one another, but several minimal pairs were found. A few are collected in the table below to demonstrate that these are indeed distinct sounds in Polish.

Figure 2: Minimal sets of vowels in Polish

Vowel	Minimal Sets			
i	[miʃ]		[tika]	
ɪ	[mɪʃ]	[wɪk]		
ɛ			[tɛ]	[lɛk]
ɛ̃				[lɛ̃k]
a	[maʃ]		[ta]	
u		[wuk]		
ɔ			[tɔ]	
ɔ̃			[tɔ̃]	

3. FRONT AND BACK VOWELS

Spectrographic contrasts between front and back vowels, or vowels with the tongue forward in the mouth and vowels with the tongue farther back in the mouth, can be observed through formant two. The frequency of a vowel's second formant correlates directly with how forward the tongue is in the mouth. In other words, a vowel articulated with the tongue farther forward in the mouth will have a higher F2. Figures 3 and 4 illustrate this spectrographic distinction between [wɪk] and [wuk]. Individual formants are shown with red lines. The beginning of formant two for each vowel is indicated by a green arrow.

Figure 3: Waveform and Spectrograph of [wɪk]

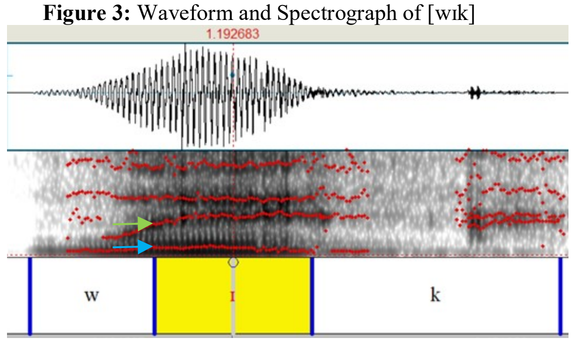
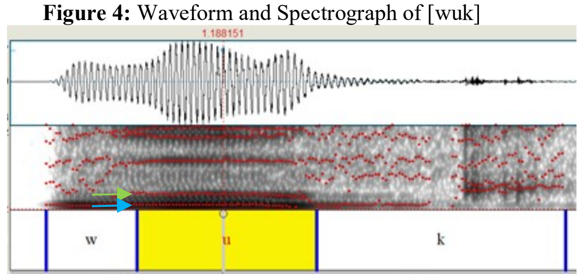


Figure 4: Waveform and Spectrograph of [wuk]



Formant measurements for simple vowels are generally taken at the vowel's midpoint, so that surrounding sounds have a minimal effect on the vowel's formant activity. (Notice the formant transition in [wɪk], where the consonant [w] rises into the following vowel.) These midpoint times are indicated in red above the waveform. As one can see, the second formant of the back vowel /u/ is much lower than that of the front vowel /i/. Indeed, when extracted from PRAAT, the second formant of /i/ was approximately 1858 Hz—the second formant of /u/ was only 883 Hz.

4. HIGH AND LOW VOWELS

Tongue height also contributes to vowel contrast, and is inversely correlated with a vowel's first formant. In other words, a vowel articulated with the tongue higher in the mouth will have a lower

F1 than a vowel articulated with the tongue lower in the mouth. The minimal pair [miʃ] and [maʃ], whose spectrograms are shown in figures 5 and 6, illustrate this concept. The beginnings of formant 1 are indicated by blue arrows.

Figure 5: Waveform and Spectrograph of [miʃ]

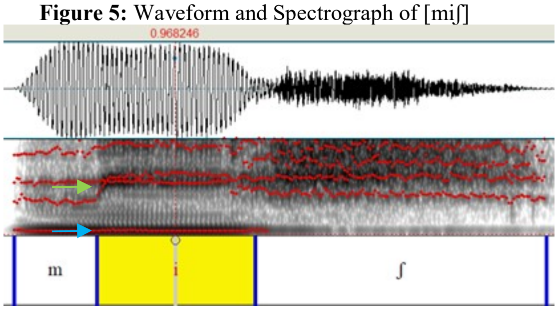
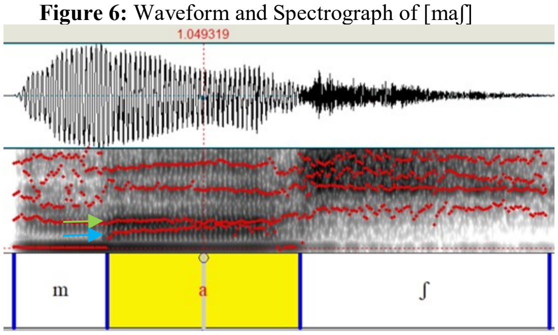


Figure 6: Waveform and Spectrograph of [maʃ]

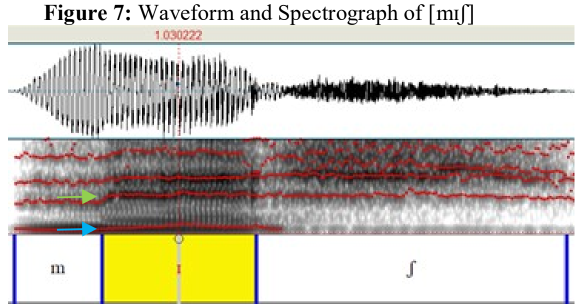


Notice that the first formant of /a/ (1326 Hz) is significantly higher than the first formant of /i/ (228 Hz). Indeed, /a/ is pronounced with the tongue in a lower position than /i/. The reason for such a drastic difference between these vowels in particular becomes evident after reviewing fig. 1. Vowels along the bottom of the IPA vowel chart are those with the lowest tongue position, and /a/ is among them. Contrastively, /i/ appears at the top of the vowel chart, where those vowels with the highest tongue height are located.

