博士論文

Sound Alternations in Slavic Languages

（スラヴ諸語における音交替）

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これまで支えてくれた両親へ

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ABBREVIATIONS

acc.	accusative
adj.	adjective
adv.	adverb
anim.	animate
dat.	dative
decl.	declarative
def.	definite
dim.	diminutive
E	English
F	French
fem.	feminine
G	German
gen.	genitive
imp.	imperative
impf.	imperfective
indef.	indefinite
inf.	infinitive
ins.	instrumental
loc.	locative
masc.	masculine
n.	noun
neut.	neuter
nom.	nominative
p.	past tense
pf.	perfective
pl.	plural (1pl: 1st person plural of non-past tense)
pp.	past participle
sg.	singular (1sg: 1st person singular of non-past tense)
v.	verb
voc.	vocative

1. INTRODUCTION

This dissertation sheds light on the sound patterns of Slavic languages. While these languages are similar in many aspects, including phonology, a number of interesting variations have also been documented. The aim of this work is to examine the common phonological mechanisms behind diverse Slavic languages and to provide new insight into phonological theory.

Most of the sound alternations that are observed among Slavic languages are also observed across world languages and should be phonologically motivated. For instance, palatalization, which is widely observed in Slavic and other languages, has been regarded as the assimilation of consonants to the adjacent front vowels or glides (§2.2). Vowel reduction is also cross-linguistically observed and is considered a phonological phenomenon that is related to unstressed syllables (§2.3.1). Notably, the occurrence of sound alternations can vary by language. Regarding palatalization, consonants may change to secondarily palatalized consonants (e.g., Russian) or change in primary articulation (e.g., Czech). Vowel reduction has also several types: for instance, [a] is attested in some languages (e.g., Belorussian) but not in others (e.g., Bulgarian). Patterns are also variable within a language. For instance, vowel–zero alternation or *yer* (§2.3.4) is a long debated topic in Slavic phonology research and is attested exclusively in some morphemes. In other words, some sound patterns cannot be explained in terms of phonology alone. This topic is an essential point in the following discussion.

This work considers morpheme-internal alternations rather than phonotactic patterns to elucidate the phonological conditions wherein the sound patterns in question occur. Previous linguistic studies have long discussed how to explain phonological processes. One approach to sound patterns is Generative Phonology, and this work is based on this approach. Under this framework, linguistic sounds are *represented* as certain abstract forms. This framework assumes that observed or *surface* sound forms are *generated* from *underlying* forms that are stored in the speakers' lexicon by virtue of phonological *grammar*. The main focus of this research is how *underlying representation* and *phonological grammar* should be assumed.

Regarding the representational issues, many researchers have proposed phonological *features* to represent abstracted linguistic sounds (§3.1). Each of these features represents a certain phonological category such as laryngeal voice, labial articulation, and backness. Earlier research assumed binary features, which either have a positive or negative value in terms of a given category. This dissertation adopts another framework wherein phonological features are *privative* because each feature assigns a certain phonological activity (§3.1.1). In other words, this work assumes that phonologically predictable and/or inactive features can be *underspecified* in the underlying forms, even when phonetically realized at the surface. Furthermore, underspecification is lexically conditioned, thus resulting in idiosyncratic or exceptional sound patterns (§3.1.3).

The literature on phonological grammar mainly proposes two mechanisms: *rules* and *constraints*. Under rule-based frameworks, sound patterns are formalized as a result of the sequecial application of phonological rules to underlying sound forms. In this type of analyses, rules are obligatorily applied under defined conditions. However, some sound patterns cannot be phonologically generalized. Although it is possible to assume an additional rule to account for the exceptionality, such an approach is too arbitrary to consider. Intermediate stages in the course of rule applications have also been questioned because such forms cannot be observed. In recent decades, researchers have proposed a surface-oriented and constraint-based approach: Optimality Thoery (§3.2), which is adopted by the current dissertation. This framework assumes *universal* constraints and one-step or *parallel* generation to resolve the aforementioned problems under rule-based theories. In summary, observed sound patterns (*outputs*) are the *optimal* candidates according to the violations of the ranked constraints: a candidate is preferred over another candidate if the former violates constraints that are ranked lower than the constraints violated by the latter.

This work demonstrates that most of the sound alternations in Slavic languages can be generalized by assuming some universal constraints that have been affirmed in the literature. By contrast, the variations among languages are formalized as differences in constraint rankings (see §4.2–§4.4). However, some researchers have objected to the parallelism because this theory refers exclusively to outputs and cannot account for phonologically *opaque* patterns,

in which given phonological processes are unattested in the presence of their triggers or given phonological processes are attested in the absence of their triggers on the surface. Accounting for Opacity under parallelism has also been attempted. This dissertation provides further support for the parallelism by analyzing several opaque patterns among Slavic languages. On the contrary, stepwise or *serial* derivation is dismissed for the arbitrariness of the division of derivational processes (§3.2.2).

One main problem for phonological analyses is that some patterns are observed without exception under certain phonological conditions, whereas others are variable. Therefore, the occurrence of sound alternations may also be related to factors beyond pure phonology. The following discussion focuses on lexical and/or morphological properties. In the literature, such variable processes have been explained by assuming specific phonological representations (§3.1.2–§3.1.3), interface constraints (§3.3.1), or stratification of the phonological lexicon (§3.3.3). This work focuses on phonological *productivity*, that is, whether a given sound pattern can be extended within the language and argues that productive alternations should be accounted for by assuming lexical stratification and stratum-specific constraints, whereas nonproductive alternations should be accounted for by assuming morpheme-specific representations and/or constraints (§4.1.3).

Although the general goal of this work is to reveal the whole system of Slavic phonology, this dissertation has several limitations. First, I will focus mainly on the following five

languages: Russian, Polish, Czech, Serbo–Croatian, and Bulgarian; all of these have been well documented by many researchers. Moreover, the target will be restricted to the standard variant of each language. Second, the focus of the paper is restricted to segmental phonology, i.e., alternations of vowels and consonants or inter-segment interactions; my discussion will not extend to autosegmental patterns such as stress or intonation. Finally, the discussion is primarily based on phonological patterns, with their phonetic detail set aside.

The chapters are organized as follows. First, in Chapter 2, I will examine the sound patterns of Slavic languages, mainly the five languages mentioned above. Next, in Chapter 3, I will discuss the theoretical background and analyze the sound patterns in question by reviewing previous phonological studies. My main focus will be on the featural representation of linguistic sounds and grammatical models predicting phonological phenomena. Based on this discussion, Chapter 4 will describe a formal analysis of the phonological patterns introduced in Chapter 2. Finally, Chapter 5 will conclude the discussion.

2. SOUND ALTERNATIONS IN SLAVIC LANGUAGES

This chapter presents the main sound alternations observed in Slavic languages (the analysis in Chapter 4). First, Section 2.1 provides an overview of the basic points in the phonology of five Slavic languages. Second, I introduce various phonological alternations: Section 2.2 examines palatalization and vowel backness alternation, and Section 2.3 examines several vowel alternations. Finally, Section 2.4 briefly lays out some other patterns, which are not targeted by the following formal analysis.

2.1. Basic facts: sound inventories and phonotactics

This section aims to overview the basic phonological characteristics of five Slavic languages: Russian (Avanesov 1984; Timberlake 2004; Knyazev and Pozharitskaya 2011), Polish (Stieber 1966; Rubach 1984; Gussmann 2007), Czech (Kučera 1961; Short 1993), Serbo–Croatian (Browne 1993; Townsend and Janda 1996), and Bulgarian (Scatton 1975, 1993; Townsend and Janda 1996).

2.1.1. Russian

Overall, Russian has 25 consonants, 15 of which have palatalized counterparts, and 6 vowels. Table 1 shows the consonants. Obstruents in the upper row are voiceless, and their voiced counterparts are given below. Consonants embedded in brackets appear only allophonically;

their appearance is triggered by voicing assimilation. The following subsections also follow this order of presentation.

	Labial	Dental/ Alveolar	Palato-alveolar	Retroflex	Alveo-palatal	Palatal	Velar
Plosive	p pʲ	t tʲ					k kʲ
	b bʲ	d dʲ					g gʲ
Fricative	f fʲ	s sʲ		ʂ	ɕ:		x xʲ
	v vʲ	z zʲ		ʐ	(ʑ:)		(ɣ)
Affricate		ʦ	ʧ				
		(ʣ)	(ʤ)				
Nasal	m mʲ	n nʲ					
Trill		r rʲ					
Lateral		l lʲ					
Glide						j	

Table 1: Consonants in Russian

Some comments are in order. First, most consonants contrast in secondary palatalization. As will be noted later, palatalized consonants have been traditionally called “soft” (Chekman 1979; Avanesov 1984, among others). Non-contrastive consonants [ʧ, ɕ:, j] have been considered inherently soft, while [ʦ, ʂ, ʐ] have been considered hard (Note that this study utilizes the diacritic [ʲ] to denote palatalized consonants following the IPA transcription, instead of [′] adpoted as the “softness” mark in Slavic linguistics as in [t′]). Second, what have been called “hushing” consonants, which have been regarded as palatoalveolars, are further divided into two categories: palatoalveolars ([ʧ (and ʤ)]) and retroflexes ([ʂ, ʐ]), following Zygis (2003), Padgett and Zygis (2003), and Hamann (2004) (see also Keating 1990). Zygis (2003)

noted that the retroflexes are observed among Slavic languages such as Polish and Serbo–Croatian (see below).

Vowel contrasts are relatively simple, as schematized in Table 2.[1] Five vowels are observed in stressed syllables, and schwa is always unstressed. The contrasts are restricted in unstressed syllables due to vowel reduction (discussed in §2.3.1; see also Crosswhite 2000). Note that stress can be assigned to any position and is lexically determined in Russian. Stress shifts are also observed in some morphological contexts. One more thing to be noticed is that a high central vowel [ɨ] is not assumed, in contrast to most previous Slavic studies. Following Padgett (2001), this study assumes that what has been regarded as [ɨ] is in fact [i] preceded by "hard" consonants. This is supported by the analysis of some sound alternations, as discussed later.

	Front	Central	Back
High	i		u
Mid	e	(ə)	o
Low		a	

Table 2: Vowels in Russian

Let us briefly discuss the significant phonotactic restrictions in the remainder of this subsection. First, voiced obstruent consonants are observed only when they precede voiced obstruent consonants or sonorants (either consonant or vowel). On the other hand, voiceless

[1] Mid vowels have been regarded as open-mid vowels ([ɛ, ɔ]) by some researchers (e.g., Rubach 2007). On the other hand, the contrast between open-mid and close-mid vowels is not observed among Slavic languages. This work thus assumes mid vowels transcribed as [e, o].

obstruents are not observed preceding voiced obstruents. In other words, regressive voicing assimilation and final devoicing are observed in Russian as well as many other Slavic languages. Note that this assimilation occurs across word boundaries as well (e.g., zɐtʃ 'to burn' ~ zɐdʒ#bi [conditional]). An exception is the voiced labial fricative [v]: while it is devoiced before a voiceless obstruent or word-finally, it does not trigger voicing of the preceding voiceless obstruents. This pattern is observed widely among Slavic languages; this peculiar consonant has been regarded as originally or "underlyingly" /w/ (Townsend and Janda 1996: see §2.4.1).

Another restriction is related to palatalization. While only palatalized or neutral consonants can precede [e] in the native phonology, any consonant can precede other vowels. This can be seen in the nominal inflecion as shown in (1): the non-palatalized stem-final consonant ([l]) changes to the palatalized counterpart ([lʲ]) when the front vowel follows, whereas the palatalized stem-final consonant emerges in the whole paradigm (such declension is attested across Slavic languages with a few exceptions such as Bulgarian). It has been documented that [i] as well as [e] cannot follow non-palatalized consonants: [ɨ] appears in this position instead (Avanesov 1984; Timberlake 2004, among others). In other words, front vowels cannot be preceded by non-palatalized consonants. Some researchers (e.g., Padgett 2001), however, have argued that the so called [ɨ] is in fact [i] following a velarized consonant,

as noted earlier. On the other hand, palatalization of consonants preceding [i] is observed, which suggests that this vowel still restricts the type of consonants that precede it.

(1) Nominal inflection in Russian[2]

'desk'		'handlebar'	
sto**l**	(nom./acc.sg.)	ru**lʲ**	(nom./acc.sg.)
sta**l**-a	(gen.sg.)	ru**lʲ**-a	(gen.sg.)
sta**l**-u	(dat.sg.)	ru**lʲ**-u	(dat.sg.)
sta**l**-om	(inst.sg.)	ru**lʲ**-om	(inst.sg.)
sta**lʲ**-e	(loc.sg.)	ru**lʲ**-e	(loc.sg.)
sta**l**-i	(nom./acc.pl.)	ru**lʲ**-i	(nom./acc.pl.)

