PATTERNS IN POLISH VOWEL~ZERO ALTERNATIONS: AN OPTIMALITY THEORY ANALYSIS

by

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1. INTRODUCTION

The Polish language exhibits many morphophonological phenomena that still confound researchers today. There are many types of alternations where word stems may exhibit two or three variants within a paradigm. Consonants may alternate with other consonants, and vowels may alternate with other vowels in certain inflectional and derivational forms. This paper deals primarily with one such alternation phenomenon: the vowel~zero alternation. In vowel~zero alternations, a vowel present in one form of a stem is not present in another form. Although these alternations may occur in words from various lexical categories, they are most common in nouns. Therefore, I further narrow down my focus in this paper to vowel~zero alternations in nouns.

I begin this paper with an introduction to the relevant characteristics of the Polish language, and move on to discussing how these relate to the morphophonological characteristics of vowel~zero alternations in nouns. I then provide a brief history of vowel~zero alternations, and follow it with a description of the problem that vowel~zero alternations pose for Polish phonology.

1.1. Polish Phonemic Inventory

Along with Sorbian, Czech, and Slovak, Polish constitutes part of the West Slavic language family. In this subsection, I provide a bit of background on the Polish language that is necessary in tackling the phonological problem of vowel~zero alternations.

In tackling any phonological problem, it is important to have an understanding of the phonemic inventory of the language. To begin with, I will make some assumptions about the vowel inventory. The chart in (#1.1) below includes some segments in brackets, whose inclusion in the phonemic inventory is often debated. I assume that all of the vowels listed below are

phonemes. However, whether or not these vowels are separate phonemes does not bear any significance to the problem and analysis presented in this paper.

(#1.1) Polish vowel inventory

i	(ɨ)	u
ɛ		ɔ
(ɛ̃)		(ɔ̃)
	a	

(summarized and adapted from Sussex & Cubberly 2006:153-162)

(#1.2) Polish consonant inventory

	labial	palatalized labial	dental/ alveolar	retroflex	palatal/ prepalatal	velar	palatalized velar
Stops	p b	(pʲ) (bʲ)	t d			k g	(kʲ) (gʲ)
Affricates			ts dz	tʂ dʐ	tɕ dʑ		
Fricatives	f v	(fʲ) (vʲ)	s z	ʂ ʐ	ɕ ʑ	x	
Nasals	m	(mʲ)	n		ɲ		
Approximants	w		l r		j		

(summarized and adapted from Sussex & Cubberly 2006:163-166)

On the other hand, the phonemic status of consonants in Polish is much more important for the present analysis, particularly with respect to palatalization effects that may often appear alongside vowel~zero alternations. The chart in (#1.2) above shows the consonantal inventory of Polish categorized by place and manner. Note that this chart too includes some segments in brackets that, depending on the researcher, may or may not be considered separate phonemes. For the purposes of this paper, I consider palatalized labials as separate phonemes, but palatalized velars as allophonic variants of plain velars.[1] This is partly because it is possible to find minimal pairs that contrast palatalized labials (#1.3).

[1] See section 6.1 for further evidence and a discussion about why palatal segments should be treated as separate phonemes in general.

(#1.3)	*wara*	[vara]	‘beware!’	*wiara*	[vʲara] ‘belief, Nom. Sg.’
	mara	[mara]	‘apparition, Nom. Sg.’	*miara*	[mʲara] ‘measure, Nom. Sg.’
	pana	[pana]	‘man, Gen. Sg.’	*piana*	[pʲana] ‘foam, Nom. Sg.’

(Sussex & Cubberly 2006:165)

Although based only on this evidence it may be possible to analyze palatalized labials as underlyingly *C+j* sequences, the status of palatalized labials as separate phonemes becomes clearer in light of onset consonant cluster data. In Polish, it is often the case that palatal consonants may only cluster with other palatal consonants, so that [st] and [ɕtɕ] are well-formed clusters, but *[stɕ] and *[ɕt] are not. A similar pattern is observed with the labial consonants, where [s] co-occurs with plain labials, and [ɕ] co-occurs with palatalized labials (#1.4). The handful of examples of [s] being followed by palatalized [pʲ] can be analyzed as having a morpheme boundary between the two segments, so that [s] is an aspectual morpheme, and [pʲ] is the first consonant in a root (#1.5).

(#1.4)	*śpiew*	[ɕpʲɛv]	‘singing, Nom. Sg.’	*sposób*	[spɔsub] ‘method, Nom. Sg.’
	świat	[ɕfʲat]	‘world, Nom. Sg.’	*swojski*	[sfɔjski] ‘homely, Nom. Sg.’
	śmiać	[ɕmʲatɕ]	‘to laugh’	*smak*	[smak] ‘taste, Nom. Sg.’

(#1.5)	*spiec*	[spʲɛts]	‘to burn, Perfective’
	piec	[pʲɛts]	‘to bake’

On the other hand, palatalized velars occur only before /i/ and /ɛ/, whereas plain velars do not (#1.6). The only exception to this rule are borrowed words such as *Kenia* [kɛɲa] ‘Kenya’, *kelner* [kɛlnɛr] ‘waiter’ (from German), *kepi* [kɛpʲi] ‘képi, hat’ (from French), etc. Furthermore, ooking at consonant cluster co-occurrences as evidence shows that [ɕ] is never followed by [k] (Saloni et al. 1994).

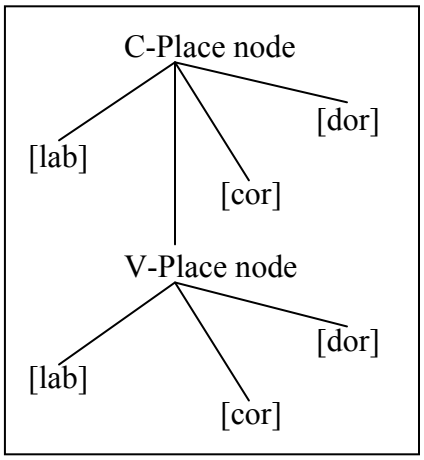
(#1.6)	*kieł*	[kʲɛw]	‘fang, Nom. Sg.’	*[kɛ]
	kij	[kʲij]	‘stick, Nom. Sg.’	*[ki]
	kaczor	[katʂɔr]	‘male duck, Nom. Sg.’	*[kʲa]
	koc	[kɔts]	‘blanket, Nom. Sg.’	*[kʲɔ]
	kura	[kura]	‘hen, Nom. Sg.’	*[kʲu]
	kąt	[kɔ̃nt]	‘corner, Nom. Sg.’	*[kʲɔ̃]
	kęs	[kɛ̃ns]	‘bite, Nom. Sg.’	*[kʲɛ̃]

Furthermore, it will become necessary throughout this paper to refer to the featural specifications of Polish phonemic segments. At this point, I turn to Morén’s (2006) Parallel Structures Model (PSM) (#1.7), in which “phonological segments are composed of a limited set of identical structures and a limited set of privative, articulator-based features” (Morén 2006: 1208). These structures and features define the limitations of the model since a language may not have any more distinctive features than those available in the model (#1.7). On the other hand, a language may use fewer features as long as these features are sufficient to distinguish each segment from all other segments in the language, and as long as these features are able to define classes of segments that undergo the same phonological processes.

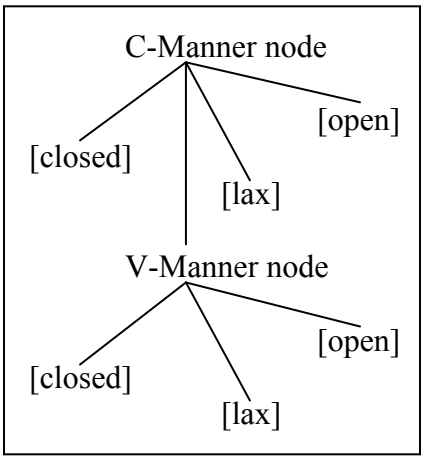
While most of my analysis can work using a traditional feature model (e.g. Clements & Hume 1995), PSM offers a better alternative when dealing with the vowel-consonant interactions discussed in section 6. This is largely because there is some freedom in whether or not a language places features under the ‘C-node’ or the ‘V-node’, so that “vowels can have ‘C-node’ features and consonants can have ‘V-node’ features” (Moren 2006: 1208 footnote). Therefore, while the features used in the PSM are “articulator-based” and as such are not assigned completely arbitrarily, the use of “C” and “V” to indicate node type is not necessarily a statement about the phonological nature of the nodes. Neither node is more important or “primary” than the other.

(#1.7) Morén's Parallel Structure's Model

(a) Place of Articulation



(b) Manner of Articulation



Using the Parallel Structures Model, I have devised the following feature geometry for Polish phonemes (#1.8). Many of the segments have feature specifications that parallel the feature geometries for Serbian and Slovenian devised by Jurgec & Morén (2008). I will return to this feature geometry at various points throughout this paper, at which time I will also attempt to explain the reasons behind assigning specific feature values to particular segments.

(#1.8) Polish Feature Geometry

Manner Description	Segment	C-Place			V-Place		C-Manner		V-Manner	
		[cor]	[dor]	[lab]	[cor]	[lab]	[cl]	[op]	[cl]	[op]
Stops	/p/			✓			✓			
	/pʲ/	✓		✓			✓			
	/t/	✓					✓			
	/tɕ/	✓			✓		✓			
	/tʂ/	✓	✓				✓			
	/ts/[2]		✓				✓			
	/k/						✓			
Fricatives	/f/			✓				✓		
	/fʲ/	✓		✓				✓		
	/s/	✓						✓		
	/ɕ/	✓			✓			✓		
	/ʂ/	✓	✓					✓		
	/x/							✓		
Nasals	/n/						✓	✓		
	/ɲ/				✓		✓	✓		
	/m/			✓			✓	✓		
	/mʲ/	✓		✓			✓	✓		
Approximants	/j/				✓		✓			✓
	/l/				✓	✓	✓		✓	
	/w/					✓	✓		✓	
Vowels	/a/									✓
	/ɛ/									
	/ɔ/					✓				
	/i/				✓				✓	
	/ɨ/								✓	
	/u/					✓			✓	
	/ɛ̃/							✓		
	/ɔ̃/					✓		✓		

1.2. Morphophonology and Vowel Alternations

Furthermore, vowel~zero alternations are often considered a morphophonological phenomenon. Therefore, it is necessary to make some statements about the morphology of Polish. Inflectional suffixes on nouns depend on three factors: gender, number, and case.

[2] Note that while it may seem strange that a segment like /ts/ is specified with a C-place[dorsal] feature, while a traditionally dorsal consonant like /k/ is not, these specifications make sense from a phonological point of view since /ts/ patterns with the other C-place[dorsal] consonants (/tʂ/ and /ʂ/) while /k/ does not. However, although I have chosen to assign this particular feature to /ts/ rather than /k/, nothing in this paper hinges on it.

Gender is considered an inherent property of nouns, and Polish nouns may be one of three possible genders: masculine, feminine, or neuter. Any noun may also be singular or plural. Finally, Polish nouns can have seven morphological case distinctions: nominative, vocative, accusative, genitive, dative, instrumental, and locative. Most inflexional suffixes are vocalic, meaning that they are minimally composed of a vowel (and in certain cases the vowel is followed by a consonant, or a consonant and another vowel). However, as the next subsection shows, it is in cases that do not have vocalic suffixes where stem vowels that are absent in other forms in the paradigm appear.

In terms of morphophonology, the following patterns can be observed regarding vowel~zero alternations:

(#1.9) Animate masculine nouns may have a vowel in the nominative singular that contrasts with no vowel elsewhere.

(a)	'dog'	*pies-Ø*	*ps-a*	*ps-y*	*ps-ów*
		[pʲɛs]	[psa]	[psɨ]	[psuf]
		(Nom. Sg.)	(Acc. Sg.)	(Nom. Pl.)	(Gen. Pl.)
(b)	'donkey'	*osioł-Ø*[3]	*osł-a*	*osł-y*	*osł-ów*
		[ɔɛɔw]	[ɔswa]	[ɔswɨ]	[ɔswuf]
		(Nom. Sg.)	(Acc. Sg.)	(Nom. Pl.)	(Gen. Pl.)

(#1.10) Inanimate masculine nouns show the same pattern, except that their accusative singular forms are identical to their nominative singular forms.

(a)	'head'	*łeb-Ø*	*łeb-Ø*	*łb-y*	*łb-ów*
		[wɛp]	[wɛp]	[wbɨ]	[wbuf]
		(Nom. Sg.)	(Acc. Sg.)	(Nom. Pl.)	(Gen. Pl.)
(b)	'cauldron'	*kocioł-Ø*[4]	*kocioł-Ø*	*kotł-y*	*kotł-ów*
		[kɔtɛɔw]	[kɔtɛɔw]	[kɔtwɨ]	[kɔtwuf]
		(Nom. Sg.)	(Acc. Sg.)	(Nom. Pl.)	(Gen. Pl.)

[3] Note that the quality of the vowel in vowel~zero alternations is usually [ɛ]. However, in a couple of cases, the vowel is [ɔ]. This will be discussed in more detail in section 6.2.
[4] See footnote 3 above.

(#1.11) Irregular feminine nouns (i.e., those that do not have the /–a/ suffix in the nominative singular) pattern the same way as masculine nouns.

(a)	'louse'	*wesz-Ø*	*wesz-Ø*	*wsz-y*	*wsz-ów*
		[vɛʂ]	[vɛʂ]	[fʂɨ]	[fʂuf]
		(Nom. Sg.)	(Acc. Sg.)	(Nom. Pl.)	(Gen. Pl.)
(b)	'village'	*wieś-Ø*	*wsi-ę*	*ws-i*	*ws-i*
		[vʲɛɕ]	[fɕɛ̃]	[fɕi]	[fɕi]
		(Nom. Sg.)	(Acc. Sg.)	(Nom. Pl.)	(Gen. Pl.)

(#1.12) Regular feminine and neuter nouns have a vowel in the genitive plural that contrasts with no vowel elsewhere.

(a)	F: 'tear'	*łz-a*	*łz-ę*	*łz-y*	*łez-Ø*
		[wza]	[wzɛ̃]	[wzɨ]	[wɛz]
		(Nom. Sg.)	(Acc. Sg.)	(Nom. Pl.)	(Gen. Pl.)
(b)	N: 'window'	*okn-o*	*okn-o*	*okn-a*	*okien-Ø*
		[ɔknɔ]	[ɔknɔ]	[ɔkna]	[ɔkʲɛn]
		(Nom. Sg.)	(Acc. Sg.)	(Nom. Pl.)	(Gen. Pl.)

Furthermore, vowel~zero alternations are not the only alternations that involve vowels. As the following data in (#1.13) suggest, there are many cases where vowels alternate with other vowels in quality.

(#1.13) Some vowel~vowel alternations in nouns:

(a)	ɔ ~ ɛ	*anioły* [aɲɔw] 'angel, Nom. Pl.'	*aniele* [aɲɛlɛ] 'angel, Loc. Sg.'
	a ~ ɛ	*wiara* [vʲara] 'faith, Nom. Sg.'	*wierze* [vʲɛzɛ] 'faith, Loc. Sg.'
(b)	u ~ ɔ	*pokój* [pɔkuj] 'room, Nom. Sg.'	*pokoje* [pɔkɔjɛ] 'room, Nom. Pl.'
	ɔ̃ ~ ɛ̃	*ząb* [zɔmb] 'tooth, Nom. Sg.'	*zęby* [zɛmbɨ] 'tooth, Nom. Pl.'[5]

[5] Note that phonemically nasal vowels are pronounced as oral vowels followed by homorganic nasal stops in pre-plosive position. In spite of this, I consider nasal vowels as separate phonemes in Polish due to their participation in various phonemic processes that exclude their oral counterparts. Conversely, oral mid vowels participate in phonemic processes that exclude their nasal counterparts.

In alternations of the sort illustrated in (#1.13a), [ɔ] or [a] elsewhere in the paradigm alternates with [ɛ] in the vocative singular and locative singular. What is interesting, however, is that the alternations in (#1.13b) pattern in a similar way to vowel~zero alternations. Recall that the vowel in vowel~zero alternations appears in cases with non-vocalic suffixes. Similarly, when [ɔ] alternates with [u], and [ɛ̃] alternates [ɔ̃], [u] and [ɔ̃] are the vowels that appear in cases with non-vocalic suffixes, while [ɔ] and [ɛ̃] appear in all other cases. This can be summarized by saying that [ɛ] is to Ø, as [u] is to [ɔ] and [ɔ̃] is to [ɛ̃].

1.3. History of Vowel Alternations

Historically, the vowel~zero alternation phenomenon is related to two vowels derived from Indo-European short ĭ and ŭ, commonly referred to as *yers*. Sussex & Cubberly (2006:111-112) posit that the location of these short vowels in the central area of the vowel space made them weak, and led to their general disappearance as phonemes in individual Slavic languages after disintegration of Common Slavic (Carlton 1990). In principle, *yers* were lost when in "weak" position and fused in terms of pronunciation with other existing vowels when in "strong" position. A *yer* was strong only when the following syllable contained a weak *yer*, whereas a *yer* was weak in all other positions (including word-finally or when the following syllable contained any other vowel). Complications to the weak/strong alternation rule arose because of resistance to consonant clusters that were potentially formed by the loss of a weak *yer*.

On the other hand, [u] and [ɔ̃] from the vowel alternations in (#1.13b) above each developed from long vowels: long [ɔ] in the case of [u] and the long nasal vowel in the case of [ɔ̃] (Sussex & Cubberly 2006:116,131). The *u* ~ *ɔ* and *ɔ̃* ~ *ɛ̃* alternations can thus be seen diachronically as alternations between long and short vowels. Syllable structure ends up being relevant because the "long" vowels [u] and [ɔ̃] occur in closed syllables at the end of a word.

Furthermore, syllable structure is also relevant to *yers* because deletion of a weak *yer* in word-final position resulted in closed syllables, while the *yer* that preceded the word-final weak *yer* became strong and vocalized. Therefore, the group of vowel alternations that include vowel~zero alternations exhibit the general tendency for vowels to be "strong" in closed syllables.

1.4. The Problem of Vowel~Zero Alternations

So far, the phenomenon of vowel~zero alternations (and vowel alternations in general) has been presented in a straightforward fashion. However, further investigation proves that vowel~zero alternations are much more complex. Consider the examples of vowel~zero alternations alongside the examples of non-alternating roots presented in the following data:

(#1.14)

	Alternating noun roots	**Non-alternating noun roots**
		Always V
(a)	[lɛv-Ø] 'lion' ~ [lv-ɛm] (Instr. Sg.)	[zlɛv-Ø] 'sink' ~ [zlɛv-ɛm] (Instr. Sg.)
(b)	[pʲɛs-Ø]'dog' ~ [ps-a] (Gen. Sg.)	[bʲɛs-Ø] 'devil' ~ [bʲɛs-a] (Gen. Sg.)
(c)	[sfɛtɛr-Ø] 'sweater' ~ [sfɛtr-ɨ] (Nom. Pl.)	[kratɛr-Ø] 'crater' ~ [kratɛr-ɨ] (Nom. Pl.)
(d)	[lɛn-Ø] 'flax' ~ [ln-u] (Gen. Sg.)	[tɛrɛn-Ø] 'terrain' ~ [tɛrɛn-u] (Gen. Sg.)
		Always Ø
(e)	[wask-a] 'stoat' ~ [wasɛk-Ø] (Gen. Pl.)	[wask-a] 'grace' ~ [wask-Ø] (Gen. Pl.)
(f)	[bagn-ɔ] 'swamp' ~ [bagʲɛn-Ø] (Gen. Pl)	[malign-a] 'delirium' ~ [malign-Ø] (Gen. Pl.)
(g)	[trumn-a] 'coffin' ~ [trumʲɛn-Ø] (Gen. Pl.)	[kɔlumn-a] 'column' ~ [kɔlumn-Ø] (Gen. Pl.)

(examples from Rubach 1984:28 and Gussmann 2007:186)

The data in the first column of the table shows that a vowel present in a word ending in a consonant is not present when that same word is followed by a vocalic suffix. In other words, the vowel breaks up two consonants when they are word-final. The two obvious ways of accounting for these alternations phonologically are through either epenthesis or syncope. In an epenthesis analysis, a vowel would be inserted between two consonants when they are word-final. In a

syncope analysis, a vowel would be deleted between two consonants when they are followed by a vocalic suffix.

However, the problem of vowel~zero alternations is clarified when we compare the data in the first column with the data in the second column. The examples in the second column of data (#1.14a-d) show nouns where the vowel [ɛ] is present throughout the paradigm in the same consonantal environment as the examples in the first column. Therefore, the data suggests that vowel~zero alternations cannot be a consequence of a process of syncope since there is no obvious way of explaining why deletion would occur in the first column but not in the second. On the other hand, the examples in the second column of data (#1.14e-g) show nouns where the vowel there is never a vowel throughout the paradigm in the same consonantal environment as the alternating vowel in the examples in the first column. Therefore, the data suggests that vowel~zero alternations cannot be a consequence of a process of epenthesis either since there is no obvious way of explaining why epenthesis would occur in the first column but not in the second.