This also accounts for a slight difference in formant 1 for /u/ and /ɪ/ in fig. 3 and 4. While the tongue position for /ɪ/ is fairly high, the vowel is produced with a lower tongue position relative to /u/. Based off the relationship that has been presented between formant 1 and tongue position, this would indicate a slightly higher F1 for /ɪ/ than /u/. Indeed, one can see that F1 in fig. 3 is slightly higher than that in fig. 4 (extracted from PRAAT as 484 Hz and 254 Hz, respectively).

Similarly, observe the variations in F2 values for /i/ and /a/ in fig. 5 and 6. While /a/ is the front-most of the lowest vowels in figure 1, it is still farther back relative to the front-most vowel /i/. This would indicate a lower F2 for /a/, which the spectrographs in figures 5 and 6 do indicate. Furthermore, one could expect the second formant of /ɪ/, which lies between /i/ and /a/ in tongue forwardness, to be lower than /i/ but higher than /a/ (see fig. 7).

Figure 7: Waveform and Spectrograph of [mɪʃ]



Indeed, formant 2 in /a/ (1366 Hz) is lower than formant 2 of /ɪ/ (2128 Hz), which is lower than formant 2 of /i/ (2670 Hz). Notice that the second formant of /ɪ/, both visually in its spectrogram and numerically by the formant calculations, is significantly closer to that of /i/ than /a/. This indicates that in terms of tongue fronting, the vowels /i/ and /ɪ/ lie close to each other, which is supported by their close horizontal placement to one another in fig. 1.

The vowel /ɪ/ also lies between /i/ and /a/ in terms of tongue height. Again, this would indicate formant 1 of /ɪ/ lies between that of /i/ and /a/. Furthermore, their spectrograms should reflective the vowels' vertical placement relative to one another. The vowel /ɪ/ has a F1 value closer to /i/ than to /a/. Once again, this is supported by fig. 5, 6, and 7 and their respective formant readings. F1 of /i/ (228 Hz) is lower than F1 of /ɪ/ (445 Hz), which is significantly lower than F1 of /a/ (1326 Hz).

FIELD REPORT 7: VOWEL FORMANT MEASURES

Cassie Maz

1. OBSERVED VOWELS

As stated in Field Report 6, six different simple vowels were observed in Polish. To recap these observed contrasts, below is the word table presented in the previous report, with an additional column on minimal pairs that were used for this report's purposes.

Table 1: Minimal Sets of Vowels in Polish

Vowel	Minimal Sets				
i	[miʃ]		[tika]		
ɪ	[mɪʃ]	[wɪk]			
ɛ			[tɛ]	[lɛk]	
ɛ̃				[lɛ̃k]	
a	[maʃ]		[ta]		
u		[wuk]			[pukpuk]
ɔ			[tɔ]		[pɔk]
ɔ̃			[tɔ̃]		

To illustrate these six vowels' first and second formant values, the following six articulations were used:

Table 2: Selected words/morphemes for acoustic analysis

Vowel	Polish Word	Translation
i	[miʃ]	'teddy bear'
ɪ	[mɪʃ]	'mouse'
ɛ	[lɛk]	'medicine'
a	[maʃ]	'do you have?'
ɔ	[pɔk]	morpheme in [pɔkɔj], 'room'
u	[wuk]	'bow'

Note that multiple recordings of these and other words expressing these vowels were taken during multiple elicitation sessions. While it would be ideal to compare formant values of these vowels occurring in identical environments, language restrictions as well as practical restrictions in sound recording limited this. Specific recordings were ultimately picked based on overall sound quality and formant analysis quality in PRAAT.

2. FORMANT EXTRACTION

To extract the first and second formants from these articulations, a script was used which extracts the formant values at a vowel's midpoint. The boundaries of each vowel were labeled manually, and boundaries were determined by acoustic perception of the sound file. The extracted F1 and F2 values are presented in the table below.

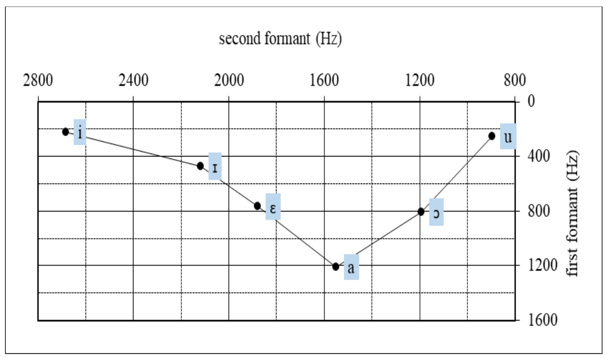
Table 3: First and Second Formants According to Script Extraction

Vowel	F1 (Hz)	F2 (Hz)
[i]	222.49445	2683.46636
[ɪ]	470.651183	2118.92941
[ɛ]	767.871574	1878.29207
[a]	1211.66944	1551.4506
[ɔ]	806.479759	1194.10984
[u]	253.570164	895.468647

3. ACOUSTIC VOWEL SPACE REPRESENTATION

These values can be represented visually in an acoustic vowel space chart, represented below.

Fig. 1: Acoustic Vowel Space Representation



4. PSYCHO-ACOUSTIC VOWEL SPACE REPRESENTATION

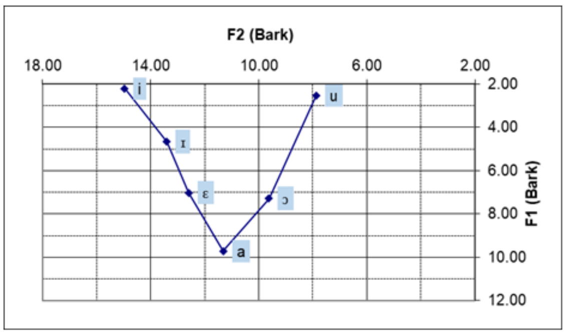
These vowels can also be charted according to psycho-acoustic values. These can be calculated from the formant values listed in table 3, and are listed for each vowel in the table below. In this analysis, psycho-acoustic values are based on Bark scores.

Table 4: Psycho-acoustic values of recorded vowels.