This issue will be discussed in §2.2. I briefly note at present that this study no longer assumes a surface [ɨ], but still assumes an underlying /ɨ/. In short, front vowels cannot surface after non-palatalized consonants.

The emergence of palatalized consonants is also restricted. First, palatalized velars are never observed in word-final positions, and quite rarely appear before back vowels in the native phonology (Institut russkogo yazyka 2013). Among native words, other palatalized consonants are not frequently followed by back vowels either, especially by [u]. In addition, palatalized consonants are unlikely to precede consonants (see §4.2.1).

Finally, while Russian is rich in consonant clusters, some sequences are unattested. For instance, word-initial clusters of three or more consonants in which the first two are identical fricatives (e.g., [ssn] and [fft]) are unacceptable, while double fricatives are observed (e.g.,

[2] The quality of vowels may vary with stress shift (see §2.3.1).

ssiləi̯ ‘with power’ vs. *__ssn__ʲegəm / səsnʲegəm ‘with snow’). Clusters of the form [fricatives + stops + nasals] are also avoided as in [izvʲe**stʲi**n] ‘famous (decl.)’ ~ [izvʲe**sn**ii̯] ‘famous.’

2.1.2. Polish

As shown in Table 3, Polish has 29 consonants, 14 of which have palatalized counterparts. Even though the inventory seems similar to that of Russian, there are many differences in phonological contrasts. One is that palatalized dental/alveolar consonants are observed exclusively across word boundaries in the native phonology and widely in loanwords; their original “soft” or palatalized (in a broad sense) counterparts are (alveo)palatals (see §2.2.1). Note that [r] changes to [ʐ] under conditions that would trigger palatalization. Although this consonant also results from the alternation of other consonants, the orthography indicates that it originates from [r] (transcribed as *rz*, and as *ż* in other cases). [l], in contrast, is regarded as soft, while its hard counterpart is [w], which has been documented historically: velarized [l] (i.e., [ɫ]), which is still observed in some dialects, has changed to [w] (Stieber 1966; Gussmann 2007).

	Labial	Dental/ Alveolar	Retroflex	Alveo-palatal	Palatal	Velar	Labial-velar
Plosive	p pʲ b bʲ	t tʲ d dʲ				k kʲ g gʲ	
Fricative	f fʲ v vʲ	s sʲ z zʲ	ʂ ʐ	ɕ ʑ		x xʲ (ɣ)	
Affricate		ʦ ʣ	ʧ (ʤ)	ʨ ʥ			
Nasal	m mʲ	n nʲ			ɲ		
Trill		r rʲ					
Lateral		l					
Glide					j		w

Table 3: Consonants in Polish

Retroflexes, which have been regarded as palatoalveolars as in Russian (see §2.1.1), and dental affricates are all hard, whereas [j] is soft. Finally, while palatalized velars have also been regarded as palatals [c, ɟ, ç] in many studies (e.g., Gussmann 2007), this study treats these consonants uniformly as fronted or secondarily palatalized velars regardless of the slight phonetic variation and transcribes them as [kʲ, gʲ, xʲ]. This also distinguishes them from Czech palatals.

The Polish vowel inventory is notable because of its nasal vowels. In addition to the five fundamental vowels, as seen in Table 4, two nasal mid vowels are observed.

	Front	Central	Back
High	i		u
Mid	e ẽ		o õ
Low		a	

Table 4: Vowels in Polish

However, their emergence is restricted. In particular, the front vowel (i.e., [ɛ̃]) loses its nasality in word-final positions (Gussmann 2007). Gussmann (2007) suggested that nasal vowels are accompanied by nasal consonants or nasalized glides when they precede consonants. In addition, [ɨ] has been assumed to occur as in Russian, but this categorization is not adopted for the same reason as that noted for Russian. Besides, unlike in Russian, the vowel contrasts are independent of stress. Moreover, stress is fixed to penultimate syllables in multisyllabic words.[3]

Phonotactic restrictions are similar to those in Russian. First, final devoicing and regressive voicing assimilation are observed. One difference is that [v] does not only fail to trigger voicing but also to undergo progressive devoicing. This is also true of [ʐ] originating from [r] (vʲatr 'wind' ~ vʲetʂe [loc.sg.] cf. vʲara 'belief' ~ vʲeʐe [loc.sg.]). This suggests that sonorant consonants were not originally likely to trigger voicing (see §2.4.1).

Second, non-palatalized (excluding alveopalatal and *neutral*) or *hard* consonants preceding front vowels are restricted as in Russian, but less strictly. In particular, [e] can follow these consonants in many cases. Another restriction on palatalization is that secondarily palatalized consonants must precede a vowel, in contrast to Russian; merger with non-palatalized consonants is observed in cases such as [kar**p**ʲ-a] 'carp (gen.sg.)' ~ [kar**p**] (nom.sg.).

[3] Some enclitics are extrametrical: stress is assigned to the second last syllables in words preceding them (e.g., véʂwi-ɛtɛe 'entered [2pl]').

2.1.3. Czech

Table 5 illustrates the consonantal inventory of Czech (see also Short 1993), in which 29 consonants are observed. One remarkable point contrasting Czech from Russian or Polish is that no contrastive secondary palatalization occurs. However, another type of palatalization is attested in Czech (discussed in detail in §2.2.1): dental stops and nasals ([t, d, n]) change to palatals ([c, ɟ, ɲ]), labial obstruents come to be followed by a palatal glide [j] (e.g., riba 'fish' ~ ri**bj**e [loc.sg.]), and [m] is followed by [ɲ] (e.g., zima 'winter' ~ zi**mɲ**e [loc.sg.]).

	Labial	Dental/ Alveolar	Palato-alveolar	Palatal	Velar	Glottal
Plosive	p	t		c	k	
	b	d		ɟ	g	
Fricative	f	s	ʃ		x	
	v	z	ʒ		(ɣ)	ɦ
Affricate		ʦ	ʧ			
		(ʣ)	(ʤ)			
Nasal	m	n		ɲ		
Trill		r				
Trill-fricative		(ɪ̝)				
		ɹ̝				
Lateral		l				
Glide				j		

Table 5: Consonants in Czech

What have been regarded as palatoalveolars are not the least retroflex and show variation (Hamann 2004); these consonants will be transcribed as palatoalveolars for simplicity. The most peculiar consonant is an alveolar trill-fricative [ɹ̝], which is pronounced as [r] with

considerable friction. In addition, a voiced glottal fricative [ɦ] is also characteristic. It developed historically from [g], which can be attested in loanwords.

The vowel system in this language is remarkable in that a length contrast is observed. As shown in Table 6, each of the five vowels has short and long counterparts. In addition, the diphthongs [ou] and [ei] are observed.

	Front	Central	Back	Diphthongs
High	i i:		u u:	ei ou
Mid	e e:		o o:	
Low		a a:		

Table 6: Vowels in Czech

Note that the length contrast is not simple: the distribution of long vowels is restrictive (see also Short 1993). First, [o:] is observed only in loanwords, since the original [o:] has been raised to [u:] in native words. Second, [e:] is only observed when it does not follow palatal consonants; it is raised to [i:] otherwise. In the spoken language, however, this raising also occurs when the vowel follows non-palatal consonants. Finally, vowel length is determined by certain morphological conditions, which results in length alternations (discussed more in detail in §2.3.3). In addition to the vowels, syllabic liquids ([r̩, l̩]) are attested in this language (e.g., tr̩x 'market'; vl̩k 'wolf'); these do not contrast in length. Like in Polish, Czech vowel contrasts are not affected by stress, which is fixed to initial syllables.

Next, I briefly mention some phonotactic restrictions. First, the voicing contrast is neutralized as in Russian and Polish. Note that the trill-fricative undergoes not only regressive

(e.g., vu̯ti ‘sausages’) but also progressive devoicing (e.g., tu̯i ‘three’). On the other hand, this consonant does not trigger voicing, which suggests that it behaves like a sonorant rather than an obstruent. /v/ undergoes only regressive devoicing and does not trigger voicing. The voiced glottal fricative ([ɦ]) changes to [x] if devoiced, while [x] simply undergoes voicing, i.e., changes to [ɣ].

Next, unlike in Russian or Polish, non-palatal(ized) consonants can freely precede front vowels. In other words, palatalization is motivated only morpho-phonologically. Another remarkable point is that [j] can precede [i], which is likely to be avoided among other Slavic as well as non-Slavic languages.

2.1.4. Serbo–Croatian

The consonant inventory in Serbo–Croatian is schematized in Table 7, where 27 consonants are observed overall. Similar to Czech, this language does not have secondarily palatalized consonants. On the other hand, several palatal or alveopalatal consonants are attested, among which [ʎ] is peculiar to this language.

	Labial	Dental/ Alveolar	Retroflex	Alveo-palatal	Palatal	Velar
Plosive	p	t				k
	b	d				g
Fricative	f	s	ʂ			x
	v	z	ʐ			(ɣ)
Affricate		ʦ	ʧ	ʨ		
		(ʣ)	ʤ	ʥ		
Nasal	m	n			ɲ	
Trill		r				
Lateral		l			ʎ	
Glide					j	

Table 7: Consonants in Serbo–Croatian

As can be seen in Table 8, five vowels are attested, as in other Slavic languages. Peculiar to this language are length and pitch accent: any vowel can lexically be either short or long and bear either rising or falling tone. In other words, accent positions are phonologically unpredictable like in Russian. On the other hand, vowel qualities do not vary depending on the accent.

	Front	Central	Back
High	i		u
Mid	e		o
Low		a	

à	short rising
ȁ	short falling
á	long rising
â	long falling

Table 8: Vowel contrast in Serbo–Croatian

One phonotactic characteristic that differs from many other Slavic languages is the absence of final devoicing in this language. However, regressive voicing assimilation is observed within consonant clusters. Another restriction is on the lateral consonant [l]: it changes to [o] in syllable-final positions (e.g., be**l**a white (fem.sg.) ~ [be**o**]/*[bel] (masc.sg.)).

2.1.5. Bulgarian

As seen in Table 9, the Bulgarian consonant inventory is similar to Russian consonant inventory: contrastive secondary palatalization occurs in 15 out of the 23 consonants. In contrast, no retroflex consonants are observed in this language (Zygis 2003; Hamann 2004), but only palatoalveolars are.

	Labial	Dental/ Alveolar	Palato-alveolar	Palatal	Velar
Plosive	p pʲ	t tʲ			k kʲ
	b bʲ	d dʲ			g gʲ
Fricative	f fʲ	s sʲ	ʃ		x (xʲ)
	v vʲ	z zʲ	ʒ		(ɣ)
Affricate		ʦ	ʧ		
		(ʣ)	(ʤ)		
Nasal	m mʲ	n nʲ			
Trill		r rʲ			
Lateral		l lʲ			
Glide				j	

Table 9: Consonants in Bulgarian

As shown in Table 10, six vowels contrast in stressed syllables, while three merge with the others in unstressed ones: [o] changes to [u], [e] to [i], and [a] to [ə] (see §2.3.1). Note that stress positions are not phonologically determined. These points are further similarities with Russian.

	Front	Central	Back
High	i		u
Mid	e	ə	o
Low		a	

Table 10: Vowels in Bulgarian

Note that the schwa is attested in not only unstressed but also stressed syllables.

As in many other Slavic languages, final devoicing and regressive voicing assimilation occur in Bulgarian. In contrast, restrictions on consonant–vowel sequences for palatalization are complicated. Before front vowels, non-velar consonants are non-palatalized, while velar ones are palatalized. Note that palatalized velars preceding non-front vowels are observed in a few loanwords.

2.2. Palatalization and vowel backness alternation

Palatalization, which is widely observed in Slavic languages as well as in many others, is a phenomenon in which a consonant brings its place of articulation toward the hard palate. In Russian, for instance, [m] in *dom* 'house' changes to [mʲ] in the locative singular *dome*. This process is widely accepted as being triggered by adjacent front vowels (Bhat 1978; Bateman 2007). Because palatalization usually occurs before front vowels or glides, whose place of articulation is near the hard palate, it has been regarded as an assimilation process (Bhat 1978; Bateman 2007; Clements and Hume 1995; Rubach 2000, 2003; Halle 2005; Gussmann 2007). This assimilation is bidirectional, in that palatalized consonants may also affect back vowels

(see §2.2.4). These consonant–vowel interactions, however, have provoked much dispute due to a number of exceptions and the pattern complexity.

The remainder of this section is organized as follows. After palatalization processes are briefly introduced in §2.2.1, the observed variations are discussed in §2.2.2 and §2.2.3. §2.2.4, in contrast, addresses the opposite process, in which vowel backness is affected by adjacent palatal(ized) consonants. Before concluding this section, §2.2.5 considers *softness*, the traditional terminology for palatalization. Finally, §2.2.6 summarizes the section.