1.5. Overview

The historical facts presented in section 1.3 would suggest that the reason for the irregularity in vowel~zero alternation patterning are a result of different phonemes. In other words, words that exhibit vowel~zero alternations are encoded with a different vowel than words that maintain a vowel throughout their paradigm. Two previous analyses along these lines are discussed in section 2. However, I intend to show that the vowel~zero alternation phenomena can for the most part be explained without recourse to positing other vowel phonemes. More importantly, I will show that there are in fact phonological patterns in vowel~zero alternation phenomena. These patterns suggest themselves through a thorough examination of Polish data.

Laskowski (1975) had presented a general overview of the environments in which vowel~zero alternations do or do not occur. In addition to his data and the data provided as examples of vowel~zero alternation phenomena by other researchers, I used various dictionaries, word lists, and personal communication with native speakers to compile my database.[6] Using this database, I was able to compare in more detail the patterns found in words that exhibit vowel~zero alternations with the patterns found in words that do not.[7]

What follows in this paper is an Optimality Theory analysis of vowel~zero alternation phenomena that attempts to bring these patterns to the forefront. Where necessary, reference to the featural representation of segments using the Parallel Structures Model and the feature specifications outlined in the table in (#1.8) will be made. The body of this paper begins with an overview of the analyses that have been presented in the past and what my personal stance on these analyses is. The next few sections move through my analysis of the phenomenon starting with the problems of syllabification and sonority, and moving on to the effects of derivational morphology. The paper concludes with an analysis of consonant-vowel interactions particularly as they pertain to vowel quality in vowel~zero alternations.

[6] I used three main types of resources that I hope reflect common usage: an orthographic dictionary (Saloni et al. 1994); a dictionary of nominal inflections (Mędak 2003); and the online dictionary at 'pl.wiktionary.org' which I hope is indicative of current usage rather than archaic prescriptivisms. For grammaticality judgements from native speakers, I am indebted to my family members and to my good friend Kamila Pizoń.

[7] See Appendix A and Appendix B for the result of organizing parts of the data.

2. REVIEW OF PREVIOUS ANALYSES

2.1. Synchronic *Yers*

Recall from the previous section the historical existence of ultra-short vowels called *yers* in Proto-Slavic. In the past, linguists took their inspiration from these Proto-Slavic *yers* in order to account for synchronic vowel-zero alternations in Polish (in addition to other Slavic languages). For Polish, synchronic *yers*, along with rules that govern their vocalization, have been posited and supported by many linguists at least as early as 1975 (e.g. Laskowski 1975, Gussmann 1980). One of the most avid proponents of synchronic *yers* in Slavic languages was Jerzy Rubach, whose 1984 work *Cyclic and Lexical Phonology: The Structure of Polish* defined synchronic *yers* and outlined the mechanisms involved in their deletion and vocalization in various environments.

Rubach (1984) cites Gussmann (1980) in defining his *yers* as high [-tense] "abstract" vowels, one front and one back, parallel to [+tense] /i/ and /ɨ/, transcribed as /ĩ/ and /ɨ̃/[8] (Rubach 1984:28-29). He names these abstract vowels "*yers*" "for purely mnemonic purposes without necessarily implying that they should correspond to the yers familiar to students of historical grammar. In fact, //ĩ// and //ɨ̃// often have nothing to do with the 'true' historical yers" (Rubach 1984:29). As an example, Rubach cites borrowings such as *sweter* 'sweater' (from English), which exhibit vowel-zero alternations but which clearly cannot contain historical *yers*.

According to Rubach (1984), there are two major mechanisms that affect synchronic *yers* in nominal paradigms: Yer Lowering (#2.1) and Yer Deletion (#2.2). Yer Lowering takes place if a *yer* is followed by another *yer* in the next syllable. In essence, /ĩ/ or /ɨ̃/ surface as the vowel [ɛ] in this context. Yer Deletion, on the other hand, states that *yers* that are not followed by

[8] Previous reasons for having two underlying types of *yers*, as opposed to one, will be discussed in more detail in section 6.1.

another *yer* in the following syllable delete. This particularly includes cases where the *yer* is word-final, thereby resulting in a closed syllable.

(#2.1) Yer Lowering {ĭ ŭ} → ɛ / ___ C_0 {ĭ ŭ}

(adapted from Rubach 1984:31 (41a))

(#2.2) Yer Deletion {ĭ ŭ} → 0

(adapted from Rubach 1984:31 (41b))

Supported by these rules, Rubach (1984) posits *yers* in many common derivational morphemes and inflectional endings. Therefore, it is often in the context of these suffixes that Yer Lowering takes place. For example, Rubach analyzes the phonetically null nominative singular ending of masculine nouns and genitive plural ending of feminine and neuter nouns is underlyingly /-ŭ/. This explains the presence of alternating [ɛ] in words such as those in (#2.3) below:

(#2.3)	Masculine:	*pies* 'dog, nom.sg.'	/pĭs+ŭ/	→	[pʲɛs]
	Feminine:	*owiec* 'sheep, gen.pl.'	/ovĭts+ŭ/	→	[ovʲɛts]
	Neuter:	*źródeł* 'spring, gen.pl.'	/ʑrudŭw+ŭ/	→	[ʑrudɛw]

(from Rubach 1984:31)

Following the rules of Yer Lowering and Yer Deletion above, *yers* will never surface phonetically in their underlying shape. This idea is further supported by the following data, which in turn provide evidence of the existence of *yers* that is independent of the [ɛ]~zero alternation phenomenon in nouns. Rubach (1984) cites Gussmann (1980:38) in pointing out that *yers*, as high lax abstract vowels, can be tensed in the middle of a derivation such as when they

are followed by the Derived Imperfective morpheme [–aj]. Therefore, in Derived Imperfective Yer Tensing, //ĭ// → [i] and //ŭ// → [ɨ] in the context of the suffix [-aj], as the rule in (#2.4) below shows:

(#2.4) D.I. Tensing [+syll, +high, -tense] → [+tense] / ___ C_0 aj]$_{D.I.}$

(from Rubach 1984:29 (44))

(#2.5)	*zamek*	/zamɨ̆k+ŭ/	→	[zamɛk]	‘lock, nom. sg.’
	zamki	/zamɨ̆k+i/	→	[zamki]	‘lock, nom. pl.’
	zamykaj	/zamɨ̆k+aj/	→	[zamɨkaj]	‘close, 2.sg.imperative imperfect’
	zamknij	/zamɨ̆k+ɲij/	→	[zamkɲij]	‘close, 2.sg.imperative perfect’

As (#2.5) above shows, the noun and verb share the same root and exhibit vowel~zero alternations in the same location, with the only difference being the quality of the vowel. While this might form a strong argument for an underlying *yer* in the root along with varying rules of its vocalization in order to account for the differences, I am not convinced by this analysis. My main concern with Rubach’s analysis is its reliance on arbitrary rules and lexical encoding. For example, what is the phonetic/phonological motivation for *yers* (or any vowels) to either lower or tense in their respective environments?[9] There is no independent reason why a *yer* should cause a preceding *yer* to lower to [ɛ]; and even if we were to accept this phonological rule, there is still the question of why any particular morpheme would cause a preceding *yer* to tense. The question of independent motivation for the phenomenon is one that is central to the analysis presented in this paper, and will be touched on in more detail in section 2.3. There, I will also discuss the

[9] This paper focuses on nouns only, and therefore I will not be discussing the vowel~zero alternation in verbs. However, it is my suspicion that these cases can be analyzed in a way similar to the analysis of vowel~zero alternations in nouns presented in this paper. See the conclusion for a brief discussion. See also section 6.2 for phonological motivation of [ɛ] in vowel~zero alternations.

phonological patterns that are apparent in the data, but which Rubach's (1984) analysis fails to account for because, for Rubach, *yers* are arbitrarily encoded.

2.2. Government Phonology and Melody Association

Although, as can be seen above, Rubach (1984) drew heavily from Gussmann's 1980 work and theory of abstract vowels as a basis for his analysis of Polish vowel~zero alternations, Gussmann recently reinterpreted *yers* as floating vowels within the framework of Government Phonology where all consonant clusters are broken up by empty nuclei, resulting in universal CV syllables. Gussmann (2007) uses a mechanism of melody association to account for the presence or absence of vocalization of his floating vowels. His rule of Melody Association is reproduced in (#2.6) below:

(#2.6) *Melody Association:*
Attach floating [ε] to the nucleus when the following nucleus has no melody attached to it.

(from Gussmann 2007:191)

In cases where the following nucleus does have a melody attached to it, a floating [ε] does not attach to its nucleus. "An unassociated melody is not pronouncable and can be regarded as eliminated or invisible to the phonology" (Gussmann 2007:192). Therefore, as the following examples show, in cases where the following nucleus is empty due to a zero inflectional ending, the floating vowel will be vocalized (#2.7). However, when the following nucleus has a melody attached to it, such as in the case of a vocalic inflectional suffix, the floating vowel will not surface (#2.8).

(#2.7) *dech* 'breath, nom. sg.'

```
O   N   O   N          O   N   O   N
|   |   |   |          |   |   |   |
x   x   x   x    →     x   x   x   x
|       |              |   |   |
d   ɛ   x              d   ɛ   x
```

(#2.8) *tchu* 'breath, gen. sg.'[10]

```
O   N   O   N          O   N   O   N
|   |   |   |          |   |   |   |
x   x   x   x    →     x   x   x   x
|       |   |          |       |   |
d   ɛ   x   u          t   ɛ   x   u
```

(from Gussmann 2007:192)

As is evident from the above example, Gussmann (2007) believes that the masculine nominative singular, and the feminine and neuter genitive plural cases are inflected with a zero suffix in the shape of an empty nucleus. In other words, both Gussmann and Rubach believe that there is a nucleus following the final consonant in words that exhibit vowel~zero alternations; however, while Gussmann believes that there is no melody attached to this nucleus, Rubach believes it is filled by a *yer*. Gussmann points out that "the pattern of alternations holds not just for different inflectional cases of nominals but also for derivationally related forms" (Gussmann 2007:192). Therefore, if an alternating vowel surfaces in a nominal stem when there is a derivational suffix attached to it, it is because there is an empty nucleus between (for example) the final consonant of the stem and the first consonant of the suffix. In this way, the mechanism of Melody Association always holds true.

In cases of several floating vowels in a row, as in examples (#2.9) and (#2.10) below, a simple algorithm for Melody Association is used. Namely, "attach the floating melody unless the

[10] Note that the change in voicing in the initial consonant is due to a regular rule of regressive devoicing in Polish.

next nucleus contains an attached melody; all melodies meeting the condition are identified in representations such as the ones above and the linking is carried out simultaneously" (Gussmann 2007:199).

(#2.9) *piesek* 'dog, dim.nom.sg.'

O	N	O		N	O		N
|	|	|		|	|		|
x	x	x	+	x	x	+	x
|		|			|		
p^j	ɛ	s		ɛ	k		Ø
'dog'				*'diminutive'*			*'masc.nom.sg.'*

	O	N	O	N	O	N
	|	|	|	|	|	|
→	x	x	x	x	x	x
	|	|	|	|	|	
	p^j	ɛ	s	ɛ	k	

(#2.10) *pieski* 'dog, dim.nom.pl.'

O	N	O		N	O		N
|	|	|		|	|		|
x	x	x	+	x	x	+	x
|		|			|		|
p^j	ɛ	s		ɛ	k		i
'dog'				*'diminutive'*			*'masc.nom.pl.'*

	O	N	O	N	O	N
	|	|	|	|	|	|
→	x	x	x	x	x	x
	|	|	|		|	|
	p^j	ɛ	s	ɛ	k	i

(from Gussmann 2007:198)

However, Gussmann's (2008) analysis, although better at providing independent motivation for vowel~zero alternations than Rubach's (1984) analysis, nevertheless does not reflect the full extent of the phonological patterns that emerge from a detailed examination of the Polish data. It is the explanation of these patterns that sets my analysis apart from those

presented in the past. I now turn to why an analysis that takes these patterns into consideration is more optimal than one that does not, and to a brief examination of one of these patterns.

2.3. Empirical Adequacy

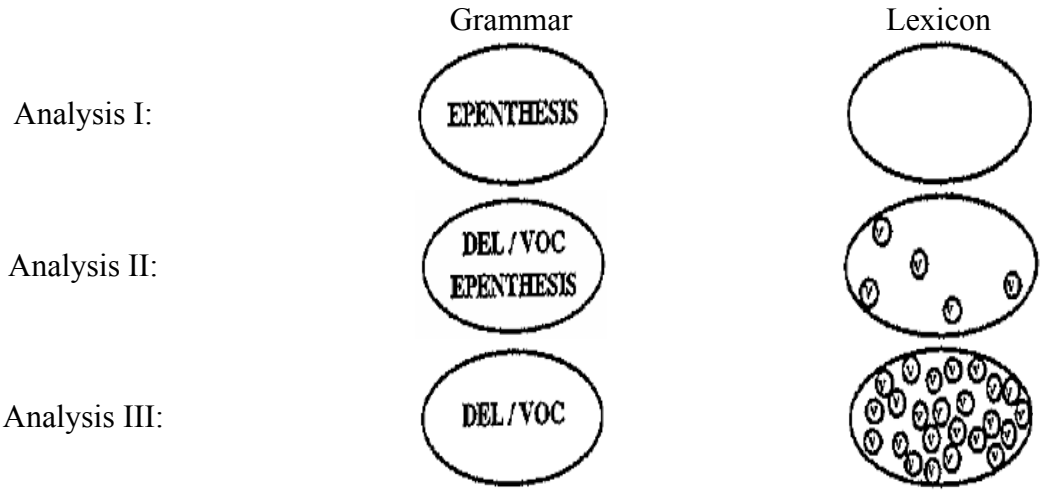
I take my definition of an optimal analysis from Mellander (2000), who analyzed vowel~zero alternations in Czech and Slovak, two West Slavic languages closely related to Polish. In his discussion of previous analyses regarding vowel~zero alternations in Slavic languages, Mellander writes:

> Since a deletion/vocalization mechanism can account for any observed vowel-zero alternation provided that an underlying *yer* is assumed, standard analyses … have relied exclusively on this mechanism to account for *all* vowel-zero alternations, and consequently have assumed the presence of underlying *yers* in *all* contexts where vowel-zero alternations occur.
>
> (Mellander 2000:214)

Mellander explains the reason for the optimality of this account by examining the various possible analyses of vowel~zero alternations in relation to linguistic constraints. Diagram (#2.11) below shows three possible analyses, while table (#2.12) shows how these analyses may be evaluated to determine the optimal one. Analysis I relies solely on an epenthesis rule, and does not encode any instances of vowel~zero alternation in the lexicon. However, as has been already shown in the introduction to this paper, pure epenthesis is unable to account for all of the vowel~zero alternation data. Therefore, Analysis I is empirically inadequate and is therefore ruled out by the EMPIRICALLY ADEQUATE constraint. Analysis III, on the other hand, relies solely on a deletion/vocalization mechanism, and therefore must encode every instance of vowel~zero alternation in the lexicon. This is in contrast with Analysis II, which relies on both a deletion/vocalization mechanism and epenthesis in order to account for the data, but which

requires fewer instances of vowel~zero alternations to be explicitly encoded in the lexicon. However, Mellander points out that it is often deemed more important to maintain a simple grammar than it is to maintain a simple lexicon. It is for this reason that Analysis III is chosen as optimal.

(#2.11) Possible analyses of vowel~zero alternations



(from Mellander 2000:215 (5))

(#2.12)

Alternation Facts	EMPIRICALLY ADEQUATE	*COMPLEX GRAMMAR	*COMPLEX LEXICON
I.	*!	*	
II.		**!	*
☞ III.		*	**

(from Mellander 2000:215 (6))

However, further examination of the Czech and Slovak data reveals a complete absence of final consonant clusters with rising sonority. The distribution facts are also supported by evidence from borrowed words, where *yers* did (#2.13) (in cases of rising sonority) or did not (#2.14) (in cases of flat or falling sonority) develop.

(#2.13) Loanwords in Slovak with alternating vowels

svet<u>e</u>r	'sweater'
motocyk<u>e</u>l	'motorcycle'
semest<u>e</u>r	'semester'
septemb<u>e</u>r	'September'

(from Mellander 2000:216 (8))

(#2.14) Loanwords in Slovak with no alternating vowels

park	**par<u>e</u>k*	'park'
film	**fil<u>e</u>m*	'film'
koncept	**koncep<u>e</u>t*	'concept'
august	**augus<u>e</u>t*	'August'

(from Mellander 2000:216 (9))

(#2.15) Loanwords in Polish with alternating vowels

swet<u>e</u>r	'sweater, Nom. Sg.'
cyrki<u>e</u>l	'drafting compass, Nom. Sg.' (from 'circle')
per<u>e</u>ł	'pearl, Gen. Pl.'

Similar sonority factors may be observed in Polish data as well (#2.15), which recall the question of empirical adequacy.[11] Positing underlying abstract vowels in the lexicon (as either *yers* or floating vowels) allows for vowel~zero alternations to occur anywhere. However, because there are patterns in the environments in which vowel~zero alternations do or do not occur, this approach is less satisfactory than one based on rules or constraints in the grammar. The lexicon can only list things; to deal with patterns, we need rules or constraints.

More specifically, Mellander explains that "Without a synchronic epenthesis rule … Analysis III is empirically inadequate; it can account neither for the distributional facts of final consonant clusters, nor for the development of alternating vowels in loanwords in Slovak"

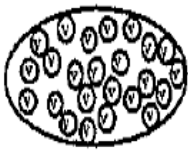
[11] See section 4.1 and Appendix A for a more detailed discussion of the sonority factors.

(Mellander 2000:216). Therefore, according to Mellander, in order to be empirically adequate, the optimal analysis must make use of both epenthesis and the deletion/vocalisation mechanism.

(#2.16) Standard analysis of vowel~zero alternations and sonority facts

Grammar Lexicon

Analysis IV:



(from Mellander 2000:217 (11))

(#2.17)

Alternation & Sonority Facts	EMPIRICALLY ADEQUATE	*COMPLEX GRAMMAR	*COMPLEX LEXICON
I.	*!	*	
☞ II.		**	*
III.	*!	*	**
IV.		**	**!

(from Mellander 2000:217 (12))

In table (#2.17) above, the Empirically Adequate constraint can be violated for two different reasons: Analysis I is observationally inadequate by failing to get the right surface forms; while Analysis III is inadequate in that it misses generalizations about where alternations occur. Finally, when given the choice between Analysis II and Analysis IV (described in #2.16), Analysis II will be deemed optimal due to its simpler lexicon. I therefore turn to an Optimality Theory analysis that avoids the use of abstract vowels in order to account for the vowel~zero alternation phenomenon in Polish nouns.

3. NON-SYLLABIC ROOTS

3.1. Optimality Theory and Syllabification

Both Mellander (2000:222) and Laskowski (1975:29) point out asyllabic roots as the most straightforward environment where underlying *yers* may be deemed unnecessary. Taking my cue from Mellander and Laskowski, I define asyllabic roots in Polish as those that do not have a constant vowel. In other words, asyllabic roots may have only one vowel, and that vowel alternates with zero. Therefore, this assumes that some of the examples of vowel~zero alternation presented in the introduction will not have any underlying vowel, whereas their non-alternating counterparts will, as in (#3.1) below:

(#3.1)	(a)			(b)		
	lew 'lion'	/lv/ → [lɛv]		*zlew* 'sink'	/zlɛv/ → [zlɛv]
	len 'flax'	/ln/ → [lɛn]		*teren* 'terrain'	/tɛrɛn/ → [tɛrɛn]
	pies 'dog'	/pʲs/ → [pʲɛs]		*bies* 'devil'	/bʲɛs/ → [bʲɛs]

As asyllabic roots, words such as those in (#3.1a) above need an epenthetic vowel in order to be syllabified. In Optimality Theory, this is a result of the interaction of DEP (#3.2) and constraints on syllable structure (#3.3).

(#3.2) DEP = Every segment of the output has a correspondent in the input.[12]
(i.e. prohibits epenthesis.)

(#3.3) NUCLEUS[13] = every word must have at least one syllable, and every syllable must have a vocalic nucleus.

(#3.4) NUCLEUS >> DEP

[12] More specifically, this constraint is the DEP-IO constraint in McCarthy & Prince 1995.
[13] The NUCLEUS constraint above is in fact used as shorthand for three separate but related constraints:
(1) Every phonological word must contain at least one syllable.
(2) The NUC constraint, which states that syllables must have nuclei (Prince & Smolensky 1993:96).
And finally and crucially for this paper:
(3) The *P/C constraint, which states that C may not associate to Peak (NUC) nodes. In other words, consonants may not be nuclei. (Prince & Smolensky 1993:96).

When NUCLEUS is ranked above DEP, as in (#3.4) above, it results in an epenthetic vowel in the environment of an asyllabic root with a zero affix, as shown in Table 1 below, as opposed to complete faithfulness of the output to the input.

Table 1: /lv+Ø/ = [lɛv] = 'lion, Nom. Sg.'

/lv+Ø/	NUCLEUS	DEP
lv	*!	
☞ lɛv		*

On the other hand, as Table 2 below illustrates, when an asyllabic root is inflected with a vocalic morpheme, the NUCLEUS constraint is not violated, and epenthesis is ruled out by DEP.

Table 2: /lv+ɨ/ = [lvɨ] = 'lion, Nom. Pl.'

/lv+ɨ/	NUCLEUS	DEP
☞ lvɨ		
lɛvɨ		*!