Vowel	F1(Bark)	F2(Bark)
[i]	2.20	14.96
[ɪ]	4.66	13.40
[ɛ]	7.02	12.59
[a]	9.71	11.32
[ɔ]	7.29	9.62
[u]	2.54	7.88

These values can be portrayed in a chart similar to that used for charting the formant values, as shown below.

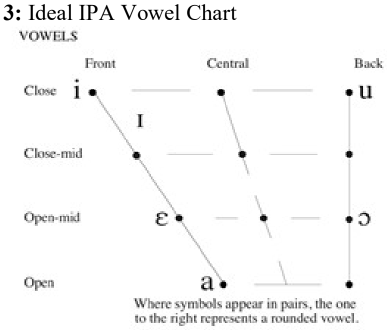
Fig. 2: Pyscho-acoustic Vowel Space Representation



5. VOWEL CHART COMPARISONS

While I'm of the opinion that the psycho-acoustic chart more accurately resembles an ideal IPA representation, in comparing the results in both figures 1 and 2 with the idealized IPA vowel chart representation first introduced in Field Report 6 (reintroduced in fig. 3 below), one finds some striking differences.

Fig. 3: Ideal IPA Vowel Chart



First of all, the higher F2 value for /ɔ/ relative to /u/ in figures 2 and 3 suggests that the consultant does not articulate this vowel as far back as /u/. This is inconsistent with the ideal chart, which posits that they are pronounced at equally far back locations of the mouth, only differing in tongue height (represented by F1, or vertical, axis). However, when reviewing the sound recording and comparing it to Ladefoged's recordings of all vowels in the general IPA [1], I still perceived the phoneme /ɔ/.

Secondly, compared to the ideal chart, /ɪ/ is located much farther away from /i/ than I would have expected in both the acoustic and psycho-acoustic representations. In figure 1, the /ɪ/ appears to differ more horizontally, while in figure 2, the /ɪ/ appears to differ more along the vertical axis. Again, when reviewing the sound recordings and Ladefoged's vowels, I found that perceptually, the sound my consultant produced is most similar to /ɪ/.

One possible explanation for these inconsistencies is that vowel chart location is not absolute. Indeed, individuals can be found to articulate vowels slightly differently. Rather, it is vowels' locations relative to one another that matters. Indeed, though /i/ and /ɪ/ are not so close as the IPA chart would suggest, in both figures 1 and 2, the /ɪ/ still occurs in a relative position to /i/, /ɛ/ and /u/ that is loyal to the vowel distributions on the IPA. That is, it is still pronounced with a tongue height between that of /u/ and /ɛ/, and a tongue position between the front-most vowel /i/ and the slightly farther back vowel /ɛ/. Similarly, though the /ɔ/ is farther to the left on the horizontal axis than one might expect, it's location relative to /ɛ/ is consistent. The phoneme /ɔ/ should occur at the same tongue height as /ɛ/, and indeed, in figures 1 and 2 the locations for /ɔ/ and /ɛ/ along the vertical axis (F1) are nearly identical.

Another possible explanation for these locations is the lack of more contrasts in Polish. Without more acoustic differences that lend meaning to Polish articulations, these vowels which do contrast have more freedom of movement, so long as they do not overlap in position relative to each other, because smaller horizontal or vertical shifts will not cause vowel confusion.

6. REFERENCES

[1] Ladefoged, Peter. (2005). *Vowels and Consonants: An Introduction to the Sounds of Languages* (2nd ed.). Oxford: Blackwell Publishing.

FIELD REPORT 8: PROSODY

Cassie Maz

1. INTONATION IN POLISH

According to other research done in the Polish language, Polish is not tonal and does not use stress contrastively at the word level [1] [2]. From my findings, Polish uses neither pitch nor stress to cue contrasting words. Instead, stress is extremely consistent in Polish, occurring most often in the penultimate syllable of a word. Pitch and stress are used at the phrase level to contrast a statement versus a question, and for emphasis, respectively.

2. STRESS PATTERNS

Polish uses a very consistent penultimate syllable stress pattern, and so cannot contrast words using stress. The only exceptions to this are borrowed words and words modified by certain suffixes [1] [2]. According to [2], a syllable's intensity is most important to cuing stress in Polish. This was evident in my data, though in some cases, vowel length also contributed to some stresses. While [2] stated that F0 tends to be more relevant to identifying stress in Polish, I did not find any such correlation.

2.1. Regular Stress

Polish tends to have penultimate stress. Even when words become suffixed, the stress shifts to the second to last syllable. This was evident in the suffixation of ['jɛnzɪk], 'language.'

Fig. 1: Waveform of ['jɛnzɪ], 'language'

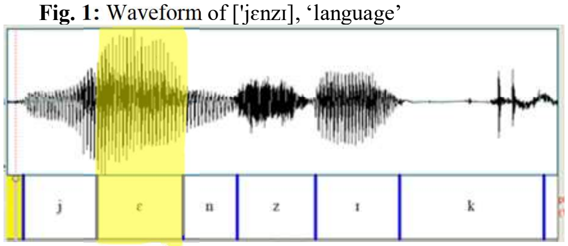


Fig. 2: Waveform of [jɛnzɪ'kami], 'with language'

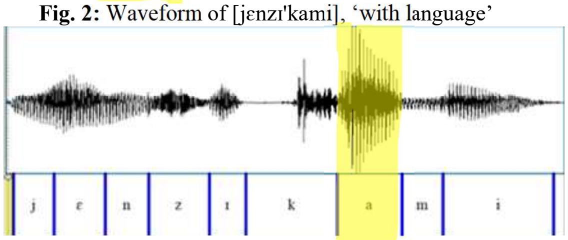


Fig. 3: Waveform of [jɛnzɪkɔz'navsa], 'linguist'