2.2.1. Overview of palatalization among Slavic languages

Item (2) illustrates some examples from Slavic languages in which consonants precede front vowels. Note that some palatalization patterns are also observed when a front glide [j] follows. However, they are related primarily to certain morphological conditions and cannot be phonologically generalized, as mentioned in §2.4.2. This work does not focus on these patterns. Another and important issue is that palatalization is not a uniform process, in that a consonant may change in different ways: a consonant is accompanied by secondary palatalization in some cases (e.g., [t] → [tʲ]), whereas a consonant changes in primary articulation in other cases (primary palatalization: e.g., [t] → [tɕ]). Moreover, the result of primary palatalization is also

variable: target consonants can emerge as palatoalveolar (or postalveolar), retroflex,[4] alveopalatal, or palatal.

(2) Palatalization in Slavic languages

a. Russian

Dental/alveolar consonants:

atvʲe**t**	'answer'	atvʲe**t**ʲ-i-tʲ	'to answer'
lʲi**t**-a-tʲ	'to fly'	lʲi**t**ʲ-e-tʲ	'to fly (somewhere)'
i**d**-u	'go (1sg)'	i**d**ʲ-i	(imp.)
va**d**-a	'water'	va**d**ʲ-e	(loc.sg.)
no**s**	'nose'	no**s**ʲ-ik	(dim.)
pala**s**-a	'stripe'	pala**s**ʲ-e	(loc.sg.)
maro**z**-ə	'frost (gen.sg.)'	maro**z**ʲ-i-tʲ	'to freeze'
slʲi**z**-a	'tear'	slʲi**z**ʲ-e	(loc.sg.)
ʂi**r**-okʲ-iː	'wide'	ʂi**r**ʲ-in-a	'width'
ga**r**-a	'mountain'	ga**r**ʲ-e	(loc.sg.)
sto**l**	'desk'	sta**l**ʲ-e	(loc.sg.)
arʲo**l**	'eagle'	or**l**ʲ-ik	(dim.)
kras**n**-əjə	'red (fem.nom.sg.)'	kras**n**ʲ-e-tʲ	'to become red'
sta**n**-u	'become (1sg)'	sta**n**ʲ-i-t	(3sg)

Labial consonants:

f-stu**p**-a-tʲ	'to enter (impf.)'	f-stu**p**ʲ-i-tʲ	(pf.)
tal**p**-a	'crowd'	tal**p**ʲ-e	(loc.sg.)
glu**b**-okʲ-iː	'deep'	glu**b**ʲ-in-a	'depth'
gu**b**-a	'lip'	gu**b**ʲ-e	(loc.sg.)
gra**f**	'earl'	gra**f**ʲ-inʲ-ə	(fem.)
lo**v**-ə	'hunt (gen.sg.)'	la**v**ʲ-i-tʲ	'to hunt'
no**v**-əjə	'new (fem.nom.sg.)'	na**v**ʲ-eːʂ-əjə	'newest (fem.nom.sg.)'
do**m**	'house'	do**m**ʲ-ik	(dim.)
xur**m**-a	'persimmon'	xur**m**ʲ-e	(loc.sg.)

Velar consonants:

pʲi**k**-u	'bake (1sg)'	pʲi**k**ʲ-i	(imp.)
rʲi**k**-a	'river'	rʲi**k**ʲ-e	(loc.sg.)
bʲirʲi**g**-u	'care (1sg)'	bʲirʲi**g**ʲ-i	(imp.)
na**g**-a	'leg'	na**g**ʲ-e	(loc.sg.)
but			
kuso**k**	'piece'	kuso**ʧ**-ik	(dim.)
slu**g**-a	'servant'	slu**ʐ**-i-tʲ	'to serve'
tʲi**x**-ə	'silent (decl.)'	tʲi**ʂ**-in-a	'silence'

[4] The retroflex consonants have been regarded as palatoalveolar in most studies (see §2.1).

b. Polish

Dental/alveolar consonants:

po**t**	‘sweat’		po**tɕ**-i-tɕ	‘to sweat’
ko**t**	‘cat’		ko**tɕ**-e	(loc.sg.)
		but	ko**t**-ek	(dim.)
mwo**d**-a	‘young (fem.sg.)’		mwo**dʑ**-i	(masc.pl.)
		cf.	mwo**d**-e	(fem.pl.)
i**d**-õ	‘go (3pl)’		i**dʑ**-e	(3sg)
no**s**	‘nose’		no**ɕ**-e	(loc.sg.)
		but	no**s**-em	(inst.sg.)
vo**z**-u	‘cart (gen.sg.)’		vo**ʑ**-i-tɕ	‘to carry’
fsta**n**-õ	‘stand up (3pl)’		fsta**ɲ**-e	(3sg)
but				
vi**n**-o	‘wine (gen.sg.)’		vi**n**-em	(inst.sg.)

Labial consonants:

skle**p**	‘shop’	skle**pʲ**-ik	(dim.)
xle**b**-a	‘bread (gen.sg.)’	xle**bʲ**-e	(loc.sg.)
	but	xle**b**-ek	(dim.)
ʂe**f**	‘chief’	ʂe**fʲ**-e	(loc.sg.)
	but	ʂe**f**-em	(inst.sg.)
pra**v**-a	‘right (fem.sg.)’	pra**vʲ**-i-tɕ	‘to correct’
ʂu**m**	‘noise’	ʂu**mʲ**-e	(loc.sg.)

Velar consonants:

kro**k**	‘step’	kro**kʲ**-em	(inst.sg.)
dro**g**-a	‘dear (fem.nom.sg.)’	dro**gʲ**-i	(masc.nom.sg.)
		dro**gʲ**-e	(neut.nom.sg.)
cf.			
oʐe**x**	‘nut’	oʐe**x**-em	(inst.sg.)

but

kro**k**	‘step’	kro**tʂ**-i-tɕ	‘to step’
		kro**tʂ**-ek	(dim.)
swu**g**-a	‘servant’	swu**ʐ**-i-tɕ	‘to serve’
mo**g**-õ	‘can (3pl)’	mo**ʐ**-e	(3sg)
su**x**-a	‘dry (fem.nom.sg.)’	su**ʂ**-i-tɕ	‘to dry’
oʐe**x**	‘nut’	oʐe**ʂ**-ek	(dim.)

c. Czech

Dental/alveolar consonants:

ʧiś**t**-a:	‘clean (fem.sg.)’	ʧiś**c**-i-t	‘to clean’
le:**t**-a-t	‘to fly’	le**c**-e-t	‘to fly (somewhere)’
mla**d**-a:	‘young (fem.sg.)’	mla**ɟ**-i:	(masc.anim.pl.)
vo**d**-a	‘water’	vo**ɟ**-e	(loc.sg.)
pļ**n**-a:	‘full (fem.sg.)’	pļ**ɲ**-i-t	‘to fill’
vi**n**-a	‘fault’	viɲ-e	(loc.sg.)
but			
xvos**t**	‘tail’	xvos**t**-ek	(dim.)
vo**d**-a	‘water’	vo**d**-ek	(dim., gen.pl.)
fsta**n**-u	‘stand up (1sg)’	fsta**n**-e	(3sg)
cf.			
no**s**	‘nose’	no**s**-e	(loc.sg.)
naka**z**-a	‘infection’	naka**z**-i-t	‘to infect’

Labial consonants (no palatalization):

e.g.,

no**v**-a:	‘new (fem.sg.)’	no**v**-i:	(masc.anim.pl.)

Velar consonants:

ru**k**-a	‘hand’	ru**ʧ**-iʧk-a	(dim.)
obla**k**	‘cloud’	obla:**ʧ**-ek	(dim.)
pe**k**-u	‘bake (1sg)’	pe**ʧ**-e	(3sg)
slu**ɦ**-a	‘servant’	slou**ʒ**-i-t	‘to serve’
mo**ɦ**-u	‘can (1sg)’	mu:**ʒ**-e	(3sg)
su**x**-a:	‘dry (fem.sg.)’	su**ʃ**-i-t	‘to dry’
but			
obla**k**	‘cloud’	obla**k**-em	(inst.sg,)
dra**ɦ**-a:	‘expensive (fem.sg.)’	dra**g**-e:	(neut.sg,)
su**x**-a:	‘dry (fem.sg.)’	su**x**-e:	(neut.sg,)

d. Serbo–Croatian

Dental/alveolar consonants (no palatalization):

i**d**-u	‘go (3pl)’	i**d**-e	(3sg)
go**r**-a	‘mountain’	go**r**-iʦ-a	(dim.)

Labial consonants (no palatalization):

ʌu**b**-av	‘love’	ʌu**b**-i-ti	‘to love’

Velar consonants:

ru**k**-a	‘hand’	ru**ʧ**-iʦ-a	(dim.)
slu**g**-a	‘servant’	slu**ʐ**-i-ti	‘to serve’
mo**g**-u	‘can (1sg)’	mo**ʐ**-e	(3sg)
mu**x**-a	‘fly’	mu**ʂ**-iʦ-a	(dim.)
but			
te**ʂk**-a	‘heavy (fem.sg.)’	te**ʂk**-i	(pl.)
ru**k**-a	‘hand’	ru**k**-e	(gen.sg.)

e. Bulgarian
Dental/alveolar consonants (no palatalization):
e.g.,

i**d**-a	'go (1sg)'	i**d**-e	(3sg)
		i**d**-i	(imp.)
go**r**-a	'forest'	go**r**-i	(pl.)

Labial consonants (no palatalization):
e.g.,

gə**b**-a	'mushroom'	gə**b**-i	(pl.)

Velar consonants:

teʂ**k**-a	'heavy (fem.sg.)'	teʂ**k**^{j}-i	(pl.)
dru**g**-a	'second (fem.sg.)'	dru**g**^{j}-i	(pl.)
but			
zna**k**	'sign'	zna**ʧ**-i	'mean (3sg)'
mo**g**-a	'can (1sg)'	mo**ʒ**-e	(3sg)

As can be seen in (2), the triggers, participants, and types of palatalization vary among these Slavic languages. These are summarized in Table 11[5] ("P" denotes primary palatalization, "S" denotes secondary, and "( )" denotes variability).

Consonants	Dental/Alveolar		Labial		Velar	
Following V	[i]	[e]	[i]	[e]	[i]	[e]
Russian	S	S	S	S	P/S	P/S
Polish	P	(P)	S	(S)	P/S	P/(S)
Czech	(P)	(P)	×	×	(P)	(P)
Serbo–Croatian	×	×	×	×	(P)	(P)
Bulgarian	×	×	×	×	P/S	P/S

Table 11 Palatalization in Slavic languages: summary

Some generalizations can be deduced. First, velar consonants can undergo palatalization in all the five languages. Second, a high front vowel [i] is more likely to trigger palatalization than a mid one [e]. This is particularly striking in Polish. Moreover, as noted in the next subsection,

[5] In some languages, the occurrence of palatalization varies by the subtype of consonants (e.g., stops vs. fricatives).

this tendency is clearly observed in loanword phonology. This implicational relationship has been documented as a cross-linguistic tendency in previous typological studies (Chen 1973; Bateman 2007). Finally, labial consonants never undergo primary palatalization. Bateman (2007) asserted that the primary palatalization of labials is almost absent across languages because of the impossibility in blending the independent articulators (i.e., the tongue blade and the lips).

The difficulty of the analysis of Slavic palatalizations comes from their phonological idiosyncrasy. First, as shown in (2), the manner in which a consonant palatalizes or whether a consonant undergoes palatalization at all may vary not only across languages but even within a language. In Russian, for instance, velar consonants surface as their secondarily palatalized counterparts in some cases, but as prepalatal consonants in others. In Polish, a consonant may not palatalize at all before [e], a context that should trigger palatalization. These facts show inconsistency in phonological processes within a context in a single language, which has provoked much dispute.

Another phonological irregularity is that palatalization may occur under conditions that seem unlikely to trigger it. As shown below, consonants may undergo palatalization before non-front vowels (3) or consonants (4).

(3) Palatalization before non-front vowels

e.g. Russian

i**d**-u	‘go (1sg)’	i**dʲ**-o-t	(3sg)
nʲi**s**-u	‘carry (1sg)’	nʲi**sʲ**-o-t	(3sg)
a**r**-u	‘cry (1sg)’	a**rʲ**-o-t	(3sg)
zi̯**v**-u	‘live (1sg)’	zi̯**vʲ**-o-t	(3sg)
pʲi**k**-u	‘bake (1sg)’	pʲi**ʧ**-o-t	(3sg)
zvu**k**	‘sound’	zvu**ʧ**-a-tʲ	‘to sound’
strʲi**g**-u	‘cut (1sg)’	strʲi**ʐ**-o-t	(3sg)
zna**k**	‘sign’	zna**ʧ**-ok	(dim.)
cf.			
si**n**	‘son’	si**n**-ok	(dim.)
grʲi**b**-ə	‘mushroom (gen.sg.)’	grʲi**b**-ok	(dim.)