3.2. Regular Epenthetic Vowel Placement

However, the NUCLEUS constraint alone cannot account for the location of the epenthetic vowel within an asyllabic root. As in the example of *lew* 'lion' in the previous section, to ensure that the epenthetic vowel appears between the two consonants of the root, we need further constraints to eliminate the surfacing of an epenthetic vowel at the two root edges. The constraints ALIGNR (#3.5) and *COMPLEXCODA (#3.6) ensure that the epenthetic vowel does not surface at the end or at the beginning of the asyllabic root.

(#3.5) ALIGN-R = the right edge of the input must coincide with the right edge of the output

(#3.6) *COMPLEXCODA = one violation per every segment in a coda beyond one (i.e. codas are allowed to consist of at most one segment)

As Table 3 below illustrates, these two constraints prefer the candidate in which the epenthetic vowel is between the two consonants of the bi-consonantal asyllabic root.

Table 3: /lv+Ø/ = [lɛv] = 'lion, Nom. Sg.'

/lv+Ø/	NUCLEUS	DEP	*COMPLEXCODA	ALIGN-R
lv	*!			
☞ lɛv		*		
ɛlv		*	*!	
lvɛ		*		*!

These same two constraints can be used to determine epenthetic vowel placement in tri-consonantal asyllabic roots. Recall that *COMPLEXCODA is violated when there is more than one consonant in a coda. Therefore, when an asyllabic root is made up of three consonants, the optimal place for vowel insertion would be between the last two consonants. This is illustrated in Tables 4 and 5 below. Particularly note that in Table 4, there are no factors other than *COMPLEXCODA that could explain the position of the epenthetic vowel; for example, in terms of sonority, [kr] (in words such as [krɛv] 'blood, Nom. Sg.' below) and [rv] (in words such as [tʂɛrv] 'redness, Nom. Sg.') are perfectly well formed onsets and codas respectively.

Table 4: /krv+Ø/ = [krɛv] = 'blood, Nom. Sg.'

/krv+Ø/	NUCLEUS	DEP	*COMPLEXCODA	ALIGN-R
krv	*!			
☞ krɛv		*		
kɛrv		*	*!	
krvɛ		*		*!
kɛrɛv		**!		

Table 5: /mgʲw+Ø/ = [mgʲɛw] = ‘fog, Gen. Pl.’

/mgʲw+Ø/	NUCLEUS	DEP	*COMPLEXCODA	ALIGN-R
mgw	*!			
☞ mgʲɛw		*		
mɛgw		*	*!	
mgwɛ		*		*!
mɛgʲɛw		**!		

What is interesting about the example in Table 5 is that it recalls the issue of historical versus synchronic accounts. Gussmann (2007:184) points out that the alternant *mgieł* [mgʲɛw] ‘gen. pl’ for the word *mgła* [mgwa] ‘mist, fog’ suggests the presence of a *yer* between the last two consonants. However, the historical fact is that a *yer* was present between the first two consonants of the root, as in Old Slavic *mĭgla* (Gussmann 2007:184). I believe that this example also proves that the synchronic process of vowel~zero alternations must be different from the mechanisms which governed Proto-Slavic *yers*. Contemporary Polish relies more on constraints on syllable structure (such as *COMPLEXCODA) rather than where the *yer* was historically. Thus *yers* in contemporary Polish have predictable placement.[14]

3.3. OCP and Epenthetic Vowel Placement

Although, as the previous section stated, the epenthetic vowel in asyllabic roots will most often occur between the final two consonants, there are some exceptions to this rule. In my examination of the data on vowel~zero alternations, I have found only two words out of the large collection of asyllabic roots which do not exhibit epenthesis between the final two consonants. These are *cześć* [tʂɛɕtɕ] ‘honour, Nom. Sg.’ and *chrzest* [xʂɛst] ‘baptism, Nom. Sg.’. Their phonetic transcriptions show that the epenthetic vowel occurs between [tʂ] and [ɕ] in the case of

[14] Note that *COMPLEXCODA is sometimes violated. Polish does allow words of the form CVCC, for example [tʂɛrv] ‘redness, Nom. Sg.’ However, coda clusters occur only in cases where the vowel is underlying, rather than in asyllabic words exhibiting vowel~zero alternations. This in turn tells us that DEP >> *COMPLEXCODA.

'honour' and between [ʂ] and [s] in the case of 'baptism'. Irregular epenthetic vowel placement in asyllabic roots is found to occur before a C-Place [coronal] fricative that differs from the preceding consonant by also being specified for another place of articulation. A section of the feature chart from the introduction is reproduced below in order to illustrate the featural differences between C-Place [coronal] consonants.

(#3.7) Features of coronal consonants

Manner Description	Segment	C-Place			V-Place		C-Manner		V-Manner	
		[cor]	[dor]	[lab]	[cor]	[lab]	[cl]	[op]	[cl]	[op]
Stops	/p/			✓			✓			
	/pʲ/	✓		✓			✓			
	/t/	✓					✓			
	/tɕ/	✓			✓		✓			
	/tʂ/	✓	✓				✓			
	/ts/		✓				✓			
	/k/						✓			
Fricatives	/f/			✓				✓		
	/fʲ/	✓		✓				✓		
	/s/	✓						✓		
	/ɕ/	✓			✓			✓		
	/ʂ/	✓	✓					✓		
	/x/							✓		

Note that it is necessary to specify the pattern as occurring before a fricative as opposed to any coronal consonant because, as will be shown later in the paper, consonant sequences of [ʂt] and [tʂtɕ] are acceptable. It is safe to make this generalization because coronal consonant-fricative sequences of differing secondary place of articulation are not attested anywhere in the Polish language.[15] Note also that the velar consonants do not take part in this process since they are not specified for any place of articulation, while the palatal labials seldom take part in this process because they often neutralize to plain labials in clusters.

[15] See Bargiełówna 1950 cited in Jarmasz 2008:27-29,84-86 for a list of attested and non-attested consonant sequences.

(#3.8) Assimilation of coronal consonants across morpheme boundaries

zszarzeć	/s+ʂ/arzeć	→ [ʂʂ]arzeć	‘become grey’
ssie	/s+ɕ/e	→ [ɕɕ]e	‘suck (3sg)’
już zimno	ju/ʐ̨+ʑ/imno	→ ju[ʐ̨ʑ]imno	‘already cold’
bogatsi	boga/t+ɕ/i	→ boga[tɕɕ]i	‘richer (pl)’
nad ziemią	na/d+ʑ/emią	→ na[dʑʑ]emią	‘over the earth’

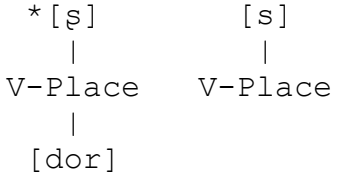
(Patkaniowska & Coleman 1944:50-51 and Dyszak 1997:151-152 cited in Jarmasz 2008:26-27)

Furthermore, Jarmasz (2008) cites several sources that list patterns of optional regressive assimilation across word and/or morpheme boundaries that involve coronal consonants (#3.8). I therefore posit an OCP constraint (#3.9) to eliminate any candidate that exhibits such consonant sequences. This will rule out independent feature geometries such as those in (#3.10) in preference for shared features such as those in (#3.11).

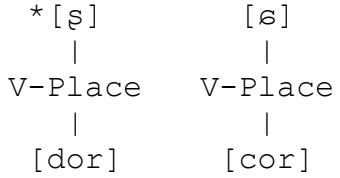
(#3.9) OCP-CORONAL = C-Place [coronal] fricatives cannot follow another C-Place [coronal] consonant specified for additional places of articulation

(#3.10) Unacceptable coronal sequence

(a)



(b)



(#3.11) Acceptable coronal sequence

Furthermore, the data shows that the OCP-CORONAL constraint is satisfied through the placement of the epenthetic vowel, as opposed to assimilation or dissimilation of one coronal fricative to the other, or the deletion of one of the coronal fricatives. Therefore, two more constraints are involved with this phenomenon and must be ranked accordingly. The MAX constraint (#3.12) will eliminate any instance of deletion, whereas the IDENT (#3.13) constraint will eliminate any instance of assimilation or dissimilation.

(#3.12) MAX = one violation per every segment present in the input that is not present in the output

(#3.13) IDENT = every segment in the output must be identical to its corresponding segment in the input

(#3.14) OCP-CORONAL, IDENT, MAX >> *COMPLEXCODA

All three constraints introduced in this section, OCP-CORONAL, IDENT, and MAX, must be ranked above *COMPLEXCODA to ensure that the epenthetic vowel surfaces between the two coronal fricatives. Furthermore, there is evidence that the DEP constraint must be ranked above *COMPLEXCODA in order to eliminate candidates with more than one epenthetic vowel. All this is illustrated in Tables 6 and 7 below.

Table 6: /tʂɛtɕ+Ø/ = [tʂɛɛtɕ] = 'honour, Nom. Sg.'

/tʂɛtɕ+Ø/	NUCLEUS	OCP-CORONAL	IDENT	MAX	DEP	*COMPLEXCODA
tʂɛtɕ	*!					
tʂɛɛtɕ		*!			*	
☞ tʂɛɛtɕ					*	*
tʂʂɛtɕ			*!		*	
tʂɛtɕ				*!	*	
tʂɛɛɛtɕ					**!	

Table 7: /xʐst+Ø/ = [xʐɛst] = 'baptism, Nom. Sg.'

/xʐst+Ø/	NUCLEUS	OCP-CORONAL	IDENT	MAX	DEP	*COMPLEXCODA
xʐst	*!					
xʐsɛt		*!			*	
☞ xʐɛst					*	*
xɛʐst		*!			*	**
xʐʂɛt			*!		*	
xʐɛt				*!	*	
xʐɛsɛt					**!	

However, when these roots are made syllabic through a vocalic suffix, the OCP-CORONAL constraint is satisfied through deletion. We therefore get forms such as the following, where the first of the two coronal fricatives is retained while the second deletes.[16]

(#3.15) /tʂɛtɕ+i/ → [tʂtɕi] 'honour, Gen. Sg.'
/xʐst+u/ → [xʐtu] 'baptism, Gen. Sg.'

An explanation for this phenomenon may be found if we consider the implications of an epenthetic segment in these forms. If the form of 'honour, Gen. Sg.' were *[tʂɛɛtɕi] and the form of 'baptism, Gen. Sg.' were *[xʐɛstu], then, following the rules of regular penultimate stress in Polish, the main stress would fall on the epenthetic vowel in both cases. However, many languages conspire against stressing (and footing) epenthetic segments (Alderete 2000). Alderete

[16] While I am unsure what determines that the second consonant, as opposed to the first, should delete in these cases, the pattern still remains.

1995 (cited in Alderete 2000) posits a HEAD-DEPENDENCE constraint (#3.16) to account for these phenomena in various languages.

(#3.16) HEAD-DEPENDENCE = one violation per every stressed segment in the output that is not present in the input

According to Aldrerete (2000), there are two main ways of ranking the HEAD-DEP constraint with respect to stress constraints (such as RHTYPE and FTALIGN). In (#3.17a) the HEAD-DEP constraint is ranked above stress constraints, which results in metrical inactivity of epenthesis. In other words, the epenthetic vowel is either not footed, or if it is footed it is not assigned stress. This may then result in stress occurring in a position other than what a language's regular stress constraints would predict. In (#3.17b), on the other hand, the HEAD-DEP constraint is ranked below stress constraints, which results in metrical activity of epenthesis. In other words, it allows epenthetic segments to be stressed and footed, resulting in completely regular stress.

(#3.17) (a) HEAD-DEP >> STRESS = metrical inactivity of epenthesis

(b) STRESS >> HEAD-DEP = metrical activity of epenthesis

(adapted from Alderete 2000:10)

However, Alderete (2000) does not mention a third possibility that follows from the interaction of HEAD-DEP and stress constraints. When epenthesis occurs in a main-stress position, both HEAD-DEP and stress constraints are violated. When neither of these violations is fatal, it is consequently possible for other lower-ranked constraints to determine the optimal candidate.

The ranking of these constraints is of course only crucial when there is a constraint that may be satisfied through a candidate with an epenthetic vowel. So far in the case of Polish, this constraint is OCP-CORONAL. Crucially, if HEAD-DEP and stress constraints are ranked above MAX (#3.18), then deletion is a possible means of satisfying the OCP constraint.

(#3.18) OCP-CORONAL, IDENT, HEAD-DEP, PENULTSTRESS >> MAX

Note that the constraint ranking above makes use of PENULTSTRESS, defined in (#3.19) below. In reality, PENULTSTRESS is shorthand for the set of constraints that generate regular penultimate stress in Polish (particularly ALIGN(PW,R,Ft,R), which aligns the right edge of a foot with the right edge of a word; and FT-FORM(Trochaic), which stressed the first of two syllables in a foot).[17]

(#3.19) PENULTSTRESS = main stress must be on the penultimate syllable, if the word is not monosyllabic

Furthermore, OCP-CORONAL and IDENT must also be ranked above MAX in order to eliminate the faithful and assimilation candidates (#3.18). When HEAD-DEP and PENULTSTRESS eliminate candidates with stress on an epenthetic segment and candidates with stress on the ultimate syllable, the optimal candidate is one with a deleted consonant. This all is illustrated in Tables 8 and 9 below.

[17] See Idsardi 1994 for a discussion about Polish stress and Optimality Theory constraints.

Table 8: /tʂɛtɕ+i/ = [tʂtɕi] = ‘honour, Gen. Sg.’

/tʂɛtɕ+i/	NUCLEUS	OCP-CORONAL	IDENT	PENULTSTRESS	HEAD-DEP	MAX	DEP
ˈtʂɛtɕi		*!					
tʂɛ.ˈɛtɕi				*!			*
ˈtʂɛ.ɛtɕi					*!		*
ˈtʂʂtɕi			*!				*
☞ ˈtʂtɕi						*	

Table 9: /xʐst+u/ = [xʐtu] = ‘baptism, Gen. Sg.’

/xʐst+u/	NUCLEUS	OCP-CORONAL	IDENT	PENULTSTRESS	HEAD-DEP	MAX	DEP
ˈxʐstu		*!					
xʐɛ.ˈstu				*!			*
ˈxʐɛ.stu					*!		*
ˈxʐʂtu			*!				*
☞ ˈxʐtu						*	

4. SONORITY HIERARCHY

4.1. Evidence of the Sonority Hierarchy

As the previous section showed, epenthesis can easily account for vowel~zero alternations in asyllabic roots. However, the question still remains of what drives epenthesis in roots that already have at least one vowel underlyingly. Recall from section 2.3 that Mellander (2000), in his analysis of Czech and Slovak, pointed out that the distribution of vowel-zero alternations and final consonant clusters coincides with sonority factors. In this section I set out to find out if similar sonority factors are at play in Polish.

Drawing on Laskowski (1975), who provides a description of the types of environments in which vowel~zero alternations occur, I compared consonant sequences that exhibit vowel~zero alternations with those that do not. Through this, I expanded Laskowski's observations and categories to include more detailed nuances I found within my own data.[18] The results of this task allowed me to devise a sonority hierarchy for Polish codas.[19]

(#4.1) Sonority Hierarchy for Polish Codas

Highest

w
n
r
j
ɕ, ʑ
tɕ, dʑ
l
ɲ
mʲ, fʲ, vʲ, pʲ, bʲ
m
x, ʂ, ʐ, s, z, f, v, k, g, t, d, ts, p, b

Lowest

[18] Refer to Appendix A for a detailed comparison of possible consonant sequences.
[19] Note that I can only claim this hierarchy to be true for codas because Polish appears to be much more lenient with respect to the consonant clusters that comprise well formed onsets.

The process of devising the hierarchy proceeded through several stages. First, the data was sorted into categories dependent on the final consonant in the cluster. Next, each category was further subcategorized by the second last consonant in the cluster. Finally, for each category, a boundary was determined that would divide the subcategories that consistently exhibit vowel~zero alternations from the subcategories that consistently do not. At this point it was important to also consider and eliminate data with consonant sequences that could be a result of other factors.[20] In the end, each final consonant category was given a ranking depending on where the boundary occurred. The assumption then follows that consistent vowel~zero alternations between a sequence of consonants were evidence that the second consonant was more sonorous than the first.

It is possible to call this ranking a sonority hierarchy because it does in fact follow some generally accepted sonority trends. Namely, more phonetically sonorous segments such as the semi-vowel [w] and the nasal [n] are ranked high on the hierarchy, whereas less phonetically sonorous segments such as plain stops and fricatives are ranked low on the hierarchy. Furthermore, it has been noted (Steriade 1982)[21] that the sonority hierarchy may differ across languages, so it is not so surprising to find a few deviations in Polish. The main place where the Polish sonority hierarchy in (#4.1) diverges from the accepted phonetic hierarchy is with respect to palatal segments. It appears that Polish consonants divide into three main groups of falling sonority: sonorants, palatals, and obstruents. The sonority hierarchy for Polish codas is reproduced below, this time with the relevant features of each segment noted.

[20] See section 5 for a discussion about these cases.
[21] See in particular Steriade 1982 chapter I section 3.4.

(#4.2) Sonority Hierarchy for Polish Codas with extra information

Segment	C-Place			V-Place		C-Manner		V-Manner		
	[cor]	[dor]	[lab]	[cor]	[lab]	[cl]	[op]	[cl]	[op]	
/w/					✓	✓		✓		sonorants (C-place unspecified & non-palatal)
/n/						✓	✓			
/r/						✓?			✓?	
/j/				✓		✓			✓	palatal segments (V-place [coronal])
/ɕ/	✓			✓			✓			
/tɕ/	✓			✓		✓				
/l/				✓	✓	✓		✓		
/ɲ/				✓		✓	✓			
/mʲ/	✓		✓			✓	✓			palatalized labials
/fʲ/	✓		✓				✓			
/pʲ/	✓		✓			✓				
/m/			✓			✓	✓			labial nasal
/f/			✓				✓			plain fricatives and stops
/s/	✓						✓			
/ʂ/	✓	✓					✓			
/x/							✓			
/p/			✓			✓				
/t/	✓					✓				
/tʂ/	✓	✓				✓				
/ts/		✓				✓				
/k/						✓				

The specific features of each of the segments in the hierarchy can shed further light on the structure of the hierarchy as a whole. Note that there is a progression in the types of place features considered more sonorous than others. Therefore, although there are some parallels between the Polish hierarchy and phonetic hierarchies, it makes more sense to think of this hierarchy as a more abstract or formal kind of sonority rather than a purely (acoustic) phonetic one.[22]

As a final note, I would like to discuss the status of the class of palatal segments. There are a couple of things to point out. First, palatalized labials are crucially more sonorous than

[22] See Rice 1992 for a discussion about sonority and formal hierarchies.

plain labials, but also crucially less sonorous than prepalatals.[23] Featurally, they are also different from both groups because they have an additional (high-sonority) coronal feature unlike their plain counterparts. However, this coronal feature occurs under the (low-sonority) C-Place node, unlike the prepalatal consonants, which have features under the (high-sonority) V-Place node. Second, it may seem strange to have [l] pattern with the palatal consonants in the hierarchy as opposed to with the sonorants. However, it is not so strange if we consider the role of [l] as the palatal counterpart to [w]. Historically, [w] developed from 'dark' [ɫ], which makes its relationship to [l] more clear. In modern Polish [w] and [l] still function together in many phonological phenomena, particularly as a plain/palatal pair in palatalizing environments (compare the [s]/[ɕ] pair in #4.3a to the [w]/[l] pair in #4.3b). This is also the reason why in the feature geometry adopted in this paper, [l] differs from [w] only by having an additional V-Place [coronal] feature.

(#4.3) Palatalization preceding locative [-ɛ]

(a)	*czas-Ø*	[tʂas]	'time, Nom. Sg.'
	czasi-e	[tʂaɕɛ]	'time, Loc. Sg.'
(b)	*dział-Ø*	[dʑaw]	'division, Nom. Sg.'
	dzial-e	[dʑalɛ]	'division, Loc. Sg.'

4.2. Optimality Theory and Sonority Hierarchy

Accounting for sonority factors in Optimality Theory turns out to be a simple process if we assume that there is a single constraint (#4.4) that is violated when the sonority hierarchy is violated.

(#4.4) CODASONORITY = segments must not increase in sonority away from the nucleus

[23] See also section 6.1 for a discussion on the status of palatalized segments as separate phonemes.

(#4.5) CODASONORITY, MAX >> DEP, *COMPLEXCODA, ALIGN-R

When CODASONORITY is ranked above DEP, it permits epenthesis to take place in coda segment sequences of rising sonority. Furthermore, MAX , *COMPLEXCODA, and ALIGN-R eliminate candidates that attempt to resolve the sonority hierarchy issue through deletion, epenthesis between the first two segments of a tri-consonant cluster, or epenthesis at the word edge, respectively. The interaction of the constraints is illustrated in the following tables:

Table 10: /ɕfʲatw+Ø/ = [ɕfʲatɛw] = 'light, Gen. Pl.'

/ɕfʲatw+Ø/	CODASONORITY	MAX	DEP	* COMPLEXCODA	ALIGN-R
ɕfʲatw	*!				
☞ ɕfʲa.tɛw			*		
ɕfʲa.twɛ			*		*!
ɕfʲaw		*!			

Table 11: /marxvʲ+Ø/ = [marxɛv] = 'carrot, Nom. Sg.'[24]

/marxvʲ+Ø/	CODASONORITY	MAX	DEP	* COMPLEXCODA	ALIGN-R
marxv	*!			**	
☞ mar.xɛv			*		
ma.rɛxv	*!		*	*	
mar.xvʲɛ			*		*!