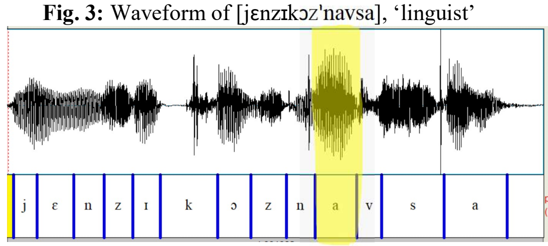


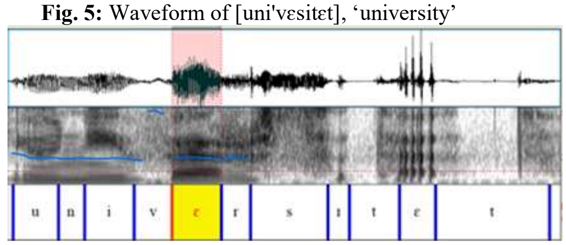
Fig. 4: Waveform of [jɛnzɪkɔznav'sami] 'with a linguist'

The waveforms of these words demonstrate the role intensity plays in cuing stress. For clarity, all stressed syllables are highlighted. The vowels with the highest amplitudes lie in the stressed syllable, which in this case, is always the penultimate syllable. This is consistent with [2]'s theory that intensity, which shows itself in amplitude, plays a large role in Polish stress.

2.2. Borrowed words

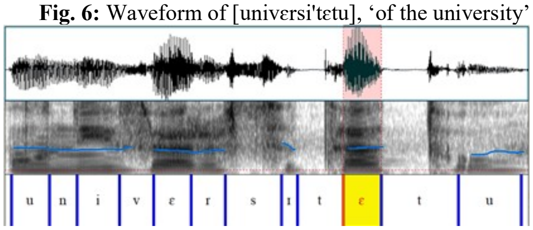
Borrowed words in Polish are exceptions to this rule, and tend to keep their original stress patterns. For instance, [univɛrsitɛt] 'university' is Latin in origin. As one can see from Fig. 5, it is expressed in the second syllable (highlighted), not the penultimate. Notice that while the amplitude of this segment is lower than the penultimate, it is higher than the amplitude of all the other syllables, and overall is the syllable with the longest duration, of about 0.094 s. In comparison, the penultimate syllable's vowel is 0.069 s.

Fig. 5: Waveform of [uni'vɛsitɛt], 'university'



However, Polish speakers have been known to shift this stress, especially when suffixation is involved, as seen in fig. 6, to the penultimate syllable. (Here, the penultimate syllable is higher in amplitude. Its duration, 0.087 s, is about the same as the duration of the second syllable's vowel, 0.084 s.)

Fig. 6: Waveform of [univɛrsi'tɛtu], 'of the university'



2.3. Some Exceptions

Some Polish words, not borrowed from other languages, also show exceptions, and deal with suffixation. Adding the suffixes [ʃmɛ] and [ʃʧɛ] tend to cause the originally penultimate stressed word to keep stress on the same syllable.

Fig. 7: Waveform/Spectrogram of [ʧɪ'tali] 'they read'

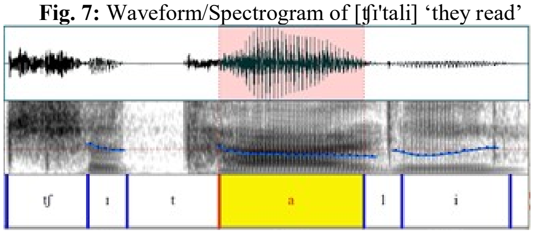


Fig. 8: Waveform/Spectrogram of [ʧɪ'taliʃmɛ] 'we read'

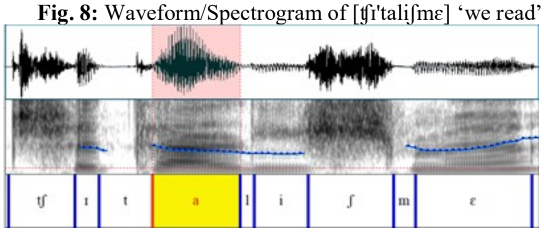
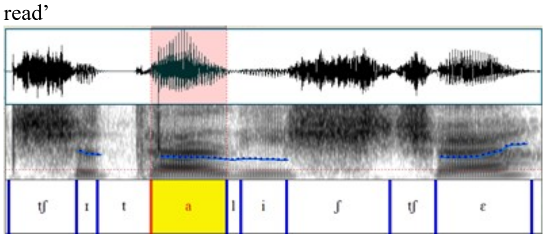


Fig. 9: Waveform/Spectrogram of [ʧɪ'taliʃʧɛ] 'you (pl.) read'



3. PHRASAL INTONATION

Though Polish does not contrast words with tones, it can be used to show phrasal meaning. The word [sklɛpa] 'store' was recorded at the end of two utterances, one meaning "Who went to the store?" (fig. 11) and the other meaning "He went to the store." (fig. 12)

Fig. 10: 'store' in isolation

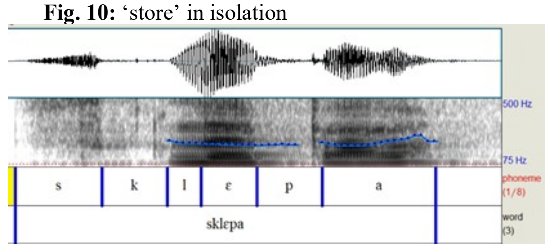


Fig. 11: 'store' at the end of a question

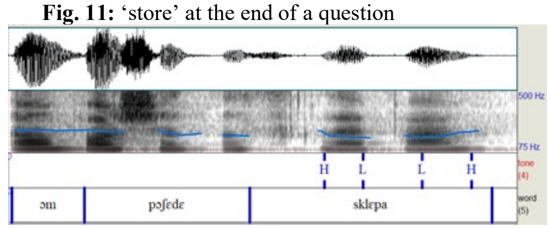
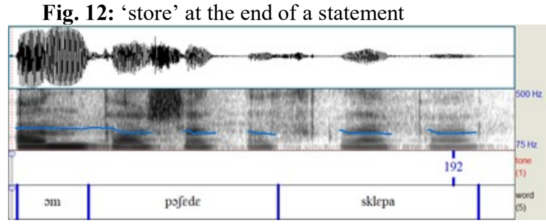


Fig. 12: 'store' at the end of a statement



As evidenced from figs. 11 and 12, pitch rises in the question, from about 182 Hz to 218 Hz, and remains level in the statement, at about 192 Hz. This phrasal tone shift is similar to what occurs in English—in a question, F0 tends to rise at the end of the utterance. Notice also that [ɔm] has a higher amplitude in fig. 12 when compared to [ɔm] in fig. 11 and the other utterances in fig. 12. I asked my consultant to say this sentence as if she were answering the question in fig. 11. Her answer suggests that Polish speakers also use stress, indicated by increased intensity, for emphasis (i.e. 'HE went to the store.')