(4) Palatalization before consonants

a. Russian

sʲi**l**-ə	‘power’	sʲi**lʲ**-n-əjə	‘strong (fem.nom.sg.)’
ru**k**-a	‘hand’	ru**ʧ**-n-ajə	(adj., fem.nom.sg.)
na**g**-a	‘leg’	no**ʂ**-k-ə	(dim.)
cf.			
svabo**d**-ə	‘freedom’	svabo**d**-n-əjə	‘free (fem.nom.sg.)’
ri**b**-ə	‘fish’	ri**b**-n-əjə	(adj., fem.nom.sg.)
manʲe**t**-ə	‘coin’	manʲe**t**-k-ə	(dim.)
ri**b**-ə	‘fish’	ri**p**-k-ə	(dim.)

b. Polish

gwo**s**	‘voice’	gwo**ɕ**-n-a	‘loud (fem.nom.sg.)’
rɛ̃**k**-a	‘hand’	rɛ̃**tʂ**-n-a	(adj., fem.nom.sg.)
stra**x**	‘awe’	stra**ʂ**-n-a	‘awful (fem.nom.sg.)’
mro**z**-u	‘frost (gen.sg.)’	mro**ʑ**-n-a	(adj., fem.nom.sg.)
cf.			
vo**d**-a	‘water’	vo**d**-n-a	(adj., fem.nom.sg.)

Given that palatalization is regarded as an assimilation of a consonant to the following front vowel, these palatalization cases are phonologically unnatural. In Slavic descriptive studies,

most researchers have accepted the historical fact that some front vowels preceded by palatalized consonants changed to back vowels or disappeared altogether over time (Meillet 1934; Shevelov 1964; Bernshtein 1974; Kolesov 1980; Townsend & Janda 1996). Even if this is true, speakers do not have access to such information in general, so it could not be the case that they take the diachronic changes into account when applying phonological principles. Therefore, synchronic phonological processes should be explained exclusively by synchronic sound patterns. In Chapter 4, these seemingly problematic cases will be explained by refined phonological and/or morpho-phonological accounts.

This concludes our basic overview of palatalization in Slavic languages. The following sections examine some important points in detail.

2.2.2. Variation in presence/absence of palatalization

As mentioned in the preceding subsection, in some cases, consonant palatalization is not determined by the phonological context alone: a consonant does not always palatalize before a front vowel. This subsection examines some examples from Slavic languages.

Let us begin with phonologically predictable positional effects. The occurrence of palatalization is known to be restricted across word boundaries (Rubach 2000, 2003). In Russian, as shown in (5), word-final consonants do not undergo palatalization even when the following word begins in a front vowel.

(5) Palatalization avoidance across word boundaries (Russian)

a. [i]

ko**t**#saɕi	‘Sasha’s cat’	ko**t**#ivana	‘Ivan’s cat’
v#dom	‘(in)to house’	**v**#izbu	‘(in)to cottage’
dru**g**#gavarʲit	‘friend is speaking’	dru**g**#idʲot	‘friend is walking’

b. [e]

s#kʲem	‘with whom’	**s**#etʲim	‘with this’
v#dom	‘(in)to house’	**v**#etəm	‘in this’
k#tamu	‘to that’	**k**#etəmu	‘to this’

In Polish, on the other hand, palatalization still occurs before word-initial [i], though the process is restricted to secondary palatalization in this context. Word-initial [e] does not trigger palatalization like in Russian. See the examples below.

(6) Palatalization avoidance across word boundaries (Polish)

a. [i]

bra**t**#fɕetw	‘brother entered’	bra**t**ʲ#id͡ʑe	‘brother is walking’
v#dom	‘(in)to house’	**v**ʲ#izbe	‘(in)to chamber’
ru**g**#domu	‘corner of house’	ru**g**ʲ#izbi	‘corner of chamber’

b. [e]

o**d**#marʲii	‘from Maria’	o**d**#evi	‘from Eva’
v#domʲe	‘in house’	**v**#europʲe	‘in Europe’
ro**k**#kotuf	‘year of cats’	ro**k**#europi	‘year of Europe’

This pattern suggests that palatalization is more likely to be triggered by [i] than by [e].

Next, let us look at loanword phonology, which is not fully predictable in terms of phonology. In Russian, as illustrated in (7), while consonants preceding /i/[6] cannot resist palatalization even among loanwords, consonants preceding /e/ can (Avanesov 1984:212–221; Timberlake 2004:60; Institut russkogo yazyka 2013:106–111).

[6] Phonemic transcription (i.e., / /) is utilized here to address as which vowel the source of vowel is categorized. As mentioned later, vowel quality on the surface may vary depending on stress in Russian: /e/ emerges as [i] in unstressed syllables.

(7) Palatalization avoindance in Russian loanwords

an**te**nə ‘antenna’; biz**ne**s ‘business’; drai̯**ve**r ‘driver’; **xe**ppenink ‘happening’

but

tʲemə ‘theme’; kəbʲi**nʲe**t ‘cabinet’; **vʲe**rsʲijə ‘version’; s**xʲe**mə ‘scheme’

cf.

tʲip ‘type’; **pʲianʲi**st ‘pianist’; **vʲiskʲi** ‘whisky’; **xʲi**t ‘hit (song)’

(based on Krysin 2000)

This also trues for the above mentioned tendency in which palatalization is more likely to occur before /i/ than before /e/. In addition, the palatalization avoidance varies depending on the place of articulation. It has been documented that dentals are likely to avoid paltalization, while velars are not (Avanesov 1984; Institut russkogo yazyka 2013). To better understand the situation, I conducted a survey of Krysin’s (2000) foreign word dictionary (Watabe 2016, 2017b). The results are summarized in Table 12.

Consonants	Dental/Alveolar		Labial		Velar	
Stress on /e/	Stressed	Unstressed	Stressed	Unstressed	Stressed	Unstressed
Non-pal.	**402 (41.7%)**	**666 (32.8%)**	**40 (9.8%)**	**7 (0.7%)**	**4 (2.5%)**	**0 (0%)**
Pal.	563 (58.3%)	1366 (67.2%)	369 (90.2%)	941 (99.3%)	158 (97.5%)	274 (100%)
Sum	965	2032	409	948	162	274

Table 12 Palatalization before /e/ in Russian loanwords

Overall, dental/alveolar consonants were more likely to resist palatalization than others. Moreover, when both dental and the other type of consonants preceded /e/ in a word, dentals were non-palatalized in most cases if non-dentals were too. This tendency is similar to that of palatalization before /i/ in Polish loanwords (consonants preceding /e/ are non-palatalized at

all): only dentals can remain non-palatalized (Gussmann 2007). These facts suggest that the place of articulation on target consonants as well as the height of front vowels is relevant to the triggering of palatalization. In particular, velars were palatalized in almost all cases. A closer look at the avoidance cases revealed that the vowel /e/ originated from English [æ] (e.g., **ke**ş ‘cache’; **xe**ppenink ‘happening’ etc.: see Watabe 2016). This observation also suggests that the height of the source vowel influences the likelihood of palatalization; English [æ] should be adapted as a vowel lower than Russian original /e/. The cross-linguistic tendency for palatalization to be increasingly likely with higher triggering vowels has been previously documented (Chen 1973; Bateman 2007).

Another finding from the survey on Russian loanwords was that this avoidance was more frequent in stressed syllables than in unstressed ones. What should be considered here is mid-vowel reduction, which will be discussed in detail in §2.3.1. For the present purpose, it is enough to note that /e/ surfaces as [i] in unstressed syllables (Avanesov 1984; Crosswhite 2000), though this process is absent in some loanwords (Avanesov 1984). Since palatalization avoidance does not occur before /i/, this suggests that the process is likely to be blocked before /e/ in unstressed syllables due to the possible appearance of [i]. Note that some researchers have mentioned that the vowel optionally changes to [i] even when the preceding consonant remains non-palatalized (Grovinskaya 1971; Kasatkin et al. 2001).

Palatalization avoidance in loanwords is also observed in other languages. As noted in the last subsection, consonants preceding [e] are non-palatalized in Polish. While consonants preceding [i] still undergo palatalization, /t, d, r/ avoid palatalization in some foreign-origin affixes:

(8) Palatalization avoidance before foreign-origin affixes
avangard-a ‘avant-garde’ avangard-izm ‘avant-gardism’

In Czech, in contrast, palatalization is generally absent in loanwords.

Another variation in palatalization is observed in Polish and Czech native words. In these languages, as can be seen in (2b, c), consonants preceding [e] remain non-palatalized in certain morphemes. The data in (9) exemplify some functional morphemes. Although the occurrence of palatalization is determined almost lexically, some phonological tendencies are relevant. First, velar stops cannot resist palatalization in Polish native words, while they can in Czech. Another is that, as seen in the last subsection, while almost all coronal consonants can undergo palatalization in Polish, fricatives never undergo palatalization in Czech.

(9) Functional morphemes beginning in [e]

a. Polish

ko**t**	‘cat’	ko**tɕ**-e	(loc.sg.)
vʲe**d**-l-i	‘carry (p.3pl)’	vʲe**dʑ**-e	(3sg)
ku**p**-ov-a-tɕ	‘to buy’	ku**p**ʲ-ets	‘buyer’
jas**n**-a	‘clear (fem.sg.)’	ja**ɕɲ**-e-tɕ	‘to make clear’
spokoi̯**n**-a	‘calm (fem.sg.)’	spokoi̯**ɲ**-e	(adv.)
but			
ko**t**	‘cat’	ko**t**-em	(inst.sg.)
		ko**t**-ek	(dim.)
jas**n**-a	‘clear (fem.sg.)’	jas**n**-e	(neut.sg.)
		jas**n**-e-go	(gen.masc./neut.sg.)
cf.			
kro**k**	‘step’	kro**k**ʲ-em	(inst.sg.)
		kro**tʂ**-ek	(dim.)
dro**g**-a	‘dear (fem.sg.)’	dro**g**ʲ-e	(neut.sg.)
		dro**g**ʲ-e-go	(gen.masc./neut.sg.)

b. Czech

vo**d**-a	‘water’	vo**ɟ**-e	(loc.sg.)
cf.			
ko**z**-a	‘goat’	ko**z**-e	(loc.sg.)
jas**n**-a:	‘clear (fem.sg.)’	jas**ɲ**-e	(adv.)
	cf.	jas**n**-e:	(neut.sg.)
vz-ɦle**d**-u	‘look (gen.sg.)’	ɦle**ɟ**-e-t	‘to look’
cf.			
sl**z**-a	‘tear’	sl**z**-e-t	‘to cry’
but			
mla**d**-a:	‘young (fem.sg.)’	mla**d**-e:	(fem.pl.)
		mla**d**-e:-ɦo	(gen.masc./neut.sg.)
dra**ɦ**-a:	‘dear (fem.sg.)’	dra**ɦ**-e:	(fem.pl.)
		dra**ɦ**-e:-ɦo	(gen.masc./neut.sg.)
ko**t**	‘cat’	ko**t**-em	(inst.sg.)
kro**k**	‘step’	kro**k**-em	(inst.sg.)
j**d**-u	‘go (1sg)’	j**d**-e	(3sg)
cf.			
mo**ɦ**-u	‘can (1sg)’	mu:**ʒ**-e	(3sg)

This type of lexical variation is also true for [i]. As mentioned in §2.1, a central high vowel [ɨ] has been documented in some languages. Recent phonetic studies, however, have asserted that

this vowel is in fact [i] (Padgett 2001), though it has not completely merged with [i] originating from /i/. See some examples below.

(10) Functional morphemes beginning in [i]

a. Russian

atvʲe**t**	‘answer’	atvʲe**t**ʲ-i-tʲ	‘to answer’
zna**k**	‘sign’	zna**ʧ**-i-tʲ	‘to signify’
sto**l**	‘table’	sto**l**ʲ-ik	(dim.)
but			
ko**t**	‘cat’	ko**t**-i	(nom.pl.)
gru**b**-ə	‘roughly’	gru**b**-ii̯	‘rough’
cf.			
zna**k**	‘sign’	zna**k**ʲ-i	(nom.pl.)
dol**g**-ə	‘long (adv.)’	dol**g**ʲ-ii̯	‘long (adj.)’

b. Polish

po**t**	‘sweat’	po**tɕ**-i	‘sweat (3sg)’
kro**k**	‘step’	kro**tʂ**-i	‘step (3sg)’
no**v**-a	‘new (fem.sg.)’	no**v**ʲ-i	(masc.human.pl.)
but			
ko**t**	‘cat’	ko**t**-i	(nom.pl.)
no**v**-a	‘new (fem.sg.)’	no**v**-i	(masc.sg.)
cf.			
kro**k**	‘step’	kro**k**ʲ-i	(nom.pl.)
dro**g**-a	‘expensive (fem.sg.)’	dro**g**ʲ-i	(masc.sg.)

c. Czech

ʧis**t**-a:	‘clean (fem.sg.)’	**ʧ**is**c**-i:	‘clean (3sg)’
slu**ɦ**-a	‘servant’	slou**ʒ**-i:	‘serve (3sg)’
mla**d**-a:	‘young (fem.sg.)’	mla**ɟ**-i:	(masc.anim.pl.)
cf.			
no**v**-a	‘new (fem.sg.)’	no**v**-i:	(masc.anim.pl.)
but			
mla**d**-a:	‘young (fem.sg.)’	mla**d**-i:	(masc.sg.)
mɲe**k**-a:	‘soft (fem.sg.)’	mɲe**k**-i:	(masc.sg.)
do**m**	‘house’	do**m**-i	(nom.pl.)
so**k**	‘juice’	so**k**-i	(acc.pl.)