On the other hand, when the same consonant sequences are not in a coda, epenthesis does not take place, as the following tables illustrate. Note that HEAD-DEP is the constraint that is fatally violated in these examples. This is consistent with the idea that epenthetic vowels should not be stressed in Polish. Due to the prominence of penultimate stress, epenthesis into the penultimate syllable, as may be the case with these consonant clusters, is banned. Nonetheless,

[24] Note that for *marchew*, the *COMPLEXCODA constraint is not crucial because the sonority violation occurs between the final two consonants of a tri-consonant cluster. However, in a word like *listew*, presumably the [stw] cluster is of equal sonority, according to the previously established hierarchy. Note also that although [vʲ] is neutralized to [v] at the end of the word, it still remains [vʲ] for purposes of Sonority.

even if the HEAD-DEP constraint were irrelevant, the DEP constraint would eliminate candidates with epenthetic vowels since the SONORITY constraint no longer motivates epenthesis.

Table 12: /ɛfʲatw+ɔ/ = [ɛfʲatwɔ] = 'light, Nom. Sg.'

/ɛfʲatw+ɔ/	HEAD-DEP	CODASONORITY	MAX	DEP	* COMPLEXCODA	ALIGN-R
☞ ɛfʲatwɔ						
ɛfʲatɛwɔ	*!			*		

Table 13: /marxvʲ+i/ = [marxvʲi] = 'carrot, Gen. Sg.'

/marxvʲ+i/	HEAD-DEP	CODASONORITY	MAX	DEP	* COMPLEXCODA	ALIGN-R
☞ mar.xvi						
mar.xɛ.vi	*!			*		
ma.rɛ.xvi	*!			*		

4.3. The Phonology of [r]

At this point it is necessary to address one glaring omission in the data in Appendix A: consonant clusters ending in [r]. This is due to the fact that the data involving [r] is the most complicated out of all the environments. As far as I can tell, there is no way of distinguishing words that exhibit vowel~zero alternations from words that do not, when confronted with a *Cr* cluster.[25] I therefore believe that the solution to this problem can only lie in the existence of an additional phoneme.

First, this additional phoneme may be due to the existence of two separate [r]s. Consider the observation (found in Jarmasz 2008:47) that the palatalised counterpart to the velar [x] is the coronal [ʂ]. Similarly, when a stem ends with [r], in all contexts where other consonants undergo palatalization, the [r] changes to [ʐ]. For example, the word [gra] 'game, Nom. Sg.' has [r] when the following segment is the feminine suffix [a], but it becomes [gʐɛ] with the [r] being replaced by [ʐ] when the following segment is the (palatalising) locative singular suffix [ɛ]. These

[25] See Appendix B for some data.

alternations reflect the historical development from *[rʲ] through a trilled fricative [r̝] to [ʐ]. If we assume that relationship of /ʂ/ to /x/ is the same as /ʐ/ to /r/, and if the phonological representation of the voiced and voiceless retroflex fricatives /ʂ/ and /ʐ/ are the same, then it follows that /x/ and /r/ also share the same phonological representation. Therefore, if /r/ is the voiced counterpart to /x/, then it follows that in terms of phonological features Polish /r/ is more like the voiced velar fricative /ɣ/.

Although it may be surprising to find a coronal liquid patterning with velars, as Jarmasz said, "The phonetic characteristics of segments have long determined the natural classes of coronals assumed, in spite of non-negligible phonological evidence pointing to another configuration" (Jarmasz 2008: 62). This statement also holds true for the discussion regarding [w] and [l] in subsection 4.1 above. Since Polish does not have a voiced velar fricative, it is possible for [r] to be the functional voiced counterpart to [x].

Therefore, if we consider [r] to be a voiced velar fricative, then we would not expect it to trigger epenthesis in *Cr* clusters because phonologically it would have one of the lowest sonority rankings in the hierarchy. On the other hand, if we consider [r] to be a liquid, then we would expect it to trigger epenthesis in *Cr* clusters because as a phonologically highly sonorant segment, most clusters that end in it would violate the sonority hierarchy. It follows then that if we posit two /r/s, one obstruent /r_1/ (or /ɣ/) and one sonorant /r_2/ (or /r/), then the *Cr* clusters which surprisingly do not exhibit vowel~zero alternations must end in /r_1/, while those that do must end in /r_2/.

However, the problem with the above account is that there is no outside evidence for [r] patterning in two different ways elsewhere. Therefore, the validity of this account is questionable. The second account, on the other hand, returns to the question of *yers*. Recall that at the end of section 2 it was not the fact that *yers* were used to account for vowel~zero

alternations that was the problem. The problem lay in the fact that *yers* were used to account for vowel~zero alternations in all cases, at the expense of ignoring other patterns. Mellander (2000) admitted that a deletion/vocalization mechanism for *yers* may be necessary in certain cases. The question of *Cr* clusters may therefore be just one of those cases where *yers* must be employed to account for the vowel~zero alternations.[26]

[26] See also Appendix A, where other examples of contexts where *yers* may have to be encoded are noted. Note particularly *Cv* sequences.

5. EXCEPTIONS TO SONORITY-BASED EPENTHESIS

Although the sonority hierarchy discussed in the previous section can account for many instances of vowel~zero alternations, there are certain exceptions. It is these exceptions that are often the counterexamples to straightforward deletion or epenthesis accounts, and form the basis of argument for abstract vowels in Polish. I have been able to divide these exceptions into three groups, and I turn to a discussion of each of them in the following sub-sections.

5.1. Native vs. Borrowed Vocabulary

In comparing roots which have the same final consonant cluster, one of the most glaring discrepancies between the group of words that exhibit vowel~zero alternations and those that do not is that the group of words that do not exhibit vowel~zero alternations appears to be entirely made up of foreign borrowings. Consider, for example, the data in (#5.1) below which highlights this contrast in three ways. In (#5.1a) a native Polish word exhibits a vowel~zero alternation between [j] and [n], while an uncommon foreign borrowing does not. In (#5.1b) a borrowing that has undergone nativization exhibits a vowel~zero alternation between [k] and [l], while a less nativized borrowing does not. Note for example that the nativized borrowing has a meaning far removed from the original source, unlike its less nativized counterpart whose meaning is identical to its source. Finally, in (#5.1c) a native word that may optionally exhibit a vowel~zero alternation contrasts with a foreign borrowing which may never do so.

(#5.1) Vowel~zero alternations and foreign vocabulary

(a)	Native:	[vɔjna] (Nom. Sg.) ~ [vɔjɛn] (Gen. Pl.) ‘war’
	Foreign:	[xlajna] (Nom. Sg.) ~ [xlajn] (Gen. Pl.) Ancient Greek costume
(b)	Nativized:	[tsɨrklɛ] (Nom. Pl.) ~ [tsɨrkʲɛl] (Nom. Sg.) ‘compass’ (from English *circle* or French *cercle*)
	Foreign:	[tsɨklɛ] (Nom. Pl.) ~ [tsɨkl] (Nom. Sg.) ‘cycle’
(c)	Native:	[sarna] (Nom. Sg.) ~ [sarɛn]/[sarn] (Gen. Pl.) ‘deer’
	Foreign:	[urnɨ] (Nom. Pl.) ~ [urn] (Nom. Sg.) ‘urn’

Kiparsky (1982:132), in his discussion of diacritic features, notes that “features like [±Foreign] have seemed more appropriate because loanwords are characteristically exceptions not just to one rule, but to a large number of rules, and tend to fall into classes exhibiting similar behavior.” In Polish, foreign borrowings not only fail to exhibit vowel~zero alternations, but also fail to exhibit many other vowel alternations found in the language, such as the very common *ɔ~u* alternation (#5.2) discussed briefly in section 1.2. Similarly, Mellander (2000:222) also points out that foreign borrowings exhibiting vowel~zero alternations in Slovak do not conform to the regular pattern of vowel harmony.

(#5.2) Vowel alternations and foreign vocabulary

Foreign	Native
[kɔvbɔj]~[kɔvbɔjɛ] ‘cowboy’	[buj]~[bɔjɛ] ‘battle’
[rɔl]~[rɔla] ‘role’	[mul]~[mɔlɛ] ‘moth’
[sɨnagɔg]~ [sɨnagɔga] ‘synagogue’	[bug]~[bɔga] ‘God’

With the understanding that borrowed vocabulary will behave differently from native vocabulary, I propose a constraint that may only be violated in cases of roots marked with a [+Foreign] diacritic (#5.3).

(#5.3) DEPFOREIGN = one violation per every segment present in the output of a morpheme of foreign origin that is not present in the input (i.e. no epenthesis within a foreign morpheme).

In this case, the constraint eliminates epenthesis within words of foreign origin. To do so, it must be ranked above CODASONORITY and DEP (#5.4). Additionally, ALIGN-R is required to rank above CODASONORITY in order to eliminate epenthesis at the edge of the word. The interaction of these constraint rankings is illustrated in Tables 14 and 15, which give an example of an [mn] coda cluster in native and borrowed vocabulary respectively[27].

(#5.4) DEPFOREIGN, ALIGN-R >> SONORITY >> DEP

Table 14: Native vocabulary: /trumʲn+Ø/ = [trumʲɛn] = 'coffin, Gen. Pl.'

/trumʲn+Ø/	DEPFOREIGN	ALIGN-R	CODASONORITY	DEP
trumn			*!	
trumnɛ		*!		*
☞ trumʲɛn				*

Table 15: Borrowed vocabulary: /kolumn+Ø/ = [kolumn] = 'column, Gen. Pl.'

/kolumn+Ø/	DEPFOREIGN	ALIGN-R	CODASONORITY	DEP
☞ kolumn			*	
kolumnɛ		*!		*
kolumɛn	*!			*

5.2. Affix Contiguity

The second group of exceptions is similar to that presented in the previous section. Here there is a lack of epenthesis in coda sequences of rising sonority, but in this case the words are native. An examination of the data reveals that epenthesis in nouns does not occur when these

[27] Note that whether or not the [m] in an [mn] cluster is palatal does not make a difference since both segments are lower on the sonority hierarchy than [n].

nouns are a combination of root plus derivational affix, as with the [zn] consonant sequence in (#5.5) below, where /-izn/ is a nominalizing suffix.[28]

(#5.5) (a) *błazen* /bwazn+Ø/ → [bwazɛn] 'fool, Nom. Sg.'
błazna /bwazn+a/ → [bwazna] 'fool, Gen. Sg.'

(b) *bielizn* /bʲɛl+izn+Ø/ → [bʲɛlizn] 'undergarment, Gen. Pl.'
bielizna /bʲɛl+izn+a/ → [bʲɛlizna] 'undergarment, Nom. Sg.'

Just as in the previous subsection, I propose a new constraint that may only be violated by affixes (#5.6).

(#5.6) DEPAFFIX = one violation per every segment present in the output of an affix that is not present in the input.

(#5.7) DEPAFFIX, ALIGN-R >> SONORITY >> DEP

Just like DEPFOREIGN in the previous section, when ranked above SONORITY and DEP (#5.7), DEPAFFIX results in a lack of epenthesis in coda sequences that are part of affixes. Tables 16 and 17 below illustrate the interaction of the constraints in simple and derived nouns.

Table 16: /bwazn+Ø/ = [bwazɛn] = 'fool, Nom. Sg.'

/bwazn+Ø/	DEPAFFIX	ALIGN-R	CODASONORITY	DEP
bwazn			*!	
bwaznɛ		*!		
☞ bwazɛn				*

Table 17: /bʲɛl+izn+Ø/ = [bʲɛlizn] = 'undergarment, Gen. Pl.'

/ bʲɛl+izn +Ø/	DEPAFFIX	ALIGN-R	CODASONORITY	DEP
☞ bʲɛlizn			*	
bʲɛliznɛ		*!		*
bʲɛlizɛn	*!			*

[28] There are other nominal suffixes whose form includes a cluster of two or more consonants (e.g. /-isk/, /-ɔɛtɛ/, /-stf/). None of these clusters explicitly violates the sonority hierarchy, and therefore an epenthetic vowel is not predicted. However, since the [zn] sequence does violate the hierarchy, I focus on the suffix /-izn/ in this section.

Furthermore, the DEPAFFIX constraint must be violated not only when there is epenthesis within an affix but also when there is epenthesis at the edge of an affix (specifically, between the affix and the stem). Consider the data in (#5.8) below and note that a [ptɕ] cluster violates the Sonority Hierarchy for Polish Codas.

(#5.8)	(a)	*kapeć-Ø*	[kapɛtɕ]	'slipper, Nom. Sg.'
		kapci-a	[kaptɕa]	'slipper, Gen. Sg.'
	(b)	*babć-Ø*	[baptɕ]	'grandmother, Gen. Pl.'
		babci-a	[baptɕa]	'grandmother, Nom. Sg.'

In (#5.8a), epenthesis occurs as predicted in order to break up a coda cluster with rising sonority. However, the same fails to occur in (#5.8b). The answer to the problem may be found if we consider the morphological structure of the two words. I assume that *kapeć* consists of only one morpheme since a new and unrelated word would be formed if we were to separate *–(e)ć* from a possible stem (*kap-a* 'bedspread cover').[29] On the other hand, *babć* can be deconstructed into the stem from *bab-a* '(old) woman', and the suffix *–ć*, which has a diminutive connotation.

Therefore, once again we have a situation where epenthesis occurs in monomorphemic words but does not occur in bimorphemic words. Tables 18 and 19 below show the interaction of these morphological factors with constraints.

Table 18: /kaptɕ+Ø/ = [kapɛtɕ] = 'slipper, Nom. Sg.'

/kaptɕ+Ø/	DEPAFFIX	ALIGN-R	CODASONORITY	DEP
kaptɕ			*!	
kaptɕɛ		*!		
☞ kapɛtɕ				*

[29] See the following subsection 5.3 for a discussion about why a vowel~zero alternation within an affix may be possible.

Table 19: /bab+tɕ+Ø/ = [babtɕ] = ‘grandmother, Gen. Pl.’

/bab+tɕ+Ø/	DEPAFFIX	ALIGN-R	CODASONORITY	DEP
☞ babtɕ			*	
babtɕɛ		*!		*
babɛtɕ	*!			*

To summarize the effects of DEPAFFIX, DEPFOREIGN and ALIGN-R one can say that all epenthetic vowels must be internal to a native root.

5.3. Unmarked Vowel Deletion

While the previous two sub-sections dealt with explaining the lack of epenthesis in environments where it is expected, this section will deal with the apparent presence of epenthesis where it is not expected. To illustrate the problem, consider the sequence [sk] in the following data:

(#5.9) (a) *pisk* [pisk] ‘squeal, Nom. Sg.’
piski [piski] ‘squeal, Nom. Pl.’

(b) *pasek* [pasɛk] ‘belt, Nom. Sg.’
paski [paski] ‘belt, Nom. Pl.’

(c) *łaska* [waska] ‘grace, Nom. Sg.’
łask [wask] ‘grace, Gen. Pl.’

(d) *łaska* [waska] ‘stoat, Nom. Sg.’
łasek [wasɛk] ‘stoat, Gen. Pl.’

An [sk] sequence has a steady sonority cline according to the hierarchy given in section 4, and as such conforms to the sonority hierarchy. Therefore, there should be no need for epenthesis, and yet we still find vowel~zero alternations in words like ‘belt’ (#5.9b) and ‘stoat’ (#5.9d) above. This is in contrast to (#5.9a) and (#5.9c), which predictably do not exhibit vowel~zero alternations.

In order to understand this, it is necessary to return to the question of derivational morphemes once again. Laskowski (1975) acknowledges the possibility that some nouns which exhibit vowel~zero alternations can be analyzed as bi-morphemic. Furthermore, in addition to

noun stems, Rubach also posited underlying *yers* in his representation of certain derivational morphemes, particularly diminutives. Diminutive suffixes consistently exhibit vowel~zero alternations, and as the examples in (#5.10) show, they may be iterative. According to Rubach, diminutive suffixes are underlyingly /ɨk/, and their vowel, just like any other *yer*, surfaces when there is another *yer* following and deletes elsewhere.

(#5.10)	*pies*	/pʲɨs+ɨ/	→	[pʲɛs]
	psa	/pʲɨs+a/	→	[psa]
	piesek	/pʲɨs+ɨk+ɨ/	→	[pʲɛsɛk]
	pieska	/pʲɨs+ɨk+a/	→	[pʲɛska]
	pieseczek	/pʲɨs+ɨk+ɨk+ɨ/	→	[pʲɛsɛtʂɛk]
	pieseczka	/pʲɨs+ɨk+ɨk+a/	→	[pʲɛsɛtʂka][30]

What is interesting about diminutives for the purpose of this paper is that in form they are identical to a common derivational morpheme found on nouns (/-(ɛ)k/). In fact, the only difference between the diminutive and the derivational morphemes is semantic. Assuming that a [k] segment at the end of a word could be indicative of a derivational morpheme, it is possible to attempt to deconstruct the words in (#5.9) above. By subtracting the nominalizing suffix /-(ɛ)k/ from [pasɛk] 'belt, Nom. Sg.' in (#5.9b), we are left with the sequence [pas] 'waist, Nom. Sg.', which bears a clear semantic relationship to the affixed word. Similarly, if we consider that there are two words for 'stoat' in the Polish language, one being [waska] in (#5.9d) above and the other [waɕitsa], we can see that both names for 'stoat' are made up of the root /was/ plus a nominalizing suffix in the shape of either /-(ɛ)k/ or /-its/.[31] Therefore, it is possible to attribute

[30] Note that Rubach also posits that the *yer* is responsible for the change in [k] consonant quality. While I cannot explain this phenomenon in my paper, it is my belief that the consonant change may be due to neutralization. See section 6.1 for a brief discussion.

[31] Note that the /s/ in the root is palatalized and surfaces as [ɕ] when followed by the high front vowel [i] in the suffix. Recall also that /-a/ is the regular feminine nominative singular suffix.

the difference in behaviour of the words in (#5.9a) and (#5.9c) versus (#5.9b) and (#5.9d) above to the idea that (#5.9a) and (#5.9c) are mono-morphemic while (#5.9b) and (#5.9d) are bi-morphemic stems.

An investigation into the common derivational affixes found in noun stems reveals three different phonological patterns.

(#5.11)(a)

[-ɛts]~[-ts]	e.g. *malec* 'little one/child, Nom. Sg.'	from *mał-y* 'small'
[-ɛk]~[-k]	e.g. *pasek* 'belt, Nom. Sg.'	from *pas* 'waist'
[-ɛɲ]~[ɲ]	e.g. *dureń* 'stupid one, Nom. Sg.'	from *dur-n-y* 'stupid'

(b)

[-b]	e.g. *wróżb* 'fortune, Gen. Pl.'	from *wróż-y-ć* 'to tell fortunes'
[-tɕ]	e.g. *babć* 'grandmother, Gen. Pl.'	from *bab-a* '(old) woman'
[-(r/l)ɲ]	e.g. *kopalń* 'mine, Gen. Pl.'	from *kop-a-ć* 'to dig'
	e.g. *cukierń* 'confectioner, Gen. Pl.'	from *cukier* 'sugar'

(c)

[-izn]	e.g. *bielizn* 'underwear, Gen. Pl.'	from *biel* 'whiteness'
[-isk]	e.g. *boisk* 'sports field, Gen. Pl.'	from *bój* 'battle'
[-ɔɛtɛ]	e.g. *ufność* 'trust, Nom. Sg.'	from *uf-n-y* 'trustful'

Group (#5.11a) is the most interesting for the purposes of this paper because the affixes that form part of the group exhibit vowel~zero alternations. The affixes in group (#5.11b) never exhibit any vowel, whereas the affixes in group (#5.11c) always exhibit a vowel. Groups (#5.11b) and (#5.11c), therefore, act as counterexamples to epenthesis or deletion respectively affecting derivational affixes as a whole. However, this is not completely the case. Note that the vowel in group (#5.11a) is *always* [ɛ], whereas the vowel in group (#5.11c) is *never* [ɛ]. Therefore, if we assume that the vowel in (#5.11a) is underlying, it is the quality of the vowel that sets the affixes apart from the affixes in (#5.11c). On the other hand, if we assume that the vowel in (#5.11a) is epenthetic, there are no phonological differences that can distinguish, for example, the [ɲ] in *dureń* in (#5.11a) from the [ɲ] in *curkierń* in (#5.11b). Therefore, unlike in

other sections of this paper, I assume that the alternating vowel in the affixes in (#5.11a) is underlying. Furthermore, I propose that an unmarked vowel [ɛ] in a derivational affix will delete when the affix is followed by a vocalic inflectional suffix.

Recall from section 3.3 that epenthesis failed to take place due to stress-related constraints. Once again I propose that stress is responsible for deletion in derivational affixes. It is necessary to make use of further constraints within the already established constraint hierarchy. These constraints need to penalize stress on unmarked vowels (i.e. [ɛ]) (#5.12) and eliminate stress within affixes (#5.13).

(#5.12) STRESS-TO-WEIGHT[32] = light/unmarked vowels should not be stressed

(#5.13) *STRESSAFFIX = affixes should not be stressed

However, neither of these individual constraints is consistently satisfied in Polish. It is important to note that unmarked vowels may be stressed when not in an affix (#5.14), and vowels in affixes may be stressed when they are not unmarked (#5.15).