4. REFERENCES

[1] Gussmann, E. (2007). *Phonology of polish*. Retrieved from https://ebookcentral.proquest.com

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FINAL FIELD PROJECT REPORT: NASAL CONSONANTS AND VOWELS

Cassie Maz

ABSTRACT

While identifying which sounds in the IPA chart are contrastive in Polish, I found that the most difficult sounds to classify were the language's various nasals. As discussed in previous reports, four nasals can be found in Polish: the bilabial /m/, the alveolar /n/, the palatal /ɲ/ and the velar /ŋ/. While examples have already been presented that show traditional spectrographic evidence of contrasts between these sounds, while exploring the language more, I discovered that spectrographic evidence alone is not sufficient. What I'd originally interpreted at faulty perception due to my being an English speaker caused me to misclassify some sounds as /n/. However, further study has shown that a combination of both spectrographic and acoustic observations must be used when classifying nasals.

Further difficulties came when trying to identify nasalized vowels. Again, a combination of both acoustic perception and spectrographic analysis were used to show the existence of these vowels, and their unique characteristics.

1. SPECTROGRAPHIC EVIDENCE OF DIFFERENT NASALS

When first finding evidence of a velar nasal in Polish, I was only looking at the spectrographic evidence. I expected the spectrogram of a velar nasal next to a vowel to show signs of a velar pinch, in which the vowel's third formant and second formants close together leading into the nasal. This velar pinch has been observed with other velar sounds, like the stops /k/ and /g/. I found that though I acoustically perceived /ŋ/ in much of my consultant's speech, when I went to look at them spectrographically, I could find no evidence to back my claims. This originally led me to believe that what I was perceiving as a velar nasal was really just an alveolar nasal.

However, when consulting sources about different nasal types, I found similar inconsistencies. Take for instance, these contrasting nasals given as examples by Ladefoged [1] for Malayalam.

Fig. 1: Waveform and spectrogram of [kʌnni], 'virgin'

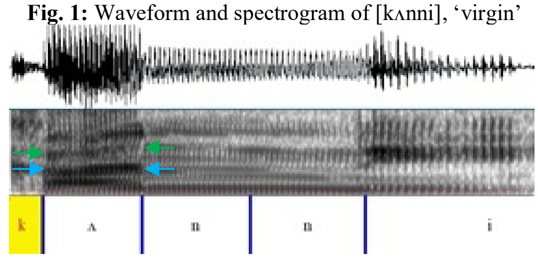


Fig. 2: Waveform and spectrogram for [kuŋŋi], 'crushed'

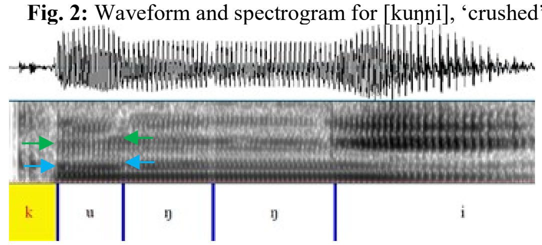
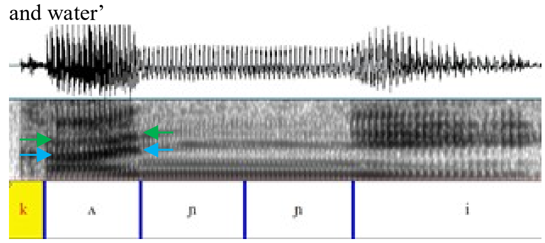


Fig. 3: Waveform and Spectrogram for [kʌɲɲi] 'boiled rice and water'

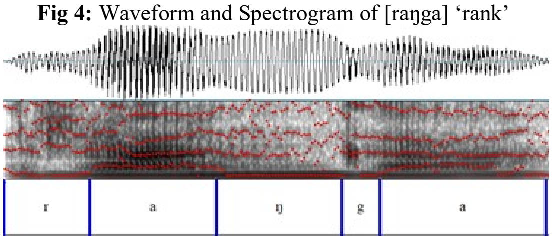


The visual spectrographic evidence for a palatal nasal that has been outlined in previous reports is reflected in figure 3: there is a rise in the proceeding vowel's second and third formants (shown with a blue and green arrow, respectively.) However, the velar pinch one might expect when encountering a velar nasal is not present in figure 2. Similarly to the alveolar /n/ in figure 1, the formant transitions lay relatively flat. The presence of a velar nasal but a lack of clear spectrographic evidence for it caused me to reevaluate many of the nasals I'd recorded.

2. IDENTIFYING NASAL CONSONANTS IN POLISH

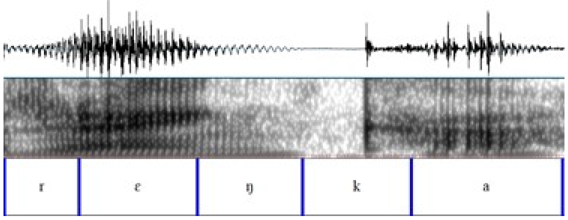
In my observations, I found that velar nasals occur only in front of velar stops, /k/ and /g/. However, there was some confusion as to if other nasals could occur in front of these stops. Originally, based purely on spectrographic evidence, I believed that alveolar nasals could also occur in front of /k/ and /g/, and I based this off the length of the stop's closure.