These variations seem to be phonologically unpredictable. On the other hand, these front vowels vary in surface forms depending on whether the preceding consonant is palatal(ized) (e.g., Knyazev and Pozharitskaya 2011 for Russian; Ćavar 2004 for Polish). For this reason,

variation in palatalization should be conditioned by the difference in underlying properties, such as between /i/ and /ɨ/. In the same manner, the two types of [e] can also be differentiated in the underlying forms (Ćavar 2004; Gussmann 2007). In Chapter 4, I will argue that this account is valid for Polish but not for Czech (see §4.1.1 as for the underlying representations, and §4.2.1 as for the OT analysis).

To summarize this subsection, while some phonological tendencies are observed, the occurrence of palatalization may vary under a given phonological condition. The next subsection, in contrast, discusses the variation in the type of palatalization.

2.2.3. Variation in the type of palatalization

As mentioned briefly in §2.1.1, velar consonants undergo both primary and secondary palatalizations in some languages. The type of palatalization that occurs is determined primarily by following morphemes, as illustrated below.

(11) Primary and secondary velar palatalizations among Slavic languages

a. Russian

Verbal derivation:

zna**k**	‘sign’	zna**ʧ**-i-tʲ	‘to mean, to signify’
slu**g**-a	‘servant’	slu**ʐ**-i-tʲ	‘to serve’
su**x**-ə	‘dry (decl.)’	su**ʂ**-i-tʲ	‘to dry’

Adjective derivation:

ru**k**-a	‘hand’	ru**ʧ**-n-oi̯	(adj.)
dol**g**-ə	‘debt (gen.sg.)’	dol**ʐ**-in	‘indebted (masc.sg.)’
stra**x**	‘awe’	stra**ʂ**-n-ii̯	‘aweful’

Present verbal conjugation:

vi-tʲi**k**-ut	‘stream outwards (3pl)’	vi-tʲi**ʧ**-i-t	(3sg)
pʲi**k**-u	‘bake (1sg)’	pʲi**ʧ**-o-t	(3sg)
ma**g**-u	‘can (1sg)’	mo**ʐ**-i-t	(3sg)
bʲirʲi**g**-u	‘care (1sg)’	bʲirʲi**ʐ**-o-t	(3sg)

Diminutive derivation:

kuso**k**	‘piece’	kuso**ʧ**-ik	(dim.)
zna**k**	‘sign’	zna**ʧ**-ok	(dim.)
na**g**-a	‘leg’	no**ʂ**-k-ə	(dim.)

Nominal derivation from adjectives:

tʲi**x**-ə	‘silent (decl.)’	tʲi**ʂ**-in-a	‘silence’

Imperatives:

pʲi**k**-u	‘bake (1sg)’	pʲi**kʲ**-i	(imp.)
bʲirʲi**g**-u	‘care (1sg)’	bʲirʲi**gʲ**-i	(imp.)

Locative singulars:

rʲi**k**-a	‘river’	rʲi**kʲ**-e	(loc.sg.)
na**g**-a	‘hand’	na**gʲ**-e	(loc.sg.)

Adjective declension:

lʲix**k**-o	‘light (decl.)’	lʲox**kʲ**-ii̯	(masc.nom.sg.)
dol**g**-ə	‘long (decl.)’	dol**gʲ**-ii̯	(masc.nom.sg.)
tʲi**x**-ə	‘silent (decl.)’	tʲi**xʲ**-ii̯	(masc.nom.sg.)
cf.			
nuʐ**n**-ə	‘necessary (decl.)’	nuʐ**n**-ii̯	(masc.nom.sg.)

b. Polish

Verbal derivation:

kro**k**	‘step’	krot**ʂ**-i-t**ɕ**	‘to step’
swu**g**-a	‘servant’	swu**ʐ**-i-t**ɕ**	‘to serve’
su**x**-a	‘dry (fem.nom.sg.)’	su**ʂ**-i-t**ɕ**	‘to dry’

Adjective derivation:

rẽ**k**-a	‘hand’	rẽt**ʂ**-n-a	(adj., fem.nom.sg.)
stra**x**	‘awe’	stra**ʂ**-n-a	‘aweful (fem.nom.sg.)’

Present verbal conjugation:

p^{j}e**k**-w	‘bake (p.masc.3sg)’	p^{j}et**ʂ**-e	(3sg)
mo**g**-w-em	‘can (p.masc.1sg)’	mo**ʐ**-e	(3sg)

Diminutive derivation:

kro**k**	‘step’	krot**ʂ**-ek	(dim.)
rẽ**k**-a	‘hand’	rõt**ʂ**-k-a	(dim.)
ro**g**-u	‘corner (gen.sg.)’	ro**ʐ**-ek	(dim.)

Instrumental singulars:

kro**k**	‘step’	kro**k**^{j}-em	(inst.sg.)
ro**g**-u	‘corner (gen.sg.)’	ro**g**^{j}-em	(inst.sg.)
cf.			
oʐe**x**	‘nut’	oʐe**x**-em	(inst.sg.)
ko**t**	‘cat’	ko**t**-em	(inst.sg.)

Adjective declension:

dro**g**-a	‘dear (fem.nom.sg.)’	dro**g**^{j}-i	(masc.nom.sg.)
		dro**g**^{j}-e	(neut.nom.sg.)
cf.			
su**x**-a	‘dry (fem.nom.sg.)’	su**x**-i	(masc.nom.sg.)
		su**x**-e	(neut.nom.sg.)
no**v**-a	‘new (fem.nom.sg.)’	no**v**-i	(masc.nom.sg.)
		no**v**-e	(neut.nom.sg.)

However, some phonological generalization emerges in these data. As can be seen above, some morphemes trigger palatalization exclusively on velars (or velar stops), for which only secondary palatalization occurs. This suggests that these differ from other types of morphemes that cause all consonants to be palatalized.

In addition to velars, coronals also undergo either primary or secondary palatalization in Polish. These patterns are almost predictable: while primary palatalization occurs within native words, secondary palatalization occurs across word boundaries (see also §2.2.2) and in loanwords:

(12) Coronal palatalization in Polish (see also Rubach 2003; Gussmann 2007)
brat ‘brother’ brat**ɕ**-e (loc.sg.)
but brat**ʲ**#i#ɕostra ‘brother and sister’
plas**tʲ**ik ‘plastic’; maks**ʲ**imum ‘maximum’ etc.

One factor that must be considered is the behaviors of liquids. While /r/ and /l/ undergo secondary palatalization in Russian, these consonants, especially /r/, show peculiar patterns in Polish and Czech. First, /r/ changes to a prepalatal fricative under the palatalizing conditions: a retroflex [ʐ̩] (or its devoiced counterpart) emerges in Polish, while a trill-fricative [r̝] (or its devoiced counterpart) appears in Czech. That is, the manner of articulation changes in these cases. This may be conditioned by the fact that trill articulation cannot be realized on the hard palate. Next, while /l/ never undergoes palatalization in Czech, non-palatalized [l] is regarded as a palatalized (*soft*) counterpart in Polish; the non-palatalized (hard) variant emerges as [w]. Polish [w] was historically velarized [l] ([ɬ]), which is preserved in several dialects (Stieber 1966; Gussmann 2007). This suggests that the dental/alveolar lateral consonant is likely to be velarized, rather than palatalized in this language. We leave the details of this aside in the following discussion.

Thus far, the variations in palatalization under a phonological condition have been reviewed. These idiosyncrasies oblige us to analyze the given sound alternations not only in terms of phonology but also from lexical and/or morphological viewpoints. We will return to this issue later.

2.2.4. Vowel backness alternations

In general, the palatalization discussed in the preceding subsections is a process in which front vowels have an influence on the preceding consonant(s). The converse is also observed among Slavic languages: consonants may change an adjacent vowel, especially in backness.

First, much attention has been paid to the contrast between the high front vowel /i/ and a high central or central-back unrounded vowel /ɨ/ in Russian and Polish, as noted in §2.2.2 (Rubach 1984; Padgett 2001; Gussmann 2007). It has been documented that [i] follows only palatal(ized) (*soft*) consonants, whereas [ɨ] follows only non-palatal(ized) (*hard*) ones. This is conspicuous in nominal declension as shown below: while a stem-final palatalized consonant is followed by [i] in the nominal plural, a non-palatalized one is followed by [ɨ].

(13) Allomorphy in Russian nominal declension

	slavar^{j}	‘dictionary’	sləvar^{j}-**i**	(nom.pl.)
vs.	səmavar	‘samovar’	səmavar-**ɨ**	(nom.pl.)

As noted earlier, however, [ɨ] has been regarded also as [i] (Padgett 2001).

In addition, some genuine vowel backness alternations are observed among Slavic languages, though their productivity seems to be low. One such alternation is from Polish and is shown below: non-high back vowels following a palatal(ized) consonant undergo fronting when they precede a palatal consonant in the inflection or derivation (Gussmann 2007). As can be seen in the last cases in (14), however, there are many exceptions.

(14) Vowel fronting in Polish

ɲ**o**s-õ	'carry (3pl)'	ɲɛɕ-e	(3sg)
dʑ**o**n-ek	'day (dim.)'	dʑɛɲ	(base)
j**a**d-õ	'travel (3pl)'	j**ɛ**dʑ-e	(3sg)
ɕfʲ**a**t	'world'	ɕfʲ**ɛ**tɕ-e	(loc.sg.)
but			
mʲ**o**d-u	'honey (gen.sg.)'	mʲ**o**dʑ-e	(loc.sg.)
vivʲ**a**d-u	'interview (gen.sg.)'	vivʲ**a**dʑ-e	(loc.sg.)

A survey of an online dictionary (*Słownik orfograficzny języka polskiego*: http://sjp.pwn.pl/) indicated that fronting was observed in only 20 out of 169 nominal declension cases (10.6%), as illustrated in Table 13.

	fronting	no fronting	sum
/o/	4 (4.3%)	88 (95.7%)	92
/a/	16 (16.5%)	81 (83.5%)	97
sum	20 (10.6%)	169 (89.4%)	189

Table 13 The fronting in Polish nominal declension

It is thus questionable that this fronting is really phonological.

A more complicated case is observed in Bulgarian. As (15) shows, [a] following a palatalized consonant alternates with [e], similar to the Polish case above.

(15) Vowel fronting in Bulgarian (see Scatton 1993)
sl^{j}**a**p ‘blind (masc.sg.)’ sl**e**p-i (pl.)

A crucial difference from the Polish case is that non-velar consonants preceding front vowels are never palatalized in Bulgarian, as noted in §2.1.5. In other words, no change in the following consonants is triggered by the inflection. One possible interpretation is that the following front vowel triggers the fronting as in vowel harmony. On the other hand, vowel harmony is generally unattested in Bulgarian. Moreover, the occurrence of this fronting is restricted to several morphemes (Scatton 1975). From these observations, I tentatively suggest that this fronting can be triggered by the following front vowels, but the occurrence is lexically restricted. These lexically specific patterns are widely observed among Slavic languages, and this topic is introduced in the next section. The theoretical analysis will be discussed in §3.1.2–§3.1.3.

This subsection has shown that back vowels can be influenced by the adjacent palatal(ized) consonant (that is, they undergo fronting). Although the mechanism seems to be similar to palatalization, in that adjacent consonants and vowels assimilate, its productivity is restricted in the fronting of non-high back vowels in Polish and Bulgarian. The low frequency will be accounted for by specific lexical properties later in Chapter 4.

2.2.5. Consonantal hardness/softness

Before concluding this section, the traditional categories related to palatalization, *hardness* and *softness*, should be briefly discussed. Palatalization has been described as consonantal "softening" in Slavic linguistics: non-palatal(ized) consonants have been regarded as "hard," while palatal(ized) ones as "soft" (Chekman 1979; Avanesov 1984; Padgett and Zygis 2003; Rubach 2007).