(#5.14)	dzɛ̲́v-ɔ	'tree/wood, Nom. Sg.'
	ɕɛkʲɛ̲́r-a	'axe, Nom. Sg.'

(#5.15)	lɔdɔw-ɨ̲́sk-ɔ	'ice rink, Nom. Sg.'
	vɨsɔk-ɔ̲́ɕtɕ-i	'height, Nom. Pl.'

In order to eliminate stressing unmarked vowels in affixes, one or both of these constraints must be ranked above MAX in order to allow deletion to occur. However, doing so

[32] The definition of this constraint is used with the assumption that feature specification is responsible for defining "heavy" versus "light" vowels. Because unlike the other vowels in the system, [ɛ] is not specified for any features, it is considered a "light" vowel. The assumption that [ɛ] is the unmarked vowel is further supported by its status as the epenthetic vowel. See also Dresher & van der Hulst (1993).

would incorrectly predict deletion in the data from (#5.14) and (#5.15) above. Therefore, a constraint conjunction that combines STRESS-TO-WEIGHT and *STRESSAFFIX must be created (#5.16).

(#5.16) [STW & *STRESSAFFIX] = unmarked vowels in affixes should not be stressed

(#5.17) [STW & *STRESSAFFIX], PENULTSTRESS >> MAX >> STW, *STRESSAFFIX

When the conjoined constraint is ranked above MAX and MAX is ranked above STRESS-TO-WEIGHT and *STRESSAFFIX individually (#5.17), it paves the way for deletion to occur in the affixes found in (#5.11a) while at the same time ensuring that deletion does not take place for all unmarked vowels or in all affixes.[33] Furthermore, recall that PENULTSTRESS is ranked above MAX and therefore eliminates any candidate with irregular stress. The interaction of the constraints as they pertain to bi-morphemic stems with unmarked vowel derivational affixes is illustrated in Tables 20 and 21 below.

Table 20: /was+ɛk+Ø/ = [wasɛk] = 'stoat, Gen. Pl'

/was+ɛk+Ø/	[STW & *STRESSAFFIX]	PENULTSTRESS	CODASONORITY	MAX
wásk				*!
wasɛ́k	*!	*		
☞ wásɛk				

Table 21: /was+ɛk+a/ = [waska] = 'stoat, Nom. Sg.'

/was+ɛk+a/	[STW & *STRESSAFFIX]	PENULTSTRESS	CODASONORITY	MAX
☞ wáska				*
wasɛ́ka	*!			
wásɛka		*!		

[33] See Smolensky 1995 in which he discusses local conjunction. He states that universally C_1 & C_2 >> C_1, C_2 and that two constraint violations are worse when they occur in the same location (p4).

On the other hand, faithful candidates of mono-morphemic stems do not violate any constraints, as Tables 22 and 23 below illustrate. Neither would these constraints be violated by a word with an underlying [ɛ] vowel, as in Table 24.

Table 22: /wask+Ø/ = [wask] = ‘grace, Gen. Pl’

/wask+Ø/	[STW & *STRESSAFFIX]	PENULTSTRESS	CODASONORITY	MAX
☞ wásk				

Table 23: /wask+a/ = [waska] = ‘grace, Nom. Sg.’

/wask+a/	[STW & *STRESSAFFIX]	PENULTSTRESS	CODASONORITY	MAX
☞ wáska				

Table 24: /dzɛ̨v+ɔ/ = [dzɛ̨vɔ] = ‘tree/wood, Nom. Sg.’

/dzɛ̨v+ɔ/	[STW & *STRESSAFFIX]	PENULTSTRESS	CODASONORITY	MAX
☞ dzɛ̨́vɔ				

6. VOWEL-CONSONANT INTERACTIONS

6.1. Consonant Neutralization

Recall from section 1.1 my decision to include palatal consonants and in particular palatalized labial consonants in the phonemic inventory of Polish rather than treating them as allophones. Since not everybody agrees that these segments should be separate phonemes, this decision is by no means uncontroversial. However, my analysis so far depends on the belief that these segments are in fact separate phonemes, and as promised in the introduction I will outline the reasoning behind this in this section.

Recall from section 2.1 that Rubach's analysis included not only one but two abstract vowels. His two *yers* differed in that /ĭ/ is [-back] while /ɨ̆/ is [+back]. The apparent need to distinguish between these two types of *yers* can be exemplified by the following data:

(#6.1)	(a)	*dzień* 'day, Nom. Sg.'	[dʑɛɲ]	*dnia* 'day, Gen. Sg.'	[dɲa]
	(b)	*den* 'bottom, Gen. Pl.'	[dɛn]	*dno* 'bottom, Nom. Sg.'	[dnɔ]
	(c)	*wieś* 'village, Nom. Sg.'	[vʲɛɕ]	*wsi* 'village, Gen. Sg.'	[vɕi]
	(d)	*wesz* 'louse, Nom. Sg.'	[vɛʃ]	*wszy* 'louse, Gen. Sg.'	[vʃɨ]

Traditionally (as in Rubach 1984), the belief was that the first consonant of both 'day' and 'bottom' was underlyingly /d/, and the first consonant of both 'village' and 'louse' was underlyingly /v/. When the vowel surfaces, as in the first column of data set (#6.1), the type of *yer* would determine the quality of the preceding consonant. Thus, a front *yer* caused palatalization on the preceding consonant, while a back *yer* did not. Therefore, according to Rubach, the underlying representation of 'day' would be /dĭɲ/, while 'bottom' would be /dɨ̆n/. However, if we assume that the consonant in 'day' is palatal underlyingly, distinguishing between two types of *yers* becomes unnecessary. Under this approach, though, we need to account for why the consonants surface as non-palatal when the epenthetic vowel is absent.

Kochetov (2002) examined the distribution of palatal consonants in Slavic languages and noticed some neutralization patterns. For example, some underlying palatal consonants surface as plain consonants when in a coda (including word-finally), and in clusters of plain and palatal consonants, the preceding consonant may be neutralized (either by assimilation or by being realized as plain by default). In essence, the contrast between plain and palatal consonants is lost in certain pre-consonantal environments, and this is most often made evident when two consonants are brought together through affixation. Kenstowicz (1994) provides some basic examples of stem-final palatal consonants becoming depalatalized when followed by a consonantal suffix.

(#6.2)		noun	adjective	
	(a)	sɛkrɛ**t**	sɛcrɛ**t**-n-ɨ	‘secret’
		bru**d**	bru**d**-n-ɨ	‘dirt’
		ɕa**n**-ɔ	ɕɛ**n**-n-ɨ	‘hay’
	(b)	vilgɔ**tɕ**	vilgɔ**t**-n-ɨ	‘humidity’
		tʂɛla**dʑ**	tʂɛla**d**-n-ɨ	‘household’
		kɔ**ɲ**	kɔ**n**-n-ɨ	‘horse’

(adapted from Kenstowicz 1994:245)

The data in (#6.2) show that plain and palatalized consonants contrast word-finally, but not when followed by another consonant. Therefore, this same phenomenon may be active in the second column of (#6.1) at the beginning of this subsection. I hypothesize that the initial consonants in *dzień* and *wieś* are palatal underlyingly, and that they lose their palatal feature due to neutralization in pre-consonantal position. For example, the underlying representation of ‘day’ is /dʑɲ/ while the underlying representation of ‘bottom’ is /dn/. The palatal affricate [dʑ] in ‘day’ is neutralized to plain [d] when there is no vowel intervening between it and the following

consonant. The same kind of neutralization occurs with prepalatal affricates when next to [ɲ] in the following suffix.

(#6.3)	*przechodzi-eń-Ø*	[pʂɛxɔdʑɛɲ]	‘passer-by, Nom. Sg.’
	przechod-ni-a	[pʂɛxɔdɲi]	‘passer-by, Nom. Pl.’
	kwieci-eń-Ø	[kfʲɛtɕɛɲ]	‘April, Nom. Sg.’
	kwiet-ni-a	[kfʲɛtɲa]	‘April, Gen. Sg.’
	barć-Ø	[bartɕ]	‘type of man-made bee-hive, Nom. Sg.’
	bart-nik-Ø	[bartɲik]	‘beekeeper, Nom. Sg.’

The process of neutralization adds to the argument central to this paper; abstract vowels are unnecessary to account for vowel~zero alternations in Polish nouns. Assuming that consonants are palatal underlyingly eliminates the need for a distinction between palatalizing and non-palatalizing vowels, including eliminating the need for two *yers*. The process of neutralization appears to be too complicated to allow me to delve deeply into it in this paper, particularly because it does not affect each type of consonant equally (see for example the prepalatal fricative in [vwɔɕɛɲ]~[vwɔɕɲɛ] where the quality of the consonant remains the same). However, it is safe to say that certain constraints exist to penalize sequences such as [dʑɲ] from the Polish language. In more general terms, as the examples in (#6.2) and (#6.3) above show, prepalatal affricates are always neutralized to plain stops when followed by either [n] or [ɲ]. This, along with the data supporting the OCP constraint in Polish shows that there are many consonant-consonant and consonant-vowel interactions at play in Polish.

6.2. Epenthetic Vowel Quality

In all of the examples of vowel~zero alternation presented in this paper so far, the quality of the epenthetic vowel is [ɛ]. However, there are a handful of instances of vowel~zero alternation in nouns where the vowel is [ɔ].

(#6.4)	(a)	*osioł*	[ɔɛɔw]	'donkey, Nom. Sg.'
		osły	[ɔswɨ]	'donkey, Nom. Pl.'
	(b)	*kozioł*	[kɔʑɔw]	'goat, Nom. Sg.'
		kozły	[kɔzwɨ]	'goat, Nom. Pl.'
	(c)	*kociołł*	[kɔtɕɔw]	'cauldron, Nom. Sg.'
		kotły	[kɔtwɨ]	'cauldron, Nom. Pl.'

In order to fully understand the nature of the epenthetic vowel in Polish, it is necessary to discover the factors that determine its quality, particularly since two types of epenthetic vowels are possible. First, it is important to narrow down the possible epenthetic vowel choices to only [ɛ] and [ɔ]. Researchers such as Kager (1999) and Lombardi (2002) have relied on universal markedness constraints such as *[+low], *[+round], and *[-back] to predict the quality of the epenthetic vowel in various languages. According to Kager, the least marked vowel is [ə], while Lombardi, who proposes a *MID constraint, posits that the least marked vowel is [ɨ]. However, no ranking of these constraints alone can predict an epenthetic vowel surfacing as [ɛ] or [ɔ], even though several languages have been attested as having epenthetic [ɛ] (see de Lacy 2002:146 for a brief list). It is at this point that I turn to de Lacy (2002), who used sonority markedness constraints to determine the quality of epenthetic vowels.

De Lacy argues that epenthesis of "marked" vowels may stem from the fact that these vowels also tend to be more sonorous, thereby better satisfying the universal need for syllable

nuclei to have high sonority. He posits the following sonority hierarchy for vowels, analogous to Kenstowicz (1996:9), and makes use of this hierarchy in several constraints.

(#6.5) Vowel sonority scale (adapted from de Lacy 2002:55)
left to right from least sonorous to most sonorous

high central vowels	<	mid central vowels	<	high peripheral vowels	<	mid high peripheral vowels	<	mid low peripheral vowels	<	low vowels
ɨ ʉ	<	ɘ ɵ ə ɚ	<	i y ɯ u	<	e ø ɤ o	<	ɛ œ ʌ ɔ	<	æ a ɶ ɑ ɒ

De Lacy's (2002:48) Designated Terminal Element (DTE or Δ) rules make reference to the vowel sonority hierarchy by specifying the minimum sonority level that a segment must have in order to be the head of a particular constituent—moraic, syllabic, foot, or prosodic word. De Lacy further posits non-DTE (or –Δ) rules which in turn specify the maximum sonority level of a non-head segment in a particular context. When DTE rules dominate non-DTE rules, the result is an epenthetic segment of high sonority, whereas when non-DTE rules dominate DTE rules, the result is an epenthetic segment of low sonority (de Lacy 2002:146). Following this, de Lacy posits that epenthetic vowels of intermediate sonority are a result of the interaction of DTE and non-DTE rules. To explain this mechanism, de Lacy states:

> There is a further property of the DTE theory: a segment can be both a DTE and a non-DTE. For example, the [i] in [pá.ti] is the DTE of the syllable and mora, but a non-DTE of the foot and PrWd. Therefore, both DTE and non-DTE constraints can apply to it. The net result can be a tug-of-war between DTE constraints and non-DTE constraints, with the result that the least marked segment is neither high sonority nor low sonority, but has a quality that is a compromise between the two extremes – e.g. [ɛ].
>
> (de Lacy 2002:144)

More specifically, he posits two rules, one DTE (#6.6) and one non-DTE (#6.7), in the form of constraints to account for [ɛ] epenthesis in Chipewyan (pp151-153).

(#6.6) $*\Delta_{\sigma} \leq \{e,o\}$ = assigns one violation for every syllable nucleus that has a sonority equal to or less than [e,o] (i.e. bans all syllable nuclei with less sonority than low-mid vowels)

(#6.7) *-$\Delta_{PrWd}\geq$\{a\} = assigns one violation for every syllable without main stress that has a sonority greater or equal to [a] (i.e. bans unstressed vowels that are equal to [a])

When used for Polish, the DTE rule in (#6.6) above narrows down the possible epenthetic vowels to [ɛ ɔ a]. On the other hand, the non-DTE rule in (#6.7) above works to eliminate [a] from the possible epenthetic vowels in Chipewyan because in Chipewyan the epenthetic vowel will never receive main stress. However, this is not the case for Polish since asyllabic roots with epenthetic vowels have main stress fall on epenthetic [ɛ]. Therefore, we need a different rule to eliminate [a] as a possible epenthetic vowel. At this point I return to Lombardi (2002) for the constraint *[+low]. However, the feature system used in this paper does not have [±low] features. Instead, it uses [open] and/or [closed] to define manner and height. A [+low] feature would be equivalent to a V-Manner [open] feature. Therefore I reformulate Lombardi's *[+low] constraint into a *V-MANNER[open] constraint (#6.8).

(#6.8) *V-MANNER[open] = vowels with V-Manner [open] features are marked (i.e. low vowels are marked)

If both the DTE constraint *$\Delta_{\sigma}\leq$\{e,o\} and the * V-MANNER[open] markedness constraint are ranked high enough to be satisfied by all epenthetic vowels, the result is that [ɛ] and [ɔ] remain as the only possible epenthetic vowels.[34]

[34] Note that although [ɛ] and [ɔ] are the only epenthetic vowels in nominal paradigms, there is one other epenthetic vowel possible in Polish. Recall from section 2.1 that [i] occurs in vowel~zero alternations in verbs. It would appear that the constraints above would eliminate such a possibility. However, recall also that de Lacy (2002) posits a series of DTE rules, and that it is their ranking with respect to non-DTE rules and other constraints that ultimately determine the quality of the epenthetic vowel. It is possible that the environment of and motivation for epenthetic vowels in verbs is different from that of nouns, and therefore the quality of the epenthetic vowel is determined through different (higher or lower ranked) constraints. See also the conclusion where the possibility of extending this analysis to other lexical categories will be briefly discussed.

Table 25: Epenthetic vowel: sonority and height

C__C	*$\Delta_\sigma \leq$ {e,o}	*V-Manner[open]
CaC		*!
CɛC		
CɔC		
CɨC	*!	
CiC	*!	
CuC	*!	

Now that the quality of the epenthetic vowel has been narrowed down to two choices, the question of the choice between [ɛ] and [ɔ] remains. In related languages such as Slovak, it has been found that vowel~zero alternations differ in quality depending on the context. In his examination of epenthesis in Slovak, a language whose alternating vowel may also be either [ɛ] or [ɔ], Mellander (2000) points out that "with the exception of *šlager* 'hit', a recent German borrowing – the value for the feature [back] of the alternating vowel is the same as that of the vowel which precedes it" (Mellander 2000:222). Therefore, a rule of progressive vowel harmony would correctly predict the alternating vowel in the following Slovak nouns, particularly if [ɛ] is the default epenthetic vowel in a word such as *ker* 'bush', in which the vowel harmony rule does not apply at all. One interesting point to note about the following examples is that they were taken from Rubach (1993), who used them to argue that the quality of the alternating vowel must be underlying due to the fact that both [ɛ] and [ɔ] appear between the same consonants.

(#6.9)

liter	'litre'
lotor	'rascal'
ker	'bush'
cukor	'sugar'
šláger	'hit'
švagor	'brother-in-law'
príjem	'receipt'
nájom	'hiring'

(Rubach 1993:137, cited in Mellander 2000:222)

However, although the Polish examples in (#6.4) at the beginning of this subsection all have [ɔ] preceding the epenthetic vowel, progressive vowel harmony is not an active process in Polish, as it is in Slovak. In example (#6.10a) below, although the preceding vowel is [ɔ], the epenthetic vowel is [ɛ]. Instead, we must turn to the consonantal environment of the epenthetic vowel for answers.

(#6.10)	(a)	*oset*	[ɔsɛt]	'thistle, Nom. Sg.'
		osty	[ɔstɨ]	'thistle, Nom. Pl.'
	(b)	*poseł*	[pɔsɛw]	'envoy, Nom. Sg.'
		posły	[pɔswɨ]	'envoy, Nom. Pl.'
	(c)	*ćma*	[tɕma]	'moth, Nom. Sg.'
		ciem	[tɕɛm]	'moth, Gen. Pl.'

An examination of the consonantal environment of the epenthetic vowel in (#6.4) at the beginning of this section shows that in all cases the preceding consonant is prepalatal (i.e. [ɕ ʑ tɕ dʑ][35]) and the following consonant is a labial glide (i.e. [w]). Both sides of the environment must be satisfied for the epenthetic vowel to surface as [ɔ]. When only one side is present, such as a following labial glide in (#6.10b) or a preceding prepalatal consonant in (#6.10c), the epenthetic vowel surfaces as [ɛ].

In order to understand this fully, it is necessary to review the features associated with both the consonants and the vowels in question, illustrated in portions of the feature chart from the introduction reproduced below.

[35] Recall from section 6.1 the assumption that alternating consonants which occur alongside vowel~zero alternations are underlyingly palatal and neutralize to alveolars in many clusters.

(#6.11) Place feature chart for selected segments

Manner Description	Segment	C-Place			V-Place	
		[cor]	[dor]	[lab]	[cor]	[lab]
Stops	/t/	✓				
	/tɕ/	✓			✓	
	/tʂ/	✓	✓			
	/ts/		✓			
Fricatives	/s/	✓				
	/ɕ/	✓			✓	
	/ʂ/	✓	✓			
Nasals	/n/					
	/ɲ/				✓	
	/m/			✓		
Approximant	/w/					✓
Vowels	/ɛ/					
	/ɔ/					✓

Notice that both the vowel [ɔ] and the approximant [w] have a V-Place [labial] feature. On the other hand, [ɛ] is not specified for any V-Place features. At the same time, prepalatal consonants such as [tɕ] and [ɕ] have a V-Place [coronal] feature. I therefore posit that the choice of [ɔ] over [ɛ] in the contexts such as [ɕ]__[w] is related to whether or not the vowel shares V-Place features with the surrounding consonants.

Recall from section 3 that the OCP-CORONAL constraint is violated whenever two adjacent coronal consonants have differing secondary places of articulation. It is now necessary to point out that this violation not only occurs for coronal consonants, but also for any sequence of segments, the crucial factor being that sequences of segments must agree with respect to V-Place features. Because a high-ranked identity constraint will eliminate instances where segments present in the input are assimilated, only epenthetic vowels will be affected.

(#6.12) OCP-V-PLACE = adjacent segments cannot have separate V-Place nodes

(#6.13) IDENT >> OCP-V-PLACE

When neither of the consonants surrounding an epenthetic vowel has V-Place feature specifications the candidate with epenthetic [ɛ] is optimal because it does not incur any violations.

Table 26: Epenthetic vowel between two plain consonants

C C | | V-Place V-Place	OCP-V-PLACE
C ɛ C \ | / ☞ V-Place	
C ɔ C | | | V-Place V-Place V-Place | [lab]	*!*

The same optimal candidate is predicted in environments where one consonant is plain and the other consonant is specified for [coronal] V-Place. In this case, the candidate with [ɛ] incurs one violation. However, it is still optimal because the candidate with [ɔ] incurs two violations, as seen in Table 27.

Table 27: Epenthetic vowel between a plain and a prepalatal consonant

C C | | V-Place V-Place | [cor]	OCP-V-PLACE
C ɛ C \ / | ☞ V-Place V-Place | [cor]	*
C ɔ C | | | V-Place V-Place V-Place | | [lab] [cor]	**!

In cases where the environment is made up of segments with only V-Place [coronal] specifications, [ɛ] and [ɔ] receive two violations each. At this point it is again necessary to return to one of the three main universal markedness constraints discussed in Kager (1999) and Lombardi (2002), namely *[+round] (#6.14). Note that the Parallel Structures Model does not include [±round] features. Rather, a [+round] feature would be equivalent to a V-Place [labial] specification. In cases where both [ɛ] and [ɔ] are equal with respect to the OCP-V-PLACE constraint, it ensures that [ɛ] is the optimal candidate, as seen in Table 28 below.

(#6.14) *V-PLACE[labial] = vowel segments which have a V-Place [labial] feature specification are more marked than segments that do not. (i.e. rounded vowels are more marked than unrounded vowels).