Fig 4: Waveform and Spectrogram of [raŋga] 'rank'



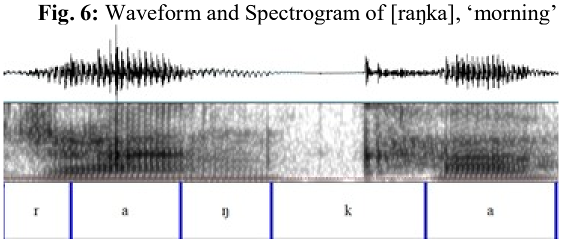
As shown in figure 4, there is little to no closure portion before the burst of /g/ in [raŋga], and I perceived the sound as velar. Seeing this pattern, I assumed that sounds with a gap indicated an alveolar nasal, not a velar. However, the spectrographic evidence for [rɛŋka] contradicted this.

Fig. 5: Waveform and Spectrogram of [rɛŋka], 'arm'



The formant transitions in figure 5 show the expected velar pinch that's indicative of a velar nasal, so in this case both acoustic and spectrographic evidence support the presence of a velar nasal. This word also has a visible stop closure. Therefore, it is possible to have a longer stop closure before a velar nasal. Knowing this, I had to reevaluate some of my earlier conclusions.

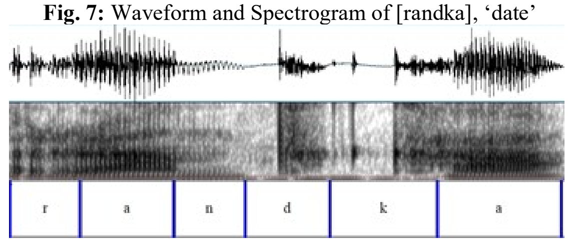
Fig. 6: Waveform and Spectrogram of [raŋka], 'morning'



As with the Ladefoged example in section 1, this word's formant transitions are not indicative of a velar nasal. When I originally heard the sound (similarly to how I'd perceived [saŋki] in report 5), I'd heard a velar nasal, but upon looking at the spectrogram I'd concluded the perception was faulty and due to my being a native English speaker. Now, with more spectrographic evidence, I know to combine both my acoustic percept and my spectrographic observations. Knowing that the formant transitions before nasals can be misleading, I re-assessed [raŋka] and [saŋki] using a more perceptual basis, and have concluded that these sounds are indeed velar.

As mentioned before, I've also observed that velar nasals come before velar stops. An acoustic contrast can be heard when comparing [raŋka] and [randka], 'date.'

Fig. 7: Waveform and Spectrogram of [randka], 'date'



The formant transitions in figures 6 and 7 look nearly identical. The contrast of these two nasals were reanalyzed acoustically and perceived differently. From an articulatory perspective, such a pattern does make sense. The transition from a velar nasal to a velar stop would be smoother than a velar to an alveolar stop such as /d/. Likewise, the alveolar stop /n/ could transition more easily to the stops /d/ and /t/ which share its place of articulation. Though it is not a general rule that the consonant following a nasal must share its place of articulation (the word [ramka], 'frame,' exists), from my observations, a rule for a shared place of articulation does apply to velar nasals.

3. WORD POSITION

In my fifth field report, I suggested that only /m/ and /n/ appear in word initial condition, while /ŋ/ cannot appear in word final position. While I still stand by these observations, one conclusion that took me a longer time to reach was that the palatal nasal cannot appear in word initial position. Perceptually, some words seemed to have a velar nasal at their onset, or perhaps a palatalized alveolar nasal, /n^j/. However, when reviewing my recordings, I found that these sounds were most likely the sequence of phonemes, /nj/. Consider the following spectrograms.

Fig. 8: Waveform and Spectrogram for [dwɔɲ], 'bell'

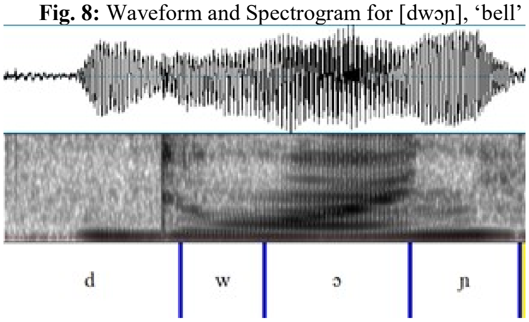


Fig. 9: Waveform and Spectrogram for [danɛ], 'given'

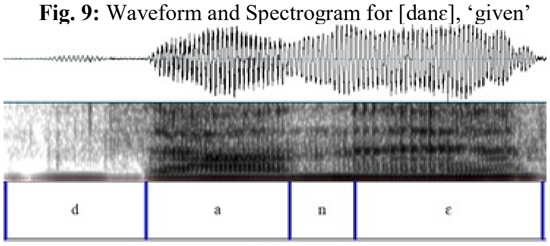
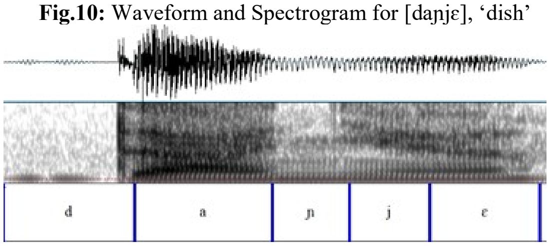


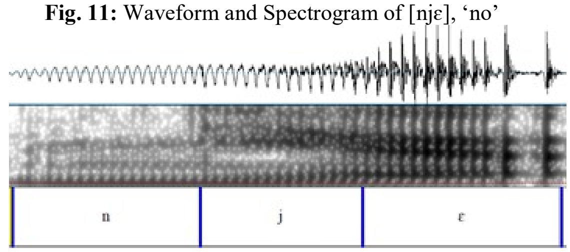
Fig.10: Waveform and Spectrogram for [daɲjɛ], 'dish'