The situation is not so simple, however. As mentioned in §2.1.3, primary palatalization of velar consonants results in the emergence of palatoalveolar or retroflex consonants. These consonants, which have been traditionally called "hushing" ("шипящий" in Russian), do not contrast in hardness/softness: while palatoalveolar consonants are categorized as soft, retroflexes are categorized as hard (Padgett and Zygis 2003). What is problematic about this classification is that hard consonants can also be caused by palatalization.

In contemporary phonological theory, other means of categorization, such as distinctive features (discussed in §3.1.1 in detail) have been proposed. Clements and Hume (1995), for instance, formalized palatalization as the spreading of [coronal, −anterior] from a front vowel. Since retroflex consonants are also specified for this feature set (Keating 1990), their analysis can uniformly account for the Slavic palatalization patterns. In other words, this process should not be regarded as consonantal "softening." On the other hand, consonantal "softness" can be reinterpreted in terms of distinctive features. Keating (1990), for instance, suggested that while

palatoalveolar or alveopalatal consonants are specified for [+distributed], retroflexes are [−distributed]. Following this analysis, “softness” can be represented as [coronal, −anterior, +distributed].

In summary, *hardness* or *softness* cannot precisely describe the consonantal contrast in palatalization, even though this category is valid in a certain way for the speakers. The following discussion thus avoids using these traditional terminologies and relies on formal description mainly in terms of distinctive features.

2.2.6. Interim summary

This section focused on consonant–vowel interactions, more concretely assimilation, among Slavic languages. First, consonants undergo palatalization before front vowels. This process varies among these languages and even within individual languages. Afterwards, we examined vowel fronting triggered by adjacent palatal(ized) consonants. While the mechanisms of vowel fronting are similar to those of palatalization, its productivity is considerably lower.

The next section, in contrast, discusses vowel alternations caused by other phonological factors such as stress and syllable structure and/or several non-phonological factors.

2.3. Vowel alternations

This section lays out several vowel alternations observed in Slavic languages, which are triggered by various factors and show several exceptions.

The remainder of the section is organized as follows. First, §2.3.1 shows reduction in unstressed syllables. Next, §2.3.2 addresses vowel raising and fronting in Polish, alternations conditioned by syllable structure. §2.3.3 considers length alternations specific to Czech. §2.3.4, overviews vowel–zero alternations (as known as *yer*), which are widespread among Slavic languages. Finally, §2.3.5 concludes the section.

2.3.1. Vowel reduction

The literature has documented that unstressed vowels undergo some *reductions* across languages (Crosswhite 2001, 2004). The current work is concerned primarily with phonological patterns, excluding phonetically motivated slight sound changes (e.g., [u, i] to [ʊ, ɪ]). The definition of "vowel reduction" in this work follows the definition by Crosswhite (2001): vowel reduction is categorical because it involves the reduction of phonological contrasts (i.e., neutralization) and is conditioned by a certain phonologically defined context (i.e., unstressed positions). As Crosswhite (2001) indicated, this phenomenon is differentiated clearly from other phonetic process that have also been named "reduction" in the literature such as the "speech reduction" observed in casual styles or under a fast tempo (cf. Warner 2011).

Vowel reduction in unstressed positions is also observed in some Slavic languages as well as many others. Let us begin with the simpler patterns observed in Bulgarian and Belorussian. In Bulgarian, as shown in (16), each [o, e, a] changes to [u, i, ə] in unstressed syllables, respectively, although they are preserved in the careful speech (Scatton 1975, 1993; Crosswhite 2004). In Belorussian, as seen in (17), mid vowels change to [a] in unstressed syllables (Mayo 1993; Crosswhite 2004).

(16) Vowel reduction in Bulgarian (Crosswhite 2004:204)

r**ó**g-uf	'of horn'	r**u**g-át	'horned'
s**é**l-u	'village'	s**i**l-á	(pl.)
gr**á**-t	'city'	gr**ə**d-éts	'town'

(17) Vowel reduction in Belorussian (Crosswhite 2004:192)

r**é**k^{j}-i	'river (nom.pl.)'	r**a**k-á	(nom.sg.)
k**ó**l	'pole'	k**a**l-á	(gen.sg.)
v^{j}**ó**sn-i	'spring (gen.sg.)'	v^{j}**a**sn-á	(nom.sg.)

These facts can be generalized as follows. First, mid vowels are likely to undergo reduction. In other words, these vowels are unattested in unstressed syllables. On the other hand, high vowels never alternate with other vowels, while low vowels (i.e., /a/) can. It has been typologically documented that mid vowels are observed in fewer languages than other vowels (Beckman 1997). It can thus be assumed that mid-vowel reduction is related to the cross-linguistic tendency for mid vowels to be more marked than others. As will be suggested later in §4.1.2, this can be formalized by certain constraints.

This tendency also holds true for Russian: as in the languages noted above, it has no reduction of high vowels; only non-high vowels change to other vowels (Crosswhite 2000).

(18) Vowel reduction in Russian

a. After non-palatalized consonants

n**ó**s	'nose'	n**a**s-ú	(loc.sg.)
		nəs-av-ói̯	'nasal'
p**ó**l	'floor'	nə-p**a**l-ú	'on (the) floor'
		ná-pəl	'onto (the) floor'
n**á**ʧ-i-l	'begin (p.masc.sg.)'	naʧ-á-tʲ	(inf.)
		nəʧ-i-l-á	(p.fem.sg.)
d**á**-tʲ	'give (inf.)'	d**a**-vá-tʲ	(impf.)
		ví-də-tʲ	'hand out (inf.)'
s**ó**sn-i	'pine (nom.pl.)'	s**a**sn-á	(nom.sg.)
v**ó**d-u	'water (acc. sg.)'	v**a**d-á	(nom.sg.)

b. After palatal(ized) consonants

vʲ**ó**-l	'carry (p.masc.sg.)'	vʲ**i**-l-á	(p.fem.sg.)
tʲ**ó**mn-ii̯	'dark'	tʲ**i**mnʲ-é-tʲ	'to get dark'
		tʲ**i**mn-at-á	'darkness'
sʲ**é**tʲ	'net'	sʲ**i**tʲ-í	(loc.sg.)
		sʲ**i**tʲ-iv-ói̯	(adj.)
nanʲ**á**-tʲ	'employ (inf.)'	nanʲ**i**-l-á	(p.fem.sg.)
rʲ**á**d-ə	'row (gen.sg.)'	rʲ**i**d-ú	(loc.sg.)
ʧ**ó**rn-ii̯	'black'	ʧ**i**rnʲ-é-tʲ	'to become black'
ʧ**é**rt	'feature (gen.pl.)'	ʧ**i**r-tá	(nom.sg.)
ʧ**á**s	'hour'	ʧ**i**s-ú	(loc.sg.)
		ʧ**i**s-av-ói̯	(adj.)
ɕ:**ó**k-u	'cheek (acc. sg.)'	ɕ:**i**k-á	(nom.sg.)
ɕ:**á**slʲif	'lucky (masc.sg.)'	ɕ:**i**slʲív-ii̯	(nom.masc.sg.)
j**ó**ʐ̩-ik	'hedgehog (dim.)'	j**i**ʐ̩-á	(gen.sg.)
paj**á**vʲ-i-t-sə	'appear (3sg)'	paj**i**vʲ-í-l-sə	(p.masc.sg.)
j**á**sn-ə	'clear (decl.)'	ab-j**i**snʲ-í-tʲ	'to explain'

c. After retroflex consonants

ʂ**é**stʲ	'six'	ʂ**i**stʲ-í	(gen.sg.)
ʐ̩**ó**n-i	'wife (nom.pl.)'	ʐ̩**i**n-í	(gen.sg.)
ʐ̩**é**nʲ-i-t-sə	'get married (3sg)'	ʐ̩**i**nʲ-í-l-sə	(p.masc.sg.)
but			
ʂ**á**g-ə	'step (gen.sg.)'	ʂ**a**gʲ-í	(nom.pl.)
ʐ̩**á**r-k-ə	'hot (decl.)'	ʐ̩**a**r-á	'heat'

A remarkable difference is that the alternation patterns depend upon whether the preceding consonant is palatal(ized). (18) illustrates the alternations of some morphemes according to stress. When they follow a non-palatal(ized) consonant, /o/ and /a/ emerge as [a] or [ə] in unstressed syllables. When they follow a palatal(ized) one, on the other hand, they change to [i] in any unstressed syllable.[7] The former case is further divided into two types: [a] emerges immediately before stressed syllables, whereas these vowels are reduced to schwa in other unstressed syllables. The effect of preceding consonants can be regarded as vowel fronting as discussed earlier, and in this case, it is restricted to unstressed syllables. This suggests that back vowels assimilate to the preceding consonants in Russian, although they resist this pressure in stressed syllables. Note that /a/ differs from /o/, in that the former does not surface as [i] following retroflex consonants, as can be seen in (18c). As noted in §2.2.5, retroflexes have been regarded as "hard" consonants, while the other posterior coronals ([ʧ, ɕ:]) along with palatalized consonants as "soft." From this, we can conclude that vowel fronting or assimilation is motivated only by "soft" consonants, whereas [o] ~ [i] alternation triggered by retroflex consonants must occur for another reason.

Vowel reduction also shows variation. In Bulgarian, as briefly noted above, this process is avoided in the careful speech. Another type of variation is related to lexical factors, as

[7] It has been documented that the non-high vowels following palatal(ized) and retroflex consonants generally emerge as [ə] in syllables following stressed positions, though also as [i] in some words (Avanesov 1984:98–102; cf. not mentioned in Crosswhite 2000). This point will not be addressed later in this work.

observed in Russian. Many researchers have mentioned that vowel reduction can be avoided in loanwords (Glovinskaya 1971; Avanesov 1984; Institut russkogo yazyka 2013). This situation recalls the loanword-specific patterns related to palatalization noted in §2.2.2, suggesting that the phonological processes observed in native words are blocked in loanwords. This topic will be discussed in §3.3.3.

This subsection has laid out vowel alternation or *reduction* in unstressed syllables among Slavic languages. I will conduct a formal analysis of this process in §4.2.2.

2.3.2. Vowel alternations conditioned by syllable structure

Syllable structure is another trigger of vowel alternations. In Polish, as exemplified in (19), [o] is raised to [u] in closed syllables in the inflection of some words (Gussmann 2007).

(19) Vowel raising in Polish

n**o**g-a	'leg'	n**u**k	(gen.pl.)
sob**o**t-a	'Saturday'	sob**u**t	(gen.pl.)
koɕtɕ**o**w-u	'church (gen.sg.)'	koɕtɕ**u**w	(nom.sg.)
r**o**bʲ-i	'do (3sg)'	r**u**p	(imp.2sg)
but			
d**o**m-u	'house'	d**o**m	(nom.sg.)
n**o**ɕ-i	'carry (3sg)'	n**o**ɕ	(imp.2sg)

Similar processes are also observed in Ukrainian: the mid vowels [o, e] change to [i] in closed syllables. Note that this pattern is variable: the vowel in closed syllables remains unchanged in some morphemes.

I conducted a survey of an online Polish dictionary (*Słownik orfograficzny języka polskiego*: http://sjp.pwn.pl/) to better understand this pattern. The target was restricted to conjugation of verbs whose imperative forms end in the stem-final consonant[8] and declension of feminine and neuter native nouns in which closed syllables appear in genitive plurals. The voicing and nasality of following consonants was examined following the assumptions of previous research (Sanders 2003; Gussmann 2007). Obstruent voicing is neutralized unless vowels follow (see §2.1.2 and §2.4.1); therefore, stem-final obstruents are voiceless in contexts wherein raising can be observed, except in first plural imperative forms, as illustrated in (20):

(20) Voicing neutralization in the raising contexts

a. Imperative verbs

voʒ-i	'transport (3sg)'	vuɕ	(imp.2sg)
		vuʒ-mi	(imp.1pl)
		vuɕ-tɕe	(imp.2pl)
cf.			
noɕ-i	'carry (3sg)'	noɕ	(imp.2sg)

b. Genitive plural nouns

koz-a	'goat'	kus	(gen.pl.)
cf.			
kos-a	'scythe'	kos	(gen.pl.)

For this reason, the current survey considered voicing on roots (or *underlying* forms: see §3.1) rather than pronounced forms.

As seen in Table 14, in the verbal conjugation, raising was observed at a high rate when [o] was followed by voiced obstruents (80.5%) and nonnasal sonorants (75.6%), but it was

[8] Verbs with citation forms that end in *-ać* were excluded because the alternation was mostly blocked among this type of verbs.

never observed when [o] was followed by voiceless obstruents or nasals. This finding is consistent with the observations in the literature. Note that the vowel preceding voiceless consonants also undergoes alternations in another verbal conjugation (e.g., ɲ**o**s-w-em ‘carry [p.masc.1sg] ~ ɲ**u**s-w [p.masc.3sg]), although the number of examples is small.

following C		raising	no raising	sum
obstruent	voiced	**265 (80.5%)**	64 (19.5%)	329
	voiceless	**0 (0.0%)**	269 (100%)	269
sonorant	nasal	**0 (0.0%)**	82 (100%)	82
	other[9]	**136 (75.6%)**	44 (24.4%)	180

Table 14 Raising in verbal conjugation.