Table 28: Epenthetic vowel between V-place [cor] and [dor] consonants

	OCP-V-PLACE	*V-PLACE[labial]
C C | | V-Place V-Place | | [cor] [cor]		
C ɛ C | | | ☞ V-Place V-Place V-Place | | [cor] [cor]	**	
C ɔ C | | | V-Place V-Place V-Place | | | [cor] [lab] [cor]	**	*!

The same situation occurs when the following segment is specified for the V-Place [labial] but the preceding segment does not have any V-Place specifications. In this case, both [ɛ] and [ɔ] get one violation each, and again, [ɛ] wins due to the *V-PLACE[labial] constraint.

Table 29: Epenthetic vowel between a plain consonant and a V-Place [lab] consonant

	OCP-V-PLACE	*V-PLACE[labial]
C C | | V-Place V-Place | [lab]		
C ɛ C \ / | ☞ V-Place V-Place | [lab]	*	
C ɔ C | \ / V-Place V-Place | [lab]	*	*!

Crucially however, when the following segment is [labial] and the preceding segment is not plain, then [ɛ] receives more violations than [ɔ] and is eliminated. This is what happens in the case of [kɔʑɔw] for example.

Table 30: Epenthetic vowel between prepalatal consonant and [w]

	OCP- V-PLACE	* V-PLACE[labial]
C C | | V-Place V-Place | | [cor] [lab]		
C ɛ C | | | V-Place V-Place V-Place | | [cor] [lab]	**!	
☞ C ɔ C | \ / V-Place V-Place | | [cor] [lab]	*	*

Table 31: Epenthetic vowel between two V-Place [lab] consonants

	OCP- V-PLACE	* V-PLACE[labial]
C C | | V-Place V-Place | | [lab] [lab]		
C ɛ C | | | V-Place V-Place V-Place | | [lab] [lab]	**!	
☞ C ɔ C \ | / V-Place | [lab]		*

Other permutations of possible sequences of segments with varying V-Place specifications where the first segment has a [labial] V-place are rare. Therefore, although Table

31 above predicts an epenthetic [ɔ] between two [w] segments, vowel alternations in this context are unattested. This is due to the fact that [w] is the highest ranked segment in the consonant sonority hierarchy, and as such should not be followed by an epenthetic segment in any cases of coda clusters in syllabic roots.

There are a couple of exceptions to this, which can be found in *Cn* coda cluster data found in Appendix A. A few words with [wn] coda clusters (i.e. *wełna* [vɛwna] ~ *wełen* [vɛwɛn] 'wool' and *czółno* [tʂuwnɔ] ~ *czółen* [tʂuwɛn] 'canoe') seem to be exceptions to the sonority rule. However, they are not exceptions to the vowel quality rule. In this case, a V-Place [labial] consonant is followed by a plain segment, and both [ɛ] and [ɔ] receive one violation leaving the *V-PLACE[labial] constraint to be the deciding factor.

Table 32: Epenthetic vowel between [labial] and plain consonants

C C | | V-Place V-Place | [lab]	OCP- V-PLACE	*V-PLACE[labial]
C ɛ C | \ / ☞ V-Place V-Place | [lab]	*	
C ɔ C \ / | V-Place V-Place | [lab]	*	*

However, while the vowel quality rule appears to be consistently true in syllabic roots, this does not seem to be the case in asyllabic roots. For example, in a word like *płeć* [pwɛtɕ] ~ *płci* [pwtɕi] 'gender', which has a V-Place[labial] consonant followed by a V-Place[coronal] consonant, the epenthetic vowel is [ɛ] even though the constraints set out in this section would

predict an epenthetic [ɔ]. Although I cannot offer a full analysis at this time, it appears that the choice of epenthetic vowel may work differently when this epenthetic vowel is the head of the prosodic word, as it is in cases of asyllabic roots. Therefore, it is my suspicion that there is a constraint that regulates vowel quality in the heads of prosodic words, and which must be ranked beneath faithfulness constraints in order to affect only epenthetic vowels in these positions.

7. CONCLUSION

Unlike many previous analyses of vowel~zero alternations, this paper brings to the foreground the patterns found in the Polish data. The patterns show that it is in fact possible to account for certain cases of vowel~zero alternations through a process of epenthesis, and other cases through a process of deletion, without having to resort to abstract or floating vowels.

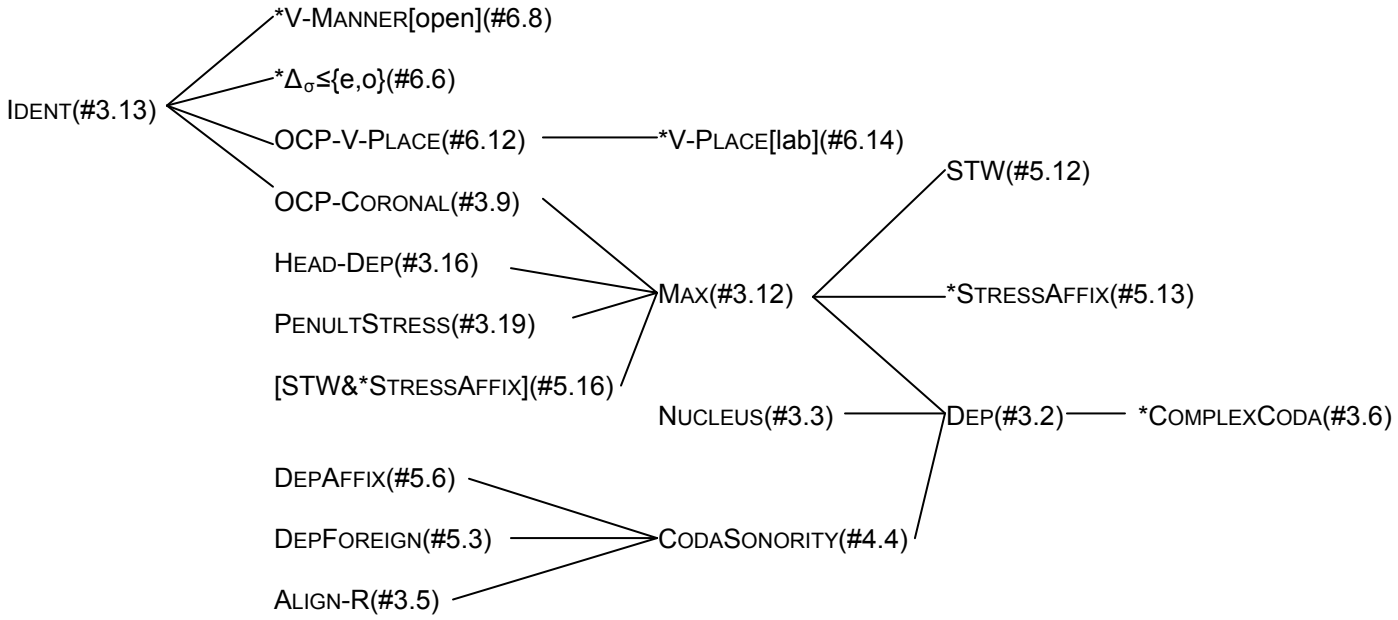
Starting with asyllabic roots, which require an epenthetic vowel in order to be vocalized, I have shown that epenthetic vowel placement is completely predictable. This is due both to the fact that the epenthetic vowel regularly appears between the final two consonants, as well as to the fact that the only exception to this is when it appears between two coronal consonants with different secondary places of articulation. Furthermore, in words that are already syllabified, it has been shown that certain consonant clusters always exhibit vowel~zero alternations, while other consonant clusters never do. This observation, in turn, pointed to sonority playing an important role in motivating epenthesis resulting in vowel~zero alternations.

Finally, section 5 has shown that an unpredicted presence or absence of vowel~zero alternations in consonant clusters is often due to one of two factors. The first and most straightforward factor is the foreign or native status of the vocabulary in question, with foreign vocabulary never exhibiting vowel~zero alternations. The second factor, on the other hand, is more complicated and involves various morphological factors. In cases where epenthesis is predicted to occur due to sonority, absence of epenthesis is a result of suffixes, which block epenthesis both within the affix and between the affix and the stem. In cases where epenthesis is not predicted to occur, presence of vowel~zero alternation is a result of an underlying [ɛ] in the suffix, which is subsequently deleted when in penultimate (i.e. stressed) position.

All of the cases above have been analyzed using constraints within Optimality Theory. Particularly interesting was the use of Alderete's (2000) HEADDEP constraint, which showed yet

another possible solution that languages employ to avoid stressing epenthetic vowels. The full constraint rankings (as summarized below in #7.1), in conjunction with the Sonority Hierarchy for Polish Codas, can account for most instances of vowel~zero alternations in Polish nouns.

(#7.1) Full Constraint Ranking



While I focused only on nouns in my research, it is my hope that the analysis presented in this paper can be extended to other lexical categories. For example, the analysis of vowel quality presented in section 6.2 would have to be extended to allow for epenthesis of [ɨ] in verbs in particular. However, there are certain aspects of the analysis presented in the paper that would not require any adjustment. For example, Laskowski (1975:38) points out that unlike the same type of cluster in nouns, *Cw* clusters in verbs do not exhibit vowel~zero alternations.

(#7.2) Verb data

pas-ł	[pasw]	'herd/pasture, 3.sg. past'	*paś-Ø-ć*	'to herd'
wióz-ł	[vʲuzw]	'transport, 3.sg. past'	*woz-i-ć*	'to transport'

An analysis of the data (#7.2) shows that this may be because in verbs a final *–w* is a past tense suffix. Therefore, the lack of epenthesis in these cases is unsurprising if we recall from section 5.2 that epenthesis is blocked from occurring between a stem and suffix.

Finally, although there are some contexts in which vowel~zero alternations cannot be explained through the above means (for example *Cr* clusters discussed in section 4.3, as well as others highlighted in Appendix A), the patterns already highlighted in this paper cannot be ignored. This shows that explaining vowel~zero alternations through encoding the lexicon with abstract vowels such as *yers* (Rubach 1984, summarized in section 2.1), or floating vowels within a mechanism of melody association (Gussmann 2007, summarized in section 2.2), cannot show the whole story of how phonological processes work in Polish.

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APPENDIX A

Sonority of consonant sequences

The table below organizes examples of consonant sequence data into a sonority hierarchy. The first consonant in a sequence is listed on the vertical axis where the segments are organized top to bottom from least to most sonorous. The second consonant in a sequence is listed on the horizontal axis where the segments are organized left to right from most to least sonorous. Cells with consonant sequences that exhibit vowel~zero alternations are white, while cells with consonant sequences that do not exhibit vowel~zero alternations are shaded. Cells with consonant sequences for which data cannot be found are left blank. Whenever a cell includes data that does not fit its white/shade specification, the piece of data will be marked with an arrow. A note explaining the anomaly can be found at the bottom of the column. General notes about sequences ending in a particular segments will also be included at the bottom of the column. Foreign vocabulary (see section 5.1) has been for the most part eliminated from the table.

	w
p/b	*diabeł* [dʲabɛw] ‘devil, Nom. Sg.’ ~ *diabła* [dʲabwa] ‘Gen. Sg.’ *kubeł* [kubɛw] ‘bucket, Nom. Sg.’ ~ *kubła* [kubwa] ‘Gen. Sg.’
t/d	*światło* [ɕfʲatwɔ] ‘light, Nom. Sg.’ ~ *świateł* [ɕfʲatɛw] ‘Gen. Pl.’ *skrzydło* [skʂɨdwɔ] ‘wing, Nom. Sg.’ ~ *skrzydeł* [skʂɨdɛw] ‘Gen. Pl.’
k/g	*piekło* [pʲɛkwɔ] ‘hell, Nom. Sg.’ ~ *piekieł* [pʲɛkʲɛw] ‘Gen. Pl.’ *śmigło* [ɕmigwɔ] ‘propeller, Nom. Sg.’ ~ *śmigieł* [ɕmigʲɛw] ‘Gen. Pl.’
ts/dz	
tʂ/dʐ	
f/v	*Paweł* [pavɛw] ‘Paul, Nom. Sg.’ ~ *Pawła* [pavwa] ‘Gen. Sg.’
s/z	*suseł* [susɛw] ‘gopher, Nom. Sg.’ ~ *susła* [suswa] ‘Gen. Sg.’ *węzeł* [vɛ̃zɛw] ‘knot, Nom. Sg.’ ~ *węzła* [vɛ̃zwa] ‘Gen. Sg.’ → *przemysł* [pʂɛmiɕw] ‘industry, Nom. Sg.’ ~ *przemysły* [pʂɛmiɕwɨ] ‘Nom. Pl.’
ʂ/ʐ	*orzeł* [ɔʐɛw] ‘eagle, Nom. Sg.’ ~ *orła* [ɔrwa] ‘Gen. Sg.’ *karzeł* [kaʐɛw] ‘dwarf, Nom. Sg.’ ~ *karła* [karwa] ‘Gen. Sg.’
x	
m	
pʲ/bʲ	
fʲ/vʲ	
mʲ	
ɲ	
l	
tɕ/dʑ	*kocioł* [kɔtɕɔw] ‘cauldron, Nom. Sg.’ ~ *kotła* [kɔtwa] ‘Gen. Sg.’
ɕ/ʑ	*osioł* [ɔɕɔw] ‘donkey, Nom. Sg.’ ~ *osła* [ɔswa] ‘Gen. Sg.’ *kozioł* [kɔʑɔw] ‘goat, Nom. Sg.’ ~ *kozła* [kɔzwa] ‘Gen. Sg.’
j	
r	*perła* [pɛrwa] ‘pearl, Nom. Sg.’ ~ *pereł* [pɛrɛw] ‘Gen. Pl.’ *berło* [bɛrwɔ] ‘scepter, Nom. Sg.’ ~ *bereł* [bɛrɛw] ‘Gen. Pl.’
n	
w	
NOTES	- In cases of [sw] sequences, words ending in *–mysł* or *–miosł* do not exhibit alternations. These endings may be considered separate morphemes, which fail to exhibit alternations in other cases as well. While the paper does not discuss these cases, the phenomenon may be related to that of affix contiguity (§5.2).

	n
p/b	*bęben* [bɛmbɛn] ‘drum, Nom. Sg.’ ~ *bębna* [bɛmbna] ‘Gen. Sg.’
t/d	→ *piętno* [pʲɛntnɔ] ‘brand/seal, ‘Nom. Sg.’ ~ *piętn* [pʲɛntn] ‘Gen. Pl.’
k/g	*suknia* [sukɲa] ‘dress, Nom. Sg.’ ~ *sukien* [sukʲɛn] ‘Gen. Pl.’ *włókno* [vwuknɔ] ‘fibre, Nom. Sg.’ ~ *włókien* [vwukʲɛn] ‘Gen. Pl.’
ts/dz	
tʂ/dʐ	
f/v	
s/z	*sosna* [sɔsna] ‘pine, Nom. Sg.’ ~ *sosen* [sɔsɛn] ‘Gen. Pl.’ *błazen* [bwazɛn] ‘fool, Nom. Sg.’ ~ *błazna* [bwazna] ‘Gen. Sg.’ → *bielizna* [bʲɛlizna] ‘underwear, Nom. Sg.’ ~ *bielizn* [bʲɛlizn] ‘Gen. Sg.’
ʂ/ʐ	*rożen* [rɔʐɛn] ‘roasting-spit, Nom. Sg.’ ~ *rożna* [rɔʐna] ‘Gen. Sg.’
x	*bochen* [bɔxɛn] ‘loaf (bread), Nom. Sg.’ ~ *bochna* [bɔxna] ‘Gen. Sg.’ *kuchnia* [kuxɲa] ‘kitchen, Nom. Sg.’ ~ *kuchen* [kuxɛn] ‘Gen. Sg.’
m	
pʲ/bʲ	
fʲ/vʲ	*grzywna* [gʐɨvna] ‘fine, Nom. Sg.’ ~ *grzywien* [gʐɨvʲɛn] ‘Gen. Pl.’ *gówno* [guvnɔ] ‘shit, Nom. Sg.’ ~ *gówien* [guvʲɛn] ‘Gen. Pl.’
mʲ	*gumno* [gumnɔ] ‘barn, Nom. Sg.’ ~ *gumien* [gumʲɛn] ‘Gen. Pl.’ *trumna* [trumna] ‘coffin, Nom. Sg.’ ~ *trumien* [trumʲɛn] ‘Gen. Pl.’
ɲ	*panna* [panna] ‘virgin, Nom. Sg.’ ~ *panien* [paɲɛn] ‘Gen. Pl.’ *wanna* [vanna] ‘tub, Nom. Sg.’ ~ *wanien* [vaɲɛn] ‘Gen. Pl.’
l	
tɕ/dʑ	*płótno* [pwutnɔ] ‘cloth, Nom. Sg.’ ~ *płócien* [pwutɕɛn] ‘Gen. Pl.’ *studnia* [studɲa] ‘well, Nom. Sg.’ ~ *studzien* [studʑɛn] ‘Gen. Pl.’
ɕ/ʑ	*wiśnia* [viɕɲa] ‘cherry, Nom. Sg.’ ~ *wisien* [viɕɛn] ‘Gen. Pl.’ *krosna* [krɔsna] ‘loom, Nom. Sg.’ ~ *krosien* [krɔɕɛn] ‘Gen. Pl.’
j	*wojna* [vɔjna] ‘war, Nom. Sg.’ ~ *wojen* [vɔjɛn] ‘Gen. Pl.’ *łajno* [wajnɔ] ‘dung, Nom. Sg.’ ~ *łajen* [wajɛn] ‘Gen. Pl.’
r	→ *sarna* [sarna] ‘deer, Nom. Sg.’ ~ *saren* [sarɛn] / *sarn* [sarn] ‘Gen. Pl.’ → *ziarno* [ʑarnɔ] ‘seed, Nom. Sg.’ ~ *ziaren* [ʑarɛn] / *ziarn* [ʑarn] ‘Gen. Pl.’
n	*fontanna* [fɔntanna] ‘fountain, Nom. Sg.’ ~ *fontann* [fɔntann] ‘Gen. Pl.’ *brytfanna* [brɨtfanna] ‘oven-pan, Nom. Sg.’ ~ *brytfann* [brɨtfann] ‘Gen. Pl.’
w	→ *wełna* [vɛwna] ‘wool, Nom. Sg.’ ~ *weł* [vɛwn] / *wełen* [vɛwɛn] ‘Gen. Pl.’ *żołna* [ʐɔwna] ‘bee-eater (bird), Nom. Sg.’ ~ *żoł* [ʐɔwn] ‘Gen. Pl.’ → *czółno* [tʂuwnɔ] ‘canoe, Nom. Sg.’ ~ *czółen* [tʂuwɛn] ‘Gen. Pl.’
NOTES	- There is so far no explanation for lack of alternations in [tn] sequences, however the presence of a nasal vowel in the word may offer a clue in further investigations. - In cases of [zn] sequences, bimorphemic words with the suffix *–izna* do not exhibit alternations (§5.2) - In cases of [rn] sequences, there is stylistic variability in the presence of alternations. This may be due to [r] and [n] at times being analyzed as equally sonorous, and at other times as [n] being more sonorous than [r]. - In cases of [wn] sequences, the behaviour is unpredictable and as such may in fact be coded underlyingly (§4.3)

	r	**j**	**ɕ/ʑ**
p/b			
t/d			
k/g			
ts/dz			
tʂ/dʐ			
f/v			
s/z			
ʂ/ʐ			
x			
m			
pʲ/bʲ			
fʲ/vʲ			
mʲ			
ɲ			
l			
tɕ/dʑ			
ɕ/ʑ			
j			
r			*pierś* [pʲɛrɕ] ‘breast, Nom. Sg.’ ~ *piersi* [pʲɛrɕi] ‘Gen. Sg.’
n			
w			
NOTES	- See Appendix B for *Cr* data.	- Words do not end in *C(V)j* sequences unless they are archaic constructions.	