As shown in figure 8, and demonstrated in previous field reports, the palatal nasal can be found in word final position (notice the rising second and third formants of /ɔ/). The palatal nasal has also often been found followed by the palatal approximant /j/, as shown in figure 10. This is presented in contrast with the word [danɛ], figure 10, which has an alveolar /n/ directly followed by the vowel /ɛ/. Figure 10 has a visible lowering of formants 2 and 3 leading into the final vowel, indicating a palatal preceding it, but this drop is not due to the nasal. When analyzing the sound in PRAAT, I was able to segment the phonemes /ɲ/, /j/, and /ɛ/, suggesting that these are all distinct sounds. Additionally, the length of /j/, about 82.6 milliseconds, suggests to me that this is not a palatalization of the preceding consonant. One might expect that the palatalized portion of a palatalized consonant would be shorter than the consonant itself, but /ɲ/ and /j/ are nearly equal in length. In fact, /ɲ/ is a bit shorter, only 79.9 milliseconds long.

Having seen this relationship in word medial position, one might be tempted to extend it to nasals in word initial position. However, here the analysis of which nasal is being uttered becomes muddled. In both figures 8 and 10, the vowel preceding the nasal indicates a palatal nasal because of the rising second and third formants. A nasal in word initial position doesn't have this indicator. Furthermore, the potential word initial /ɲ/'s I've observed are all followed by /j/.

Fig. 11: Waveform and Spectrogram of [njɛ], 'no'



In figure 11, one sees some difference in phoneme durations. The /j/ is about 76.2 milliseconds long, while the /n/ is 88.2 milliseconds long. However, word initial nasals have been found to be a similar length, suggesting that this length is a consequence of the nasal's word position and is independent of its pairing with /j/. For example, in a recording of [nɔs], 'nose', the initial /n/ was 85.7 milliseconds long; in a recording of [nots], 'night,' the initial /n/ was 97.9 milliseconds long. So, once again, the phoneme's duration suggests that the /j/ is an individual sound, not a portion of the preceding nasal.

One may be tempted to call the word initial nasal palatal, but the falling formants are due to the /j/'s influence, not the nasal's. Therefore, the analysis done thus far in inconclusive as to whether the initial nasal in figure 11 is an /n/ or an /ɲ/. Based on acoustic perceptions of segments in [njɛ], and the visible spectrographic activity, I would argue that the word initial nasal is alveolar. However, it may also be plausible to suggest that the /ɲj/ pattern in word medial position can be extended to word initial utterances.

4. NASALIZED VOWELS

In addition to the six simple vowels observed in the sixth field report, two nasalized vowels, /ɔ̃/ and /ɛ̃/ have been identified Polish [2]. In field report 4, the nasal vowel /ã/ was mistakenly perceived. Indeed, identifying nasalized vowels has proved challenging. Often what I initially perceived acoustically as a nasalized vowel was revealed through spectrographic analysis to be a vowel followed by a nasal consonant. During my investigations, the nasalized vowel /ɔ̃/ was more clearly identified than /ɛ̃/.

When looking for nasalized vowels, I tried to find certain spectrographic changes from the simple to nasalized form. Because nasal sounds must travel through both the oral and nasal cavity, dampening can be expected. This damping often causes the formant values of a nasal to be unclear. Consequently, one might expect the formant values of a nasalized vowel to be less clear than its simple counterpart.

Though /ɔ̃/ was not found in contrast with /ɔ/ during the elicitation sessions, it was found frequently in contrast with /a/, and for the purposes of identifying general vowel intensity and the quality of formant extraction, this sufficed.

Fig. 12: Waveform and Spectrogram for [mazak], 'marker'

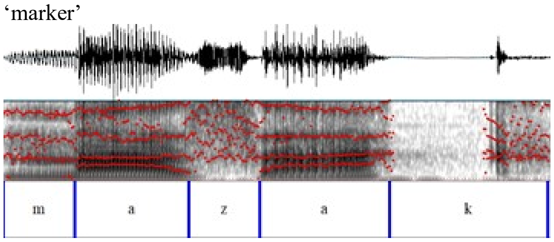
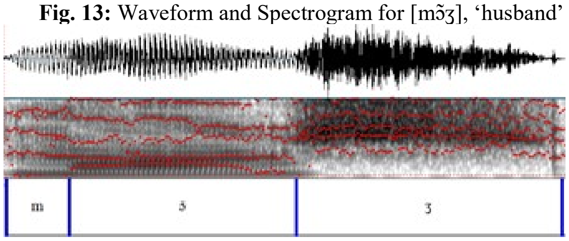


Fig. 13: Waveform and Spectrogram for [mɔ̃ʒ], 'husband'



Immediately one can see from the vowels' waveforms that the amplitude of the nasalized vowel (figure 13) is much lower than that of the simple vowel (figure 12). The simple vowel's amplitude is demonstrably higher than the nasal preceding it and the fricative following it, a regular phenomenon, since nasals and fricatives tend to be dampened. The nasalized vowel, on the other hand, has a dampened amplitude that is nearly equal to the preceding /m/, and less than the /ʒ/ that follows.

Additionally, the PRAAT formant tracker, indicated by red dots, appears to have had more trouble tracking the higher formants of figure 13's vowel. While the formants three and four in figure 12 appear fairly linear, the readings become more scattered for figure 13, and even resemble the scattered trackings found in its preceding nasal, perhaps indicating nasal-like qualities in the vowel.

While this example gave relatively clear evidence for a nasalized /ɔ/, finding spectrographic evidence for a nasalized /ɛ/ proved much trickier. Indeed, many vowels originally thought to be nasalized /ɛ/'s turned out to be /ɛ/ followed by a nasal. Take for example, [lɛk], 'bow,' and [lɛŋk], 'anxiety.' The latter was first thought be [lɛ̃k], but the spectrographic evidence indicated otherwise.