This investigation did not consider the internal structure of the verbs concerned. Therefore, the data include verbs derived from a single root by attaching prefixes (e.g., xodʑitɕ ‘to go’ → f-xodʑitɕ ‘to enter,’ vi-xodʑitɕ ‘to go out,’ etc.). I did not unify such derived verbs because of the finding that variations were observed among verbs comprising common verbal roots. See (21) for examples:

(21) Variation in the vowel raising among verbs of a common root

xuw**o**dʑ-i	‘cool (3sg)’	xuw**u**tɕ	(imp.2sg)
but			
pʂe-xuw**o**dʑ-i	‘overcool (3sg)’	pʂe-xuw**o**tɕ	(imp.2sg)

This information suggests that the occurrence of alternation is not determined by roots. We will return to this topic later.

[9] [l] and [j]. [r] is unattested under the given morphological condition, which would change to [ʐ] or its devoiced counterpart, [ʂ] (see also §2.2.3).

Let us move to the nominal declension. As seen in Table 15, the tendency was similar to that in the imperatives. As Gussmann (2007) noted, however, this alternation also occurred when [o] preceded voiceless obstruents, though the rate was still low. When [o] preceded nasal consonants, in contrast, the alternation was still unattested at all.

following C		raising	no raising	sum
obstruent	voiced	**52 (85.2%)**	9 (14.8%)	61
	voiceless	**9 (15.0%)**	51 (85.0%)	59
sonorant	nasal	**0 (0.0%)**	23 (100%)	35
	other[10]	**17 (48.6%)**	18 (51.4%)	23

Table 15 Raising in declension of feminine and neuter native nouns.

It should be noted here that, as shown in (22), this process was also observed among loanwords, though the examples were few in total.

(22) Vowel raising among Polish loanwords

garder**o**b-a	'closet'	garder**u**p	(gen.pl.)	< F: *garde-robe* 'closet'
m**o**d-a	'mode'	m**u**t	(gen.pl.)	
r**o**l-a	'role'	r**u**l	(gen.pl.)	

Interestingly, the alternation was not observed when [o] preceded voiceless consonants, and only one case appeared in which [o] preceded a sonorant.

The facts mentioned so far suggest that the raising pattern has been extended within Polish phonology. First, this process should have been conditioned by following voiced or nonnasal sonorant consonants. Next, it has been extended to the cases where voiceless consonants follow

[10] [l], [r], and [j].

or to loanwords. Note that, as mentioned earlier, obstruent voicing is not observed under the raising conditions. This pattern is not extended to contexts in which nasal consonants, which are phonetically voiced, follow. These observations lead to the following assumptions. First, phonetic voicing does not trigger the alternation. Furthermore, voicing on obstruent or nonnasal sonorant consonants should be phonologically differentiated from voicing on nasal consonants. These situations are formalized in §4.3.1.

Backness alternation is also conditioned by syllable structure in Polish. As shown below, nasal vowels alternate in backness when syllable structure changes: the back vowel surfaces in closed syllables, while the front vowel surfaces in open syllables (Gussmann 2007). This process also has exceptions.

(23) Backness alternation of Polish nasal vowels

bw**õ**t	'error'	bw**ẽ**d-u	(gen.sg.)
r**õ**k	'hand (gen.pl.)'	r**ẽ**k-a	(nom.sg.)
but			
s**õ**t	'court'	s**õ**d-u	(gen.sg.)
mʲj**ẽ**s	'meat (gen.pl.)'	mʲj**ẽ**s-a	(gen.sg.)

The survey of the same online dictionary indicated that backness alternation was observed in 41 out of 189 nominal declension cases (27.3%), as illustrated in Table 16.

citation form	alternation	no alternation	sum
C-final	**27 (32.9%)**	55 (67.1%)	92
V-final	**14 (20.6%)**	54 (79.4%)	97
sum	**41 (27.3%)**	109 (72.7%)	189

Table 16 Backness alternation of nasal vowels in nominal declension.

This result suggests that the backness alternation of nasal vowels is not as productive as the above mentioned vowel raising. Note that since nasal vowels are unattested in most languages from which Polish loanwords originate, it cannot be ascertained whether this process extends to the loanwords.

While these alternations are lexically conditioned, another type of blocking factor should be noted: even alternating morphemes fail to undergo the processes if a diminutive affix /-ek/ follows. See some examples below:

(24) Blocking of alternations before a diminutive affix /-ek/

a. Raising

v**u**s	'wagon'		v**o**z-u	(gen.sg.)
		but	v**u**z-ek/ *v**o**z-ek	(dim.)
n**u**k	'leg (gen.pl.)'		n**o**g-a	(nom.sg.)
		but	n**u**ʐ-ek / *n**o**ʐ-ek	(dim., gen.pl.)

b. Nasal vowel alternation

gow**õ**p	'dove'		gow**ẽ**bʲ-a	(gen.sg.)
		but	gow**õ**b-ek/ *gow**ẽ**b-ek	(dim.)
r**õ**k	'hand (gen.pl.)'		r**ẽ**k-a	(nom.sg.)
		but	r**õ**tʂ-ek / *r**ẽ**tʂ-ek	(dim., gen.pl.)

As can be seen in (24), while these alternations occur in the nominal inflections, raising and fronting are unattested in the diminutive derivations despite the syllables being open. One main characteristic of this affix is that its initial vowel is deleted when another vowel follows (see §2.3.4 as for this alternation). The vowel is, therefore, absent in many inflected forms of this type of diminutives, as shown below:

(25) Vowel deletion in a diminutive affix /-ek/

a. Raising

v**u**s	'wagon'	v**u**s-k-u	(dim., gen.sg.)
		v**u**s-kʲ-em	(dim., inst.sg.) etc.
n**u**k	'leg (gen.pl.)'	n**u**ʂ-k-a	(dim., nom.sg.)
		n**u**ʂ-k-õ	(dim., inst.sg.) etc.

b. Nasal vowel alternation

gow**õ**p	'dove'	gow**õ**p-kʲ-i	(dim., nom.pl.)
		gow**õ**p-k-am	(dim., dat.pl.) etc.
r**õ**k	'hand (gen.pl.)'	r**õ**tʂ-kʲ-i	(dim., nom.pl.)
		r**õ**tʂ-k-am	(dim., dat.pl.) etc.

In the forms in which the affix-initial vowel is deleted, the alternations should be predictable. This observation suggests that the seemingly exceptional cases in (24) are motivated by uniformity within the inflectional paradigm for the diminutives. As will be noted later, paradigm uniformity is also observed in some other alternation patterns. This issue will be discussed in §3.3.2.

2.3.3. Vowel length alternations

Vowel length is not contrastive in most Slavic languages. One exception is Serbo–Croatian, introduced in §2.1.4, in which vowels are lexically specified for length along with tone (rising or falling). Another, more complicated case is that of Czech, in which several vowel length alternations are observed (Short 1993; Scheer 2003; Ziková 2016).

(26) shows that the length of stem-final vowels may alternate in Czech nominal declension. This alternation may be accompanied by raising of mid vowels. Given that long [o] and long

[e] following palatal consonants are not attested in general among Czech native words (Short 1993), this process may result from the avoidance of certain long vowels.

(26) Vowel length alternation in Czech nominal declension

ʒ**a**p	'frog (gen.pl.)'	ʒ**a:**b-a	(nom.sg.)
l**i**ɦ-u	'alcohol (gen.sg.)'	l**i:**ɦ	(nom.sg.)
d**o**m-u	'house (gen.sg.)'	d**u:**m	(nom.sg.) /*do:m
vj**e**r	'belief (gen.pl.)'	v**i:**r-a	(nom.sg.) /*vje:r-a
but			
ɦl**a**f	'head (gen.pl.)'	ɦl**a**v-a	(nom.sg.)
kl**a:**t	'log (gen.pl.)'	kl**a:**d-a	(nom.sg.)
m**i:**r-u	'peace (gen.sg.)'	m**i:**r	(nom.sg.)
m**o**st-u	'bridge (gen.sg.)'	m**o**st	(nom.sg.)
ɦɲ**e**v-u	'anger (gen.sg.)'	ɦɲ**e**f	(nom.sg.)

This length alternation seems to be triggered by the change in syllable structure. On the other hand, syllable structure itself does not determine vowel length: both short and long vowels can emerge in any syllable, open or closed. Rather, vowel length is conditioned morphologically: nominal singulars always end in a long vowel when the alternation occurs. This generalization is also questionable, however, in that short vowels can emerge in the nominal singulars of non-alternating nouns.

To understand the pattern underlying this alternation, I conducted a survey on an online Czech dictionary (*Slovník spisovného jazyka českého*: http://ssjc.ujc.cas.cz/). The target vowels were restricted to /a/ and /i/ because the emergence of the other long vowels is restricted. Loanwords were excluded from the survey. The results are summarized in Table 17 (see also Watabe 2017a).

/a/	shortening	no shortening	sum
C-final	**4 (1.6%)**	253 (98.4%)	257
V-final	**19 (14.8%)**	109 (85.2%)	128
sum	**23 (6.0%)**	362 (94.0%)	385

/i/	shortening	no shortening	sum
C-final	**3 (3.3%)**	87 (96.7%)	90
V-final	**14 (20.9%)**	53 (79.1%)	67
sum	**17 (10.8%)**	140 (89.2%)	157

Table 17 Length alternation in Czech nominal declension

Overall, the alternation occurred at a considerably low rate: 6.0% for /a/ and 10.8% for /i/. Although V-final nouns, in which the citation forms end in vowels, were more likely to undergo alternation than C-final ones, in which the citation forms end in consonants, the rate was at most 20.9% for /i/. Furthermore, this process did not extend to loanwords, suggesting that this alternation is not productive and is lexically conditioned.

There is also a productive pattern, however. (27) shows that root-final short vowels are lengthened when the diminutive affix /-(e)k/ follows.

(27) Lengthening in Czech diminutive derivation

d**a**r	‘gift’	d**a:**r-ek	(dim.)
fil**a**v-a	‘head’	fil**a:**f-k-a	(dim.)
ram**e**n-o	‘shoulder’	ram**e:**n-k-o	(dim.)
m**o**st	‘bridge’	m**u:**st-ek	(dim.)
telef**o**n	‘telephone’	telef**o:**n-ek	(dim.)
epigr**a**m	‘epigram’	epigr**a:**m-ek	(dim.)
but			
sv**a**l	‘muscle’	sv**a**l-ek	(dim.)
okr**e**s	‘district’	okr**e**s-ek	(dim.)

A survey on the same dictionary showed that this process occurs frequently among masculine and neuter nouns, as shown in Table 18 (see also Watabe 2017a). The productivity is further

supported by the fact that this process is observed in several loanwords as well (e.g., telef**o**n ‘telephone’ ~ telef**o:**nek).

	lengthening	no lengthening	sum
masc.	**467 (64.3%)**	259 (35.7%)	726
fem.	**80 (16.8%)**	396 (83.2%)	476
neut.	**49 (79.0%)**	13 (21.0%)	62

Table 18 Lengthening in Czech diminutive derivation by an affix /-(e)k/

Shortening is also observed in diminutive derivation, as illustrated in (28).

(28) Shortening in Czech diminutive derivation

b**a:**b-a	‘gramma’	b**a**p-k-a	(dim.)
mr**a:**s	‘frost’	mr**a**z-i:k	(dim.)
sɲ**i:**x	‘snow’	sɲ**e**ʒ-ek	(dim.)
but			
k**a:**r-a	‘cart’	k**a:**r-k-a	(dim.)
peɲ**i:**s	‘coin’	peɲ**i:**z-ek	(dim.)

While this also occurs in the affixation of different affixes such as /-i:k/ (only for masculine nouns), the frequency was low, as shown in Table 19, especially before /-(e)k/.

		shortening	no shortening	sum
/-(e)k-/	masc.	**6 (1.3%)**	473 (98.7%)	479
	fem.	**30 (19.6%)**	123 (80.4%)	153
	neut.	**0 (0%)**	15 (100%)	15
/-i:k/		**15 (39.5%)**	23 (60.5%)	38

Table 19 Shortening in Czech diminutive derivation

When we examine the relationship between the diminutive derivation and the above mentioned declension, the shortening was likely found to occur in the derivation if it did so in the

declension also. Table 20 divides the findings of Table 19 according to whether shortening (or length alternation) occurs in the nominal declension. This indicates that the rate of shortening in diminutive derivation was apparently heightened by the same process in the nominal declension.

		shortening in declension			no shortening in declension		
		shortening	no	sum	shortening	no	sum
/-(e)k/	masc.	**4 (50.0%)**	4 (50.0%)	8	2 (0.4%)	469 (99.6%)	471
	fem.	**21 (67.7%)**	10 (32.3%)	31	9 (7.4%)	113 (92.6%)	122
	neut.	**0 (0%)**	2 (100%)	2	0 (0%)	13 (100%)	13
/-i:k/		**10 (100%)**	0 (0%)	10	5 (17.9%)	23 (82.1%)	28

Table 20 Shortening in Czech diminutive derivation (detail)

This finding suggests that this shortening process is lexical (that is, specific to several nominal morphemes), rather than conditioned morphologically, i.e., by declension or derivation. Its productivity is thus low (note that the length alternation was observed exclusively in the declension of several nouns), but the same phonological process can extend to other morphological patterns. The lengthening, in contrast, must be triggered by the affix /-(e)k/. This alternation thus occurs frequently and can extend to loanwords.