	tɕ/dʑ
p/b	*kapeć* [kapɛtɕ] ‘slipper, Nom. Sg.’ ~ *kapcia* [kaptɕa] ‘Gen. Sg.’ *kopeć* [kɔpɛtɕ] ‘soot, Nom. Sg.’ ~ *kopcia* [kɔptɕa] ‘Gen. Sg.’ → *babcia* [baptɕa] ‘grandmother, Nom. Sg.’ ~ *babć* [baptɕ] ‘Gen. Pl.’
t/d	
k/g	*łokieć* [wɔkʲɛtɕ] ‘elbow, Nom. Sg.’ ~ *łokcia* [wɔktɕa] ‘Gen. Sg.’ *dziegieć* [dʑɛgʲɛtɕ] ‘birch tar, Nom. Sg.’ ~ *dziegcia* [dʑɛgtɕa] ‘Gen. Sg.’
ts/dz	
tʂ/dʐ	
f/v	
s/z	
ʂ/ʐ	
x	
m	
pʲ/bʲ	
fʲ/vʲ	
mʲ	
ɲ	
l	
tɕ/dʑ	
ɕ/ʑ	*liść* [liɕtɕ] ‘leaf, Nom. Sg.’ ~ *liścia* [liɕtɕa] ‘Gen. Sg.’ *gwóźdź* [gvuʑdʑ] ‘nail, Nom. Sg.’ ~ *gwoździa* [gvoʑdʑa] ‘Gen. Sg.’
j	
r	*śmierć* [ɕmʲɛrtɕ] ‘death, Nom. Sg.’ ~ *śmierci* [ɕmʲɛrtɕi] ‘Gen. Sg.’ *żerdź* [ʐɛrdʑ] ‘perch, Nom. Sg.’ ~ *żerdzi* [ʐɛrdʑi] ‘Gen. Sg.’
n	
w	*żółć* [ʐuwtɕ] ‘bile/gall, Nom. Sg.’ ~ *żółci* [ʐuwtɕi] ‘Gen. Sg.’
NOTES	- In the case of *babcia*, [-tɕ] is analyzed as a suffix which blocks epenthesis between it and the stem of the word (§5.2)

	l
p/b	*wróbel* [vrubɛl] ‘sparrow, Nom. Sg.’ ~ *wróbla* [vrubla] ‘Gen. Sg.’ *cypel* [tsɨpɛl] ‘promontory, Nom. Sg.’ ~ *cypla* [tsɨpla] ‘Gen. Sg.’
t/d	*kundel* [kundɛl] ‘mongrel, Nom. Sg.’ ~ *kundla* [kundla] ‘Gen. Sg.’ *butla* [butla] ‘bottle/jug, Nom. Sg.’ ~ *butel* [butɛl] ‘Gen. Pl.’
k/g	cyrkiel [tsɨrkʲɛl] ‘compass, Nom. Sg.’ ~ *cyrkla* [tsɨrkla] ‘Gen. Sg.’ *węgiel* [vɛ̃gʲɛl] ‘coal, Nom. Sg.’ ~ *węgla* [vɛ̃gla] ‘Gen. Sg.’ → *cykl* [tsɨkl] ‘cycle, Nom. Sg.’ ~ *cykle* [tsɨklɛ] ‘Nom. Pl.’
ts/dz	*hycel* [xɨtsɛl] ‘dog-catcher, Nom. Sg.’ ~ *hycla* [xɨtsla] ‘Gen. Sg.’ *frędzla* [frɛndzla] ‘fringe, Nom. Sg.’ ~ *frędzel* [frɛndzɛl] ‘Gen. Sg.’
tʂ/dʐ	
f/v	*kartofel* [kartɔfɛl] ‘potato, Nom. Sg.’ ~ *kartofla* [kartɔfla] ‘Gen. Sg.’ *kufel* [kufɛl] ‘tankard, Nom. Sg.’ ~ *kufla* [kufla] ‘Gen. Sg.’
s/z	*kapsel* [kapsɛl] ‘(bottle) cap, Nom. Sg.’ ~ *kapsla* [kapsla] ‘Gen. Sg.’
ʂ/ʐ	*dyszel* [dɨʂɛl] ‘shaft, Nom. Sg.’ ~ *dyszle* [dɨʂlɛ] ‘Nom. Pl.’ *kaszel* [kaʂɛl] ‘cough, Nom. Sg.’ ~ *kaszle* [kaʂlɛ] ‘Nom. Pl.’
x	*chochla* [xɔxla] ‘ladle, Nom. Sg.’ ~ *chochel* [xɔxɛl] ‘Gen. Pl.’
m	
pʲ/bʲ	
fʲ/vʲ	
mʲ	
ɲ	
l	
tɕ/dʑ	
ɕ/ʑ	*myśl* [mɨɕl] ‘thought, Nom. Sg.’ ~ *myśli* [mɨɕli] ‘Gen. Sg.’ *rzęśl* [zɛ̃ɕl] ‘Callitriche (plant), Nom. Sg.’ ~ *rzęśli* [zɛ̃ɕli] ‘Gen. Sg.’
j	
r	
n	
w	
NOTES	- The word *cykl* may still be marked with a [+Foreign] diacritic, which blocks epenthesis within the morpheme (§5.1).

	ɲ	**mʲ**
p/b	→ *wapń* [vapɲ] ‘calcium, Nom. Sg.’ ~ *wapnia* [vapɲa] ‘Gen. Sg.’	
t/d	*truteń* [trutɛɲ] ‘drone, Nom. Sg.’ ~ *trutnia* [trutɲa] ‘Gen. Sg.’	
k/g	*ogień* [ɔgʲɛɲ] ‘fire, Nom. Sg.’ ~ *ognia* [ɔgɲa] ‘Gen. Sg.’	
ts/dz		
tʂ/dʐ	*łączeń* [wɔ̃tʂɛɲ] ‘Butomus (plant), Nom. Sg.’ ~ *łącznia* [wɔ̃tʂɲa] ‘Gen. Sg.’ *uczeń* [utʂɛɲ] ‘student, Nom. Sg.’ ~ *ucznia* [utʂɲa] ‘Gen. Sg.’	
f/v		
s/z		
ʂ/ʐ	*skórzeń* [skuʐɛɲ] ‘leather belt, Nom. Sg.’ ~ *skórznie* [skuʐɲɛ] ‘Nom. Pl.’	
x		
m		
pʲ/bʲ	*ropień* [rɔpʲɛɲ] ‘abscess, Nom. Sg.’ ~ *ropnia* [rɔpɲa] ‘Gen. Sg.’ *stopień* [stɔpʲɛɲ] ‘degree, Nom. Sg.’ ~ *stopnia* [stɔpɲa] ‘Gen. Sg.’	
fʲ/vʲ		
mʲ		
ɲ		
l	*kopalnia* [kɔpalɲa] ‘mine, Nom. Sg.’ ~ *kopalń* [kɔpalɲ] ‘Gen. Pl.’	
tɕ/dʑ	→ *kwiecień* [kfʲɛtɕɛɲ] ‘April, Nom. Sg.’ ~ *kwietnia* [kfʲɛtɲa] ‘Gen. Sg.’ → *przechodzień* [pʂɛxɔdʑɛɲ] ‘passer-by, Nom. Sg.’ ~ *przechodnia* [pʂɛxɔdɲa] ‘Gen. Sg.’	
ɕ/ʑ	*baśń* [baɕɲ] ‘fairy tale, Nom. Sg.’ ~ *baśni* [baɕɲi] ‘Gen. Sg.’ *jaźń* [jaʑɲ] ‘the self, Nom. Sg.’ ~ *jaźni* [jaʑɲi] ‘Gen. Sg.’ → *więzień* [vʲɛ̃ʑɛɲ] ‘prisoner, Nom. Sg.’ ~ *więźnia* [vʲɛ̃ʑɲa] ‘Gen. Sg.’	
j		
r	*cierń* [tɕɛrɲ] ‘thorn, Nom. Sg.’ ~ *cierni* [tɕɛrɲi] ‘Gen. Sg.’ *czerń* [tʂɛrɲ] ‘black, Nom. Sg.’ ~ *czerni* [tʂɛrɲi] ‘Gen. Sg.’ → *dureń* [durɛɲ] ‘stupid person, Nom. Sg.’ ~ *durnia* [durɲa] ‘Gen. Sg.’	
n		
w		
NOTES	- In the case of *wapń*, the lack of alternation may be due to the fact that it is a technical term. As such it behaves more in line with the class of foreign vocabulary (§5.1). See also *Cm* sequences. - Many words that exhibit alternations and end in *–ń* (for example *kwiecień* from *kwiat* ‘flower’ and *więzień* from *wiązać* ‘to tie’) are instances of bimorphemic words where the suffix unmarked vowel deletes (§5.3)	

	fʲ/vʲ	**pʲ/bʲ**
p/b		
t/d		
k/g	*cerkiew* [tsɛrkʲɛf] ‘Orthodox church, Nom. Sg.’ *~ cerkwi* [tsɛrkfi] ‘Gen. Sg.’ *żagiew* [ʐągʲɛv]‘fire-brand, Nom. Sg.’ *~ żagwi* [ʐągvi] ‘Gen. Sg.’	
ts/dz		
tʂ/dʐ		
f/v		
s/z		
ʂ/ʐ		
x	*marchew* [marxɛf] ‘carrot, Nom. Sg.’ *~ marchwi* [marxfi] ‘Gen. Sg.’ *warząchew* [vaʐ̃xɛf]‘wooden spoon, Nom. Sg.’ *~ warząchwi* [vaʐ̃xfi] ‘Gen. Sg.’	
m		
pʲ/bʲ		
fʲ/vʲ		
mʲ		
ɲ		
l		
tɕ/dʑ		
ɕ/ʑ		
j		
r	*czerw* [tʂɛrv]‘red, Nom. Sg.’ *~ czerwi* [tʂɛrvi] ‘Gen. Sg.’	*karp* [karp] ‘carp, Nom. Sg.’ *~ karpia* [karpʲa] ‘Gen. Sg.’
n	→ *konew* [kɔnɛv] ‘ancient unit of measure, Nom. Sg.’ *~ konwi* [kɔnvi] ‘Gen. Sg.’	
w	*żółw* [ʐuwv] ‘turtle, Nom. Sg.’ *~ żółwia* [ʐuwvʲa] ‘Gen. Sg.’	*kiełb* [kʲɛwb] ‘gudgeon (fish), Nom. Sg.’ *~ kiełbie* [kʲɛwbʲɛ] ‘Nom. Pl.’
NOTES	- The presence of alternation in *konew* may be explained by the fact that it is an archaic unit of measurement, and as such is not used much in modern Polish.	

	m
p/b	
t/d	→ *widmo* [vidmɔ] ‘phantom, Nom. Sg.’ ~ *widm* [vidm] ‘Gen. Pl.’ → *kadm* [kadm] ‘cadmium, Nom. Sg.’ ~ *kadmu* [kadmu] ‘Gen. Sg.’
k/g	
ts/dz	
tʂ/dʐ	
f/v	
s/z	→ *pasmo* [pasmɔ] ‘strand/skein, Nom. Sg.’ ~ *pasm* [pasm] / *pasem* [pasɛm] ‘Gen. Pl.’ → *wulgaryzm* [vulgarɨzm] ‘vulgarity, Nom. Sg.’ ~ *wulgaryzmu* [vulgarɨzmu] ‘Gen. Sg.’ → *pismo* [pismɔ] ‘alphabet/penmanship, Nom. Sg.’ ~ *pism* [pism] ‘Gen. Pl.’ → *osm* [ɔsm] ‘osmium (chem.), Nom. Sg.’ ~ *osmu* [ɔsmu]‘Gen. Sg.’
ʂ/ʐ	→ *ciżma* [tɕiʐma] ‘ancient footwear, Nom. Sg.’ ~ *ciżem* [tɕiʐɛm] / *ciżm* [tɕiʐm] ‘Gen. Pl.’ → *jarzmo* [jaʐmɔ] ‘yoke, Nom. Sg.’ ~ *jarzem* [jaʐɛm] / *jarzm* [jaʐm] ‘Gen. Pl.’
x	
m	
pʲ/bʲ	
fʲ/vʲ	
mʲ	
ɲ	
l	*bielmo* [bʲɛlmɔ] ‘endosperm, Nom. Sg.’ ~ *bielm* [bʲɛlm] ‘Gen. Pl.’ *film* [film] ‘film/movie, Nom. Sg.’ ~ *filmy* [filmɨ] ‘Nom. Pl.’
tɕ/dʑ	→ *zaćma* [zatɕma] ‘cataract, Nom. Sg.’ ~ *zaćm* [zatɕm] / *zaciem* [zatɕɛm] ‘Gen. Pl.’ *wiedźma* [vʲɛdʑma] ‘witch, Nom. Sg.’ ~ *wiedźm* [vʲɛdʑm] ‘Gen. Pl.’
ɕ/ʑ	*taśma* [taɕma] ‘tape, Nom. Sg.’ ~ *taśm* [taɕm] ‘Gen. Pl.’
j	→ *najem* [najɛm] ‘rental, Nom. Sg.’ ~ *najmu* [najmu] ‘Gen. Sg.’ *ujma* [ujma] ‘detriment/prejudice, Nom. Sg.’ ~ *ujm* [ujm] ‘Gen. Sg.’
r	*pokarm* [pɔkarm] ‘food/feed, Nom. Sg.’ ~ *pokarmu* [pɔkarmu] ‘Gen. Sg.’
n	
w	*hełm* [xɛwm] ‘helmet, Nom. Sg.’ ~ *hełmu* [xɛwmu] ‘Gen. Sg.’
NOTES	- As with *wapń* in *Cɲ* sequences above, the lack of alternation in *kadm* and *osm* may be due to them patterning with foreign vocabulary because they are specialized terminology (§5.1). - In the case of *widmo* (from *widzieć* ‘to see’) and *pismo* (from *pisać* ‘to write’), lack of alternation may be due to *–m* being a nominalizing suffix. Furthermore, examples of [zm] sequences are often due to the *–yzm* suffix, which does not exhibit alternation either (§5.2). - The variability in [ʐm] sequences may be due to [m] optionally being considered of equal sonority as plain fricatives and stops. - The presence of alternation in *zaciem* and *najem* may be due to the words being bimorphemic with a prefix plus an asyllabic root. This phenomenon is not discussed in this paper, but is part of a possible pattern. See also examples of *Ct* sequences in syllabic roots that behave as though they are asyllabic.

	x	**ʂ/ʐ̩**
p/b		*wieprz* [vʲɛpʂ] ‘hog, Nom. Sg.’ *~ wiepsze* [vʲɛpʂɛ] ‘Nom. Pl.’
t/d		*mistrz* [mistʂ] ‘master, Nom. Sg.’ *~ mistrze* [mistʂɛ] ‘Nom. Pl.’
k/g		
ts/dz		
tʂ/dʐ̩		
f/v		
s/z	*pascha* [pasxa] ‘passover, Nom. Sg.’ *~ pasch* [pasx] ‘Gen. Pl.’	
ʂ/ʐ̩	*zmierzch* [zmʲɛʂx] ‘twilight, Nom. Sg.’ *~ zmierzchu* [zmʲɛʂxu] ‘Gen. Sg.’ *wierzch* [vʲɛʂx] ‘top/surface, Nom. Sg.’ *~ wierzchu* [vʲɛʂxu] ‘Gen. Sg.’	
x		
m		*komża* [kɔmʐa] ‘surplice, Nom. Sg.’ *~ komż* [kɔmʐ] ‘Gen. Pl.’ *zamsz* [zamʂ] ‘suede, Nom. Sg.’ *~ zamszu* [zamʂu] ‘Gen. Sg.’
pʲ/bʲ		
fʲ/vʲ		
mʲ		
ɲ		
l	*olcha* [ɔlxa] ‘alder, Nom. Sg.’ *~ olch* [ɔlx] ‘Gen. Pl.’	*olsza* [ɔlʂa] ‘alder, Nom. Sg.’ *~ olsz* [ɔlʂ] ‘Gen. Pl.’
tɕ/dʑ		
ɕ/ʑ		
j		
r	*parch* [parx] ‘ringworm, Nom. Sg.’ *~ parcha* [parxa] ‘Gen. Sg.’	*marsz* [marʂ] ‘march, Nom. Sg.’ *~ marsze* [marʂɛ] ‘Gen. Sg.’ *wiersz* [vʲɛrʂ] ‘poem, Nom. Sg.’ *~ wiersze* [vʲɛrʂɛ] ‘Nom. Pl.’
n	*koncha* [kɔnxa] ‘architecture element, Nom. Sg.’ *~ konch* [kɔnx] ‘Gen. Pl.’	*czynsz* [tʂinʂ] ‘lease, Nom. Sg.’ *~ czynsze* [tʂinʂɛ] ‘Nom. Pl.’ *branża* [branʐa] ‘branch (business), Nom. Sg.’ *~ branż* [branʐ] ‘Gen. Pl.’
w		*fałsz* [fawʂ] ‘falseness, Nom. Sg.’ *~ fałszu* [fawʂu] ‘Gen. Sg.’
NOTES		

	s/z
p/b	*gips* [gips] ‘gypsum, Nom. Sg.’ ~ *gipsy* [gipsɨ] ‘Nom. Pl.’ *kobza* [kɔbza] ‘ancient musical instrument’ ~ *kobz* [kɔbz] ‘Gen. Pl.’
t/d	
k/g	*kleks* [klɛks] ‘inkblot, Nom. Sg.’ ~ *kleksy* [klɛksɨ] ‘Nom. Pl.’ *fuks* [fuks] ‘luck, Nom. Sg.’ ~ *fuksy* [fuksɨ] ‘Nom. Pl.’
ts/dz	
tʂ/dʐ	
f/v	
s/z	
ʂ/ʐ	
x	
m	*giemza* [gʲɛmza] ‘chamois leather, Nom. Sg.’ ~ *giemz* [gʲɛmz] ‘Gen. Pl.’
pʲ/bʲ	
fʲ/vʲ	
mʲ	
ɲ	
l	*puls* [puls] ‘pulse, Nom. Sg.’ ~ *pulsu* [pulsu] ‘Gen. Sg.’
tɕ/dʑ	
ɕ/ʑ	
j	*pejs* [pɛjs] ‘lock of hair, Nom. Sg.’ ~ *pejsy* [pɛjsɨ] ‘Nom. Pl.’ *łajza* [wajza] ‘hobo, Nom. Sg.’ ~ *łajz* [wajz] ‘Gen. Pl.’
r	*kurs* [kurs] ‘course, Nom. Sg.’ ~ *kursy* [kursɨ] ‘Nom. Pl.’
n	*szansa* [ʂansa] ‘chance, Nom. Sg.’ ~ *szans* [ʂans] ‘Gen. Pl.’
w	*zołza* [zɔwza] ‘unpleasant woman, Nom. Sg.’ ~ *zołz* [zɔwz] ‘Gen. Pl.’ *pełz* [pɛwz] ‘crawl, Nom. Sg.’ ~ *pełzy* [pɛwzɨ] ‘Nom. Pl.’
NOTES	

	f/v
p/b	
t/d	→ *listwa* [listfa] ‘(wooden) slat, Nom. Sg.’ ~ *listew* [listɛf] ‘Gen. Pl.’ → *bitwa* [bitfa] ‘battle, Nom. Sg.’ ~ *bitw* [bitf] / *bitew* [bitɛf] ‘Gen. Pl.’ *płetwa* [pwɛtfa] ‘flipper, Nom. Sg.’ ~ *płetw* [pwɛtf] ‘Gen. Pl.’ *państwo* [paɲstfɔ] ‘country, Nom. Sg.’ ~ *państw* [paɲstf] ‘Gen. Pl.’
k/g	*sakwa* [sakfa] ‘travel bag/pannier, Nom. Sg.’ ~ *sakw* [sakf] ‘Gen. Pl.’ *pigwa* [pigva] ‘quince (plant) Nom. Sg.’ ~ *pigw* [pigv] ‘Gen. Pl.’ → *pluskwa* [pluskfa] ‘bedbug, Nom. Sg.’ ~ *pluskiew* [pluskʲɛf] ‘Gen. Pl.’
ts/dz	
tʂ/dʐ	
f/v	
s/z	*nazwa* [nazva] ‘name, Nom. Sg.’ ~ *nazw* [nazv] ‘Gen. Pl.’
ʂ/ʐ	→ *poszwa* [pɔʂfa] ‘linen cover, Nom. Sg.’ ~ *poszew* [pɔʂɛf] ‘Gen. Pl.’ → *łyżwa* [wiʐva] ‘skate, Nom. Sg.’ ~ *łyżew* [wiʐɛv] ‘Gen. Pl.’
x	→ *pochwa* [pɔxfa] ‘vagina, Nom. Sg.’ ~ *pochw* [pɔxf] / *pochew* [pɔxɛf] ‘Gen. Pl.’ *lichwa* [lixfa] ‘usury, Nom. Sg.’ ~ *lichw* [lixf] ‘Gen. Pl.’
m	
pʲ/bʲ	
fʲ/vʲ	
mʲ	
ɲ	
l	*bulwa* [bulva] ‘tuber, Nom. Sg.’ ~ *bulw* [bulv] ‘Gen. Pl.’
tɕ/dʑ	
ɕ/ʑ	
j	
r	*barwa* [barva] ‘hue, Nom. Sg.’ ~ *barw* [barv] ‘Gen. Pl.’ *przerwa* [pʂɛrva] ‘pause, Nom. Sg.’ ~ *przerw* [pʂɛrv] ‘Gen. Pl.’
n	*kanwa* [kanva] ‘aida cloth, Nom. Sg.’ ~ *kanw* [kanv] ‘Gen. Pl.’
w	*chałwa* [xawva] ‘halva (food), Nom. Sg.’ ~ *chałw* [xawv] ‘Gen. Pl.’
NOTES	- The variable and unexpected alternation in certain forms involving *Cv* sequences may be due to them being coded underlyingly. The situation is similar to *Cr* sequences (§4.3).