Fig. 14: Waveform and Spectrogram for [lɛk] 'bow'

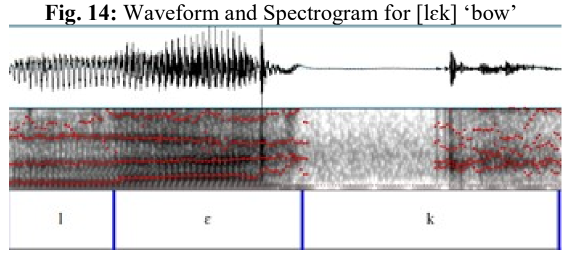
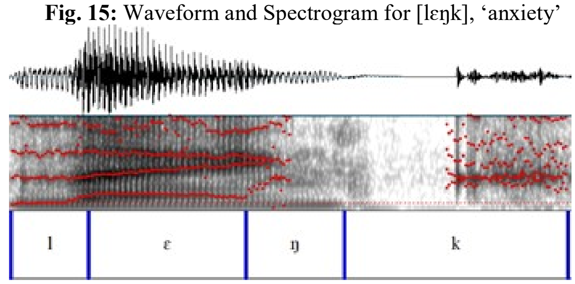


Fig. 15: Waveform and Spectrogram for [lɛŋk], 'anxiety'



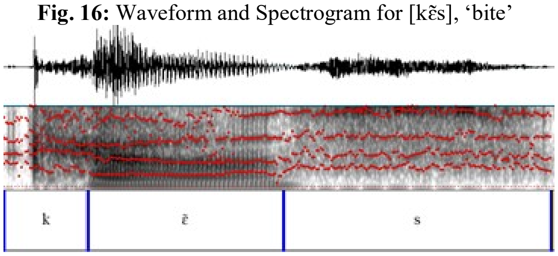
From the two figures above, one can see that the vowel /ɛ/ in both figures is not dampened to the levels of its surrounding consonants, and the nasal following /ɛ/ in figure 15 is made evident by the utter lack of formant tracking in that section of the spectrogram. While figure 13 portrays qualities of a vowel and a nasal throughout (like dampening formant readings) figure 15 shows a stark change in articulation.

Furthermore, the movement of the /ɛ/'s second and third formants in figure 15 indicate that the following sound is not only a nasal, but a velar nasal. This pattern is consistent with the earlier observation of velar nasals are always followed by velar stops. (Similar analysis changed the originally perceived [bãk] in field report 4 to [baŋk], 'bank.')

4.1. Considerations and Contradictions

Though several sources indicate the existence of the nasalized vowel /ɛ̃/, it was not found often during our elicitation sessions. One possible example of it that I found was [kɛ̃s].

Fig. 16: Waveform and Spectrogram for [kɛ̃s], 'bite'



This word's spectrogram shows consistent formant activity throughout the vowel, and weak third and fourth formant extractions. This would indicate a nasalized vowel. However, as seen in the sound's spectrogram, only the second portion of vowel's amplitude is dampened. This would indicate a vowel followed by a nasal. When attempting to segment the vowel portion further, I could not find a clear divide between the vowel and nasal portion, but I wouldn't want to immediately conclude that this is proof of a vowel that is nasalized throughout. Indeed, one can even see in the waveform for figure 13 that the tail end of the vowel /ɔ̃/ has a slightly lower amplitude than the rest (though the contrast is not quite so extreme as in figure 15).

Instead, I would take this as possible evidence that nasalized vowels in Polish are not monophthongs. They tend to show characteristics of diphthongs, smoothly transitioning from one place of articulation to another. Even the example [mɔ̃ʒ], which shows more consistency in terms of nasal qualities, has some indicators that the beginning of the nasalized vowel is more "vowel-like," while the end is more "nasal-like." The vowel's first formant in figure 13 drops at the end of the vowel, something that tends to happen when a vowel is followed by a bilabial nasal /m/ or alveolar nasal /n/. Just as in [kɛ̃s], it is hard to separate the vowel and nasal portions of [mɔ̃ʒ], but the very end of the vowel is perceptibly more nasal-like than the beginning.

4.2. Word Position of Nasalized vowels

While the only recordings I took show nasalized vowels in word medial positions, this is not conclusive evidence that they cannot occur in word initial or final position. Indeed, I've only brushed the surface of the complexities of nasalized vowels in the Polish language.

One hypothesis I do have concerning nasalized vowels concerns which other sounds they can occur next to. The only nasalized vowels that I have observed appear before fricatives, such as /ʒ/, /s/, and /ʃ/ (figures 13, 16, and 17, respectively). However, the opposite does not hold. A fricative preceded by a nasal sound does not guarantee that the nasal is a nasalized vowel, as demonstrated in figure 18's clear distinction between /ɛ/ and /n/.

Fig 17: Waveform and Spectrogram for [vɔ̃ʃ] 'snake'

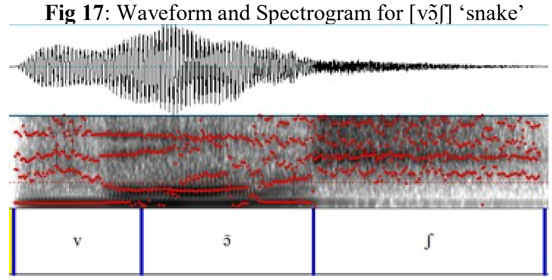
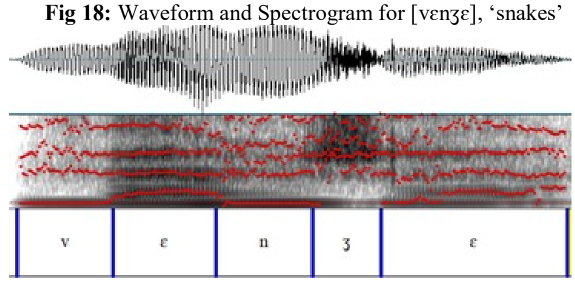


Fig 18: Waveform and Spectrogram for [vɛnʒɛ], 'snakes'



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[2] Gussmann, E. (2007). *The phonology of polish.* Oxford;New York;: Oxford University Press.