	tʂ/dʐ̩
p/b	
t/d	
k/g	
ts/dz	
tʂ/dʐ̩	
f/v	
s/z	
ʂ/ʐ̩	*chrząszcz* [xʂɔ̃ʂtʂ] ‘beetle, Nom. Sg.’ ~ *chsząszcze* [xʂɔ̃ʂtʂɛ] ‘Nom. Pl.’ *deszcz* [dɛʂtʂ] ‘rain, Nom. Sg.’ ~ *deszcze* [dɛʂtʂɛ] ‘Nom. Pl.’
x	
m	
pʲ/bʲ	
fʲ/vʲ	
mʲ	
ɲ	*opończa* [ɔpɔɲtʂa] ‘tarp/poncho, Nom. Sg.’ ~ *opończ* [ɔpɔɲtʂ] ‘Gen. Pl.’
l	
tɕ/dʑ	
ɕ/ʑ	
j	*pejcz* [pɛjtʂ] ‘short whip, Nom. Sg.’ ~ *pejcze* [pɛjtʂɛ] ‘Nom. Pl.’
r	*skurcz* [skurtʂ] ‘cramp, Nom. Sg.’ ~ *skurcza* [skurtʂa] ‘Nom. Pl.’
n	*klincz* [klintʂ] ‘clinch, Nom. Sg.’ ~ *klincze* [klintʂɛ] ‘Nom. Pl.’
w	
N O T E S	

	ts/dz
p/b	→ *kierpce* [kʲɛrptsɛ] ‘traditional footwear, Nom. Pl.’ ~ *kierpec* [kʲɛrpɛts] ‘Gen. Pl.’
t/d	
k/g	
ts/dz	
tʂ/dʐ	
f/v	*drzewce* [dzɛftsɛ] ‘section of firearm, Nom. Sg.’ ~ *drzewc* [dzɛfts] ‘Gen. Pl. *szewc* [ʂɛfts] ‘shoemaker, Nom. Sg.’ ~ *szewce* [ʂɛftsɛ] ‘Nom. Pl.’
s/z	
ʂ/ʐ	→ *dworzec* [dvɔzɛts] ‘(train) station’ ~ *dworce* [dvortsɛ] ‘Nom. Pl.’ → *mędrzec* [mɛ̃ndzɛts] ‘magi, Nom. Sg.’ ~ *mędrcy* [mɛ̃ndrtsɨ] ‘Nom. Pl.’
x	
m	
pʲ/bʲ	→ *skrzypce* [skʂɨptsɛ] ‘fiddle, Nom. Pl.’ ~ *skrzypiec* [skʂɨpʲɛts] ‘Gen. Pl.’ → *chłopiec* [xwɔpʲɛts] ‘boy, Nom. Sg.’ ~ *chłopcy* [xwɔptsɨ] ‘Nom. Pl.’
fʲ/vʲ	→ *owca* [ɔftsa] ‘sheep, Nom. Sg.’ ~ *owiec* [ɔvʲɛts] ‘Gen. Pl.’ → *biurowiec* [bʲurɔvʲɛts] ‘skyscraper, Nom. Sg.’ ~ *biurowce* [bʲurɔftsɛ] ‘Nom. Pl.’
mʲ	→ *samiec* [samʲɛts] ‘male, Nom. Sg.’ ~ *samce* [samtsɛ] ‘Nom. Pl.’ → *Niemiec* [ɲɛmʲɛts] ‘German, Nom. Sg.’ ~ *Niemcy* [ɲɛmtsɨ] ‘Nom. Pl.’
ɲ	*słońce* [swɔɲtsɛ] ‘sun, Nom. Sg.’ ~ *słońc* [swɔɲts] ‘Gen. Pl.’ → *taniec* [taɲɛts] ‘dance, Nom. Sg.’ ~ *tańce* [taɲtsɛ] ‘Nom. Pl.’
l	*filc* [filts] ‘felt, Nom. Sg.’ ~ *filce* [filtsɛ] ‘Nom. Pl.’ *walc* [valts] ‘waltz, Nom. Sg.’ ~ *walce* [valtsɛ] ‘Nom. Pl.’ → *malec* [malɛc] ‘small one, Nom. Sg.’ ~ *malce* [maltsɛ] ‘Nom. Pl.’ → *walec* [valɛts] ‘cylinder, Nom. Sg.’ ~ *walce* [valtsɛ] ‘Nom. Pl.’
tɕ/dʑ	→ *czyściec* [tʂiɕtɕɛts]‘purgatory, Nom. Sg.’ ~ *czyśćce* [tʂiɕtɕtsɛ] ‘Nom. Pl.’
ɕ/ʑ	→ *półpasiec* [puwpaɕɛts] ‘herpes zoster, Nom. Sg.’ ~ *półpaśca* [puwpaɕtsa] ‘Gen. Sg.’
j	*lejce* [lɛjtsɛ] ‘reins, Nom. Pl.’ ~ *lejc* [lɛjts] ‘Gen. Pl.’ *trójca* [trujtsa] ‘trinity, Nom. Sg.’ ~ *trójc* [trujts] ‘Gen. Pl.’ → *kojec* [kɔjɛts] ‘(animal) pen, Nom. Sg.’ ~ *kojca* [kɔjtsa] ‘Gen. Sg.’
r	*serce* [sɛrtsɛ] ‘heart, Nom. Sg.’ ~ *serc* [sɛrts] ‘Gen. Pl.’ *twierdza* [tfʲɛrdza] ‘claim, Nom. Sg.’ ~ *twierdz* [tfʲɛrdz] ‘Gen. Pl.’
n	*punca* [puntsa] ‘smithy tool, Nom. Sg.’ ~ *punc* [punc] ‘Gen. Pl.’
w	
NOTES	- Words ending in *Cts* clusters that exhibit alternation may be analyzed as bimorphemic constructions with a *–ec* suffix (§5.3).

	k/g
p/b	→ *snopek* [snɔpɛk] ‘haystack, Nom. Sg.’ ~ *snopka* [snɔpka] ‘Gen. Sg.’
t/d	→ *kładka* [kwadka] ‘footbridge, Nom. Sg.’ ~ *kładek* [kwadɛk] ‘Gen. Pl.’ → *smutek* [smutɛk] ‘sadness’ ~ *smutku* [smutku] ‘Gen. Sg.’
k/g	
ts/dz	*Płuck* [pwutsk] ‘name of town, Nom. Sg.’ ~ *Płucku* [pwutsku] ‘Gen. Sg.’ → *placek* [platsɛk] ‘flat cake, Nom. Sg.’ ~ *placki* [platski] ‘Nom. Pl.’
tʂ/dʐ	→ *beczka* [bɛtʂka] ‘barrel, Nom. Sg.’ ~ *beczek* [bɛtʂɛk] ‘Gen. Pl.’ → *boczek* [bɔtʂɛk] ‘bacon, Nom. Sg.’ ~ *boczku* [bɔtʂku] ‘Gen. Sg.’
f/v	→ *agrafka* [agrafka] ‘safety pin, Nom. Sg.’ ~ *agrafek* [agrafɛk] ‘Gen. Pl.’
s/z	*klęska* [klɛ̃ska] ‘tragedy, Nom. Sg.’ ~ *klęsk* [klɛ̃sk] ‘Gen. Pl.’ *mózg* [muzg] ‘brain, Nom. Sg.’ ~ *mózgu* [muzgu] ‘Gen. Sg.’ → *kreska* [krɛska] ‘line, Nom. Sg.’ ~ *kresek* [krɛsɛk] ‘Gen. Pl.’
ʂ/ʐ	→ *szyszka* [ʂɨʂka] ‘pine cone, Nom. Sg.’ ~ *szyszek* [ʂɨʂɛk] ‘Gen. Pl.’ *zwyżka* [zvɨʐka] ‘raise, Nom. Sg.’ ~ *zwyżek* [zvɨʐɛk] ‘Gen. Pl.’
x	
m	
pʲ/bʲ	
fʲ/vʲ	
mʲ	
ɲ	
l	*wilk* [vilk] ‘wolf, Nom. Sg.’ ~ *wilki* [vilki] ‘Nom. Pl.’ *walka* [valka] ‘fight, Nom. Sg.’ ~ *walk* [valk] ‘Gen. Pl.’ → *kalka* [kalka] ‘carbon paper, Nom. Sg.’ ~ *kalk* [kalk] / *kalek* [kalɛk] ‘Gen. Pl.’
tɕ/dʑ	→ *bociek* [bɔtɕɛk] ‘stork, Nom. Sg.’ ~ *boćki* [bɔtɕki] ‘Nom. Pl.’
ɕ/ʑ	→ *Baśka* [baɕka] ‘Barbara (dim.), Nom. Sg.’ ~ *Basiek* [baɕɛk] ‘Gen. Pl.’
j	*strajk* [strajk] ‘strike (union), Nom. Sg.’ ~ *strajku* [strajku] ‘Gen. Sg.’ → *trójka* [trujka] ‘three, Nom. Sg.’ ~ *trójek* [trujɛk] ‘Gen. Pl.’
r	*kark* [kark] ‘nape, Nom. Sg.’ ~ *karki* [karki] ‘Nom. Pl.’ *targ* [targ] ‘market, Nom. Sg.’ ~ *targi* [targi] ‘Nom. Pl.’ → *worek* [vɔrɛk] ‘sack (dim.), Nom. Sg.’ ~ *worki* [vɔrki] ‘Nom. Pl.’
n	
w	*pułk* [puwk] ‘regiment, Nom. Sg.’ ~ *pułki* [puwki] ‘Nom. Pl.’ *czołg* [tʂɔwg] ‘(army) tank, Nom. Sg.’ ~ *czołgi* [tʂɔwgi] ‘Nom. Pl.’ → *półka* [puwka] ‘shelf, Nom. Sg.’ ~ *półek* [puwɛk] ‘Gen. Pl.’
NOTES	- Words ending in *Ck* clusters that exhibit alternation may be analyzed as bimorphemic constructions with a *–ek* suffix (§5.3).

	t/d
p/b	*krypt* [krɨpt] ‘crypt, Nom. Sg.’ ~ *krypty* [krɨptɨ] ‘Nom. Pl.’
t/d	
k/g	*punkt* [punkt] ‘point, Nom. Sg.’ ~ *punkty* [punktɨ] ‘Nom. Pl.’
ts/dz	→ *ocet* [ɔtsɛt] ‘vinegar, Nom. Sg.’ ~ *octu* [ɔtstu] ‘Gen. Sg.’
tʂ/dʐ	*uczta* [utʂta] ‘party (event), Nom. Sg.’ ~ *uczt* [utʂt] ‘Gen. Pl.’ *poczta* [pɔtʂta] ‘(mail) post, Nom. Sg.’ ~ *poczt* [pɔtʂt] ‘Gen. Pl.’ → *poczet* [pɔtʂɛt] ‘ancient cavalry unit, Nom. Sg.’ ~ *poczty* [pɔtʂtɨ] ‘Nom. Pl.’
f/v	*haft* [xaft] ‘embroidery, Nom. Sg.’ ~ *hafty* [xaftɨ] ‘Nom. Pl.’
s/z	*chwast* [xfast] ‘weed, Nom. Sg.’ ~ *chwasty* [xfastɨ] ‘Nom. Pl.’ *jazda* [jazda] ‘ride, Nom. Sg.’ ~ *jazd* [jazd] ‘Gen. Pl.’ → *oset* [ɔsɛt] ‘thistle, Nom. Sg.’ ~ *ostu* [ɔstu] ‘Gen. Sg.’
ʂ/ʐ	*koszt* [kɔʂt] ‘cost, Nom. Sg.’ ~ *koszty* [kɔʂtɨ] ‘Nom. Pl.’ *areszt* [arɛʂt] ‘arrest, Nom. Sg.’ ~ *aresztu* [arɛʂtu] ‘Gen. Sg.’
x	*płachta* [pwaxta] ‘(fabric) sheet, Nom. Sg.’ ~ *płacht* [pwaxt] ‘Gen. Pl.’ *szlachta* [ʂlaxta] ‘nobility, Nom. Sg.’ ~ *szlacht* [ʂlaxt] ‘Gen. Pl.’
m	
pʲ/bʲ	
fʲ/vʲ	
mʲ	
ɲ	
l	*palto* [paltɔ] ‘coat, Nom. Sg.’ ~ *palt* [palt] ‘Gen. Pl.’ *dekolt* [dɛkɔlt] ‘neckline, Nom. Sg.’ ~ *dekolty* [dɛkɔltɨ] ‘Nom. Pl.’ *szyld* [ʂɨld] ‘sign, Nom. Sg.’ ~ *szyldy* [ʂɨldɨ] ‘Nom. Pl.’
tɕ/dʑ	
ɕ/ʑ	
j	*wójt* [vujt] ‘village officer, Nom. Sg.’ ~ *wójty* [vujtɨ] ‘Nom. Pl.’ *pajda* [pajda] ‘chunk, Nom. Sg.’ ~ *pajd* [pajd] ‘Gen. Pl.’
r	*żart* [ʐart] ‘joke, Nom. Sg.’ ~ *żarty* [ʐartɨ] ‘Nom. Pl.’ *morda* [mɔrda] ‘snout, Nom. Sg.’ ~ *mord* [mord] ‘Gen. Pl.’
n	*akcent* [aktsɛnt] ‘accent, Nom. Sg.’ ~ *akcenty* [aktsɛntɨ] ‘Nom. Pl.’ *dyktando* [dɨktandɔ] ‘dictation, Nom. Sg.’ ~ *dyktanda* [dɨktanda] ‘Nom. Pl.’
w	*krztałt* [kʂtawt] ‘shape, Nom. Sg.’ ~ *krztałty* [kʂtawtɨ] ‘Nom. Pl.’ *fałda* [fawda] ‘fold, Nom. Sg.’ ~ *fałd* [fawd] ‘Gen. Pl.’
NOTES	- In words such as *ocet* and *oset*, the initial [ɔ] may not count towards syllabification. Although this possibility is not discussed in the paper, these words may be patterning with asyllabic roots. - The word *poczet* is archaic and rarely used in modern Polish.

	p/b
p/b	
t/d	
k/g	
ts/dz	
tʂ/dʐ	*liczba* [litʂba] ‘number, Nom. Sg.’ ~ *liczb* [litʂb] ‘Gen. Pl.’
f/v	
s/z	*wyspa* [vɨspa] ‘island, Nom. Sg.’ ~ *wysp* [vɨsp] ‘Gen. Pl.’ *izba* [izba] ‘chamber, Nom. Sg.’ ~ *izb* [izb] ‘Gen. Pl.’ → *półwysep* [puwvɨsɛp] ‘peninsula, Nom. Sg.’ ~ *półwyspy* [puwvɨspɨ] ‘Nom. Pl.’
ʂ/ʐ	*wierzba* [vʲɛʐba] ‘carving, Nom. Sg.’ ~ *wierzb* [vʲɛʐb] ‘Gen. Pl.’ *ciżba* [tɕiʐba] ‘crowd, Nom. Sg.’ ~ *ciżb* [tɕiʐb] ‘Gen. Pl.’
x	
m	*lampa* [lampa] ‘lamp, Nom. Sg.’ ~ *lamp* [lamp] ‘Gen. Pl.’ *bomba* [bɔmba] ‘bomb, Nom. Sg.’ ~ *bomb* [bɔmb] ‘Gen. Pl.’
pʲ/bʲ	
fʲ/vʲ	
mʲ	
ɲ	*hańba* [xaɲba] ‘shame, Nom. Sg.’ ~ *hańb* [xaɲb] ‘Gen. Pl.’
l	*strzelba* [stʂɛlba] ‘rifle, Nom. Sg.’ ~ *strzelb* [stʂɛlb] ‘Gen. Pl.’
tɕ	
ɕ	*prośba* [prɔɕba] ‘request, Nom. Sg.’ ~ *próśb* [pruɕb] ‘Gen. Pl.’ *groźba* [grɔʑba] ‘threat, Nom. Sg.’ ~ *gróźb* [gruʑb] ‘Gen. Pl.’
j	*knajpa* [knajpa] ‘pub, Nom. Sg.’ ~ *knajp* [knajp] ‘Gen. Pl.’ *łajba* [wajba] ‘boat, Nom. Sg.’ ~ *łajb* [wajb] ‘Gen. Pl.’
r	*farba* [farba] ‘paint, Nom. Sg.’ ~ *farb* [farb] ‘Gen. Pl.’ *pasierb* [paɕɛrb] ‘step-son, Nom. Sg.’ ~ *pasierba* [paɕɛrba] ‘Gen. Sg.’ → *torba* [tɔrba] ‘bag, Nom. Sg.’ ~ *toreb* [tɔrɛb] ‘Gen. Pl.’
n	
w	
NOTES	- Words such as *półwysep* and *torba* may be underlyingly encoded (§4.3). These are the only two examples of alternation in *Cb* clusters that I have found.

APPENDIX B

Patterns in *Cr* and *Cɛr* sequences

The table below illustrates lack of predictability in vowel~zero alternations involving C and r sequences. The words in the first column exhibit a constant [ɛ] throughout the paradigm; the words in the second column exhibit vowel~zero alternations; and the data in the third column exhibit lack of a vowel in Cr sequences throughout the paradigm. Selected word data is organized by gender as well as type of consonant involved. Etymologically native words (i.e. words of Slavic origin) are marked with asterisks to show that foreignness is also not a predicting factor. All words are listed in their nominative singular form.

		constant [ɛ]	**alternating [ɛ]**	**absent [ɛ]**
Masculine	***labial stop + r***	*amper* [ampɛr] 'ampere' *papier* [papʲɛr] 'paper'	**ceber* [tsɛbɛr] 'type of container' *koliber* [kɔlibɛr] 'hummingbird' **koper* [kɔpɛr] 'dill'	**bóbr* [bubr] 'beaver' **żubr* [ʐubr] 'bison'
	coronal stop + r	*bohater* [bɔxatɛr] 'hero' *dromader* [drɔmadɛr] 'dromedary camel' *folder* [fɔldɛr] 'folder' *helikopter* [hɛlikɔptɛr] 'helicopter' *komputer* [kɔmputɛr] 'computer' *lider* [lidɛr] 'leader' *miliarder* [miljardɛr] 'billionaire' *parter* [partɛr] 'ground floor' *sutener* [sutɛnɛr] 'pimp' *skuter* [skutɛr] 'scooter'	*ester* [ɛstɛr] 'ester (chemistry)' *sweter* [sfɛtɛr] 'sweater' *sylwester* [sɨlvɛstɛr] 'New Year's Eve' *tender* [tɛndɛr] 'tender (coal-car)'	*cedr* [tsɛdr] 'cedar' **jesiotr* [jɛɕɔtr] 'sturgeon' *litr* [litr] 'litre' *metr* [mɛtr] 'metre' *centymetr* [tsɛntɨmɛtr] 'centimetre' *kilometr* [kilɔmɛtr] 'kilometre' *teatr* [tɛatr] 'theatre' **wiatr* [vʲatr] 'wind'

	velar stop ***+ r***	*dżoker* [dzɻɔkɛr] ‘joker’ *hamburger* [hamburgɛr] ‘hamburger’ *kier* [kʲɛr] ‘hearts (cards)’ *likier* [likʲɛr] ‘liqueur’ **ogier* [ɔgʲɛr] ‘stallion’ *poker* [pɔkɛr] ‘poker’	**cukier* [tsukʲɛr] ‘sugar’ *szwagier* [ʂfagʲɛr] ‘brother-in-law’	
	fricative ***+ r***	*deser* [dɛsɛr] ‘dessert’ *laser* [lasɛr] ‘laser’ *pasażer* [pasazɻɛr] ‘passanger’ *rower* [rɔvɛr] ‘bicycle’ *renifer* [rɛnifɛr] ‘reindeer’ *rewolwer* [rɛvɔlvɛr] ‘revolver (gun)’ *reżyser* [rɛzɻisɛr] ‘director (film)’ *serwer* [sɛrvɛr] ‘server (internet)’		*szyfr* [ʂɨfr] ‘cipher/code’
	sonorant ***+ r***	*fryzjer* [frɨzjɛr] ‘barber’ *inżynier* [inzɻɨnɛr] ‘engineer’ *kontroler* [kɔntrɔlɛr] ‘controller (inspector)’ *kawaler* [kavalɛr] ‘bachelor’ *kelner* [kɛlnɛr] ‘waiter’ *milioner* [miljɔnɛr] ‘millionaire’ *numer* [numɛr] ‘number’ *premier* [prɛmʲɛr] ‘premier’ *seler* [sɛlɛr] ‘celery’ *sufler* [suflɛr] ‘theatre prompter’	**mamer* [mamɛr] ‘prison (slang)’	

Feminine	***labial stop*** ***+ r***			*kobra* [kɔbra] ‘cobra’ *zebra* [zɛbra] ‘zebr’
	coronal stop ***+ r***	*litera* [litɛra] ‘letter’	*flądra* [flɔ̃dra] ‘flounder’ **kołdra* [kɔwdra] ‘comforter’ *salamandra* [salamandra] ‘salamander’	*katedra* [katɛdra] ‘cathedral’ **siostra* [ɕɔstra] ‘sister’ *tundra* [tundra] ‘tundra’
	velar stop ***+ r***	**siekiera* [ɕɛkʲɛra] ‘axe’	**iskra* [iskra] ‘spark’	**ikra* [ikra] ‘roe (caviar)’
	fricative ***+ r***	*atmosfera* [atmɔsfɛra] ‘atmosphere’		*cyfra* [tsɨfra] ‘number’
	sonorant ***+ r***	*cholera* [xɔlɛra] ‘cholera’ *kamera* [kamɛra] ‘camera (video)’ *premiera* [prɛmʲɛra] ‘premiere’		
Neuter	***labial stop*** ***+ r***		**srebro* [srɛbrɔ] ‘silver’ **żebro* [ʐɛbrɔ] ‘rib’	**dobro* [dɔbrɔ] ‘good’
	coronal stop ***+ r***		**biodro* [bʲɔdrɔ] ‘hip’ **futro* [futrɔ] ‘fur’ **jądro* [jɔ̃drɔ] ‘testicle/nucleus’ **piętro* [pʲɛ̃trɔ] ‘storey/level’ **wiadro* [vʲadrɔ] ‘bucket’	