2.3.4. Yer*: vowel–zero alternation*

Another type of vowel alternation is deletion or vowel–zero alternation, which is widespread among Slavic languages. Traditionally, this type of alternating vowel, which has evoked much dispute so far, has been called *yer*[11]in Slavic linguistics.

To describe this phenomenon simply, morpheme-final vowels can be deleted when another vowel follows in morphological processes. As illustrated below, the vowels that participate in this process vary from language to language: [e] can be deleted in Polish and Czech, [a] in Serbo–Croatian, and [e] and [ə] in Bulgarian. While four vowels undergo deletion on the surface in Russian, taking into account the reduction discussed in §2.2.1, we can generalize that only vowels whose underlying forms are /o/ and /e/ can be deleted ([ə] and [i] are their unstressed variants). Some examples from nominal declension are illustrated in (29). Crucially, a number of exceptions are also observed, as with other various vowel alternations, as discussed above.

[11] This denotes the ultrashort vowels in Common Slavic, which have been lost in certain positions. The historical vowel loss resulted in the synchronic vowel–zero alternation.

(29) Vowel–zero alternation among Slavic languages

a. Polish

pʲ**e**s	‘dog’	ps-a	(gen.sg.)
s**e**n	‘sleep’	sn-u	(gen.sg.)
d**e**x	‘breath’	tx-u	(gen.sg.)
but			
tɕ**e**ɲ	‘shade’	tɕ**e**ɲ-a	(gen.sg.)
s**e**r	‘cheese’	s**e**r-a	(gen.sg.)

b. Czech

d**e**n	‘day’	dn-e	(gen.sg.)
r**e**t	‘lip’	rt-u	(gen.sg.)
dom**e**k	‘house (dim.)’	domk-u	(gen.sg.)
but			
svj**e**t	‘world’	svj**e**t-a	(gen.sg.)
d**e**x	‘breath’	d**e**x-u	(gen.sg.)

c. Serbo–Croatian

p**a**s	‘dog’	ps-a	(gen.sg.)
dob**a**r	‘good (masc.sg.)’	dobr-i	(masc.pl.)
but			
d**a**n	‘day’	d**a**n-i	(nom.pl.)

d. Bulgarian (Vowel reduction is not addressed.)

d**e**n	‘day’	dn-i	(pl.)
koz**e**l	‘goat’	kozl-i	(pl.)
lak**ə**t	‘elbow’	lakt-i	(pl.)
vʲat**ə**r	‘wind’	vetr-ove	(pl.)
but			
es**e**n	‘autumn’	es**e**n-i	(pl.)
uʧit**e**l	‘teacher’	uʧit**e**l-i	(pl.)
z**ə**p	‘tooth’	z**ə**b-i	(pl.)
pr**ə**t	‘pole’	pr**ə**t-ove	(pl.)

e. Russian

lʲ**ó**t	‘ice’	lʲd-á	(gen.sg.)
rʲimʲ**é**nʲ	‘belt’	rʲimnʲ-í	(nom.pl.)
zám**ə**k	‘castle’	zámk-əm	(inst.sg.)
vʲétʲ**i**r	‘wind’	vʲétr-u	(dat.sg.)
but			
səmalʲ**ó**t	‘airplane’	səmalʲ**ó**t-i	(nom.pl.)
svʲ**é**t	‘light’	svʲ**é**t-ə	(gen.sg.)
póv**ə**t	‘cause’	póv**ə**d-u	(dat.sg.)
utʃ̑ítʲ**i**lʲ	‘teacher’	utʃ̑ítʲ**i**lʲ-im	(inst.sg.)

Some comments are in order. First, while the overall frequency of the vowel–zero alternation is low (e.g., 1,092 out of 20,563 Russian masculine nouns in Gouskova and Becker’s (2013) survey), this alternation is also attested among loanwords except in Russian:

(30) Vowel–zero alternation in loanwords

a. Polish

kartof**e**l	‘potato’	kartofl-a	(gen.sg.)	< G: *Kartoffel* ‘potato’
sfet**e**r	‘swater’	sfetr-a	(gen.sg.)	

b. Czech

kax**e**l	‘tile’	kaxl-e	(gen.sg.)	< G: *Kachel* ‘tile’
vortsest**e**r	‘Worcester sauce’	vortsestr-u	(gen.sg.)	

c. Serbo–Croatian

komuniz**a**m	‘communism’	komnizm-a	(gen.sg.)
subjek**a**t	‘subject’	subjekt-a	(gen.sg.)

d. Bulgarian

logarit**ə**m	‘logarithm’	logaritm-i	(pl.)
komp**ʲ**ut**ə**r	‘computer’	komp**ʲ**utr-i	(pl.)
cf.			
brauz**ə**r	‘browser’	brauz**ə**r-i	(pl.)

Second, the alternation in the contemporary languages is not fully explained in terms of etymology or history, though the diachronic change in which ultrashort vowels *ĭ* (ь) and *ŭ* (ъ) (*yer*) were lost resulted in vowel–zero alternation. Gouskova (2012) suggested that several alternating nouns had not historically included the ultrashort vowel. On the other hand, historically ultrashort vowels may not undergo deletion in contemporary languages. In other words, etymologically identical words may undergo alternation in some, but not all, languages. That is exactly the case.

(31) Variation among contemporary languages

a. Noun ‘day’

Polish:	d͡ʑ**e**ɲ (nom.sg.)	dɲ-a (gen.sg.)
Czech:	d**e**n (nom.sg.)	dn-e (gen.sg.)
Bulgarian:	d**e**n (sg.)	dn-i (pl.)
Russian:	d^{j}**e**n^{j} (nom.sg.)	dn^{j}-i (nom.pl.)
vs.		
Serbo–Croatian:	d**a**n (nom.sg.)	d**a**n-i(nom.pl.)

b. Noun ‘breath’

Polish:	d**e**x	(nom.sg.)	tx-u	(gen.sg.)
vs.				
Czech:	d**e**x	(nom.sg.)	d**e**x-u	(gen.sg.)
cf.				
Russian:	voz-d**u**x ‘air’; d**i**x-a-n^{j}-ije ‘breathing’			

For instance, as seen in (31), while the noun for ‘day’ (< Common Slavic ****dĭnĭ***) undergoes alternation in many Slavic languages, but not in Serbo–Croatian. In contrast, although the noun ‘breath’ (< Common Slavic ****dūx***) did not originally include yer, the deletion is observed in

Polish. To summarize, although it is not highly productive, vowel–zero alternation has extended its range in each contemporary language.

To analyze this phonological process, we should first consider whether it is deletion or insertion. First, with regard to the languages in which more than one vowel undergoes this alternation, insertion is not plausible: it would be unclear what determines which vowel is inserted. Moreover, insertion is not phonologically motivated in general. As can be seen in (32), some consonant clusters are attested word-finally (Gouskova 2012).

(32) No motivation for insertion

a. Polish

sfet**e**r	'swater'	sfetr-a	(gen.sg.)	cf. me**tr**	'meter'

b. Czech

kous**e**k	'piece'	kousk-u	(gen.sg.)	cf. kio**sk**	'kiosk'

c. Russian

padar**ə**k	'gift'	padark-ə	(gen.sg.)	cf. nasmə**rk**	'runny nose'

In some cases, nevertheless, insertion seems to occur to avoid unacceptable word-final consonant clusters. Notable examples are from Serbo–Croatian (Browne 1993:316) and Bulgarian loanwords:

(33) Vowel insertion in loanwords

a. Serbo–Croatian

subjek**a**t	'subject'	subjekt-a	(gen.sg.)
komuniz**a**m	'communism'	komunizm-a	(gen.sg.)

b. Bulgarian

ansambə**l**	'ensemble'	ansambl-i	(pl.)
logaritə**m**	'logarithm'	logaritm-i	(pl.)

Note, however, that it is not uncontroversial for loanwords to be accepted as they appear in their source language; it is possible for the forms above to have been perceived as forms with the inserted vowel at the time they were adopted. To uniformly account for the alternation patterns, it should be stated that the alternation is deletion rather than insertion.

Another issue is the phonological unpredictability of this phenomenon. In addition to the lexical exceptions in which deletion is completely absent, there are certain morphological contexts that block this process. As can be seen in (34), while morpheme-final vowels are deleted in some cases, this deletion is not observed in certain morphological conditions.

(34) Context blocking vowel–zero alternation

a. Diminutive affixes

[Polish]	pʲ**e**s	‘dog’		ps-a	(gen.sg.)
			but	pʲ**e**s-ek	(dim.)
[Czech]	dom**e**k	‘small house’		domk-u	(gen.sg.)
			but	dom**e**ʧ-ek	(dim.)
[Russian]	dʲ**é**nʲ	‘day’		dnʲ-á	(gen.sg.)
			but	dʲ**i**nʲ-ók	(dim.)

b. Genitive plural suffix (Serbo–Croatian)

trgov**a**ʦ	‘merchant’	trgofʦ-a		(gen.sg.)
	but	trgov**a:**ʦ-a:		(gen.pl.)

c. Verbal conjugation

[Russian]	v**a**-ʂ-l-á	‘enter (p.fem.sg.)’	v**a**-ʂó-l / *f-ʂó-l	(p.masc.sg.)
cf.	v**a**-rt-u	‘in (the) mouth’	*v**a**-rot / v-rot	‘into (the) mouth’
[Czech]	v**e**-ʂ-l-a	‘enter (p.fem.sg.)’	v**e**-ʂe-l / *f-ʂe-l	(p.masc.sg.)

cf. [Polish] v**e**-ʂ-w-a ‘enter (p.fem.3sg)’ *v**e**-ʂed-w/f-ʂed-w (p.masc.3sg)

As can be seen in (34a), deletion is blocked in several languages when the diminutive suffixes ([-ek] or [-ok]) follow. In Serbo–Croatian, as shown in (34b), the genitive plural suffix ([-a:]) blocks the deletion, lengthening the given vowel. More complicated cases are observed in Russian and Czech verbal conjugation (Gouskova 2012 as for Russian): while proclitic-final vowels can be deleted unless an unacceptable cluster would result, they are consistently preserved within a verbal conjugation. Interestingly, this is not the case in Polish.

Previous research has shown that vowel deletion is blocked if the following vowel can also undergo alternation (Gussmann 2007; Scheer and Ziková 2009; Gouskova 2012). In addition to the verb in (34c), the diminutive affixes in (34a) also undergo alternation, as seen in (35) (see also 24 in §2.3.2).

(35) Vowel–zero alternation in diminutive affixes

[Polish]	p^{j}**e**s	'dog'	ps-a	(gen.sg.)
	p^{j}es-**e**k	(dim.)	p^{j}**e**s-k-u	(gen.sg.)
[Czech]	dom**e**k	'small house'	domk-u	(gen.sg.)
	dome$\int$-**e**k	(dim.)	dom**e**$\int$-k-u	(gen.sg.)
[Russian]	d^{j}**é**n^{j}	'day'	dn^{j}-á	(gen.sg.)
	d^{j}in^{j}-**ó**k	(dim.)	d^{j}**i**n^{j}-k-a	(gen.sg.)

For prepositions, however, a vowel does not emerge even if the following vowel undergoes deletion (see 34c: see also Gouskova 2012). One possible explanation for this is paradigm uniformity, noted in §2.3.2. The vowel deletion in the preceding morphemes is phonologically blocked in many inflected forms in which the vowel in the following affix is deleted. Since prepositions are not inflected, paradigm uniformity should not apply. Nevertheless, the Serbo–

Croatian genitive plural suffix shown in (34b) cannot be explained, since it is not an alternating vowel.

2.3.5. Interim summary

This subsection has focused on various vowel alternations in Slavic languages. Although they are triggered by purely phonological factors such as stress and syllable structure to some extent, other factors such as lexical and morphological properties are also relevant. Chapter 4 will present a formal analysis from various perspectives.

2.4. Other issues

Before concluding this chapter, this section mentions several processes left aside in the preceding sections. Note that these sound alternations will not be targeted by the theoretical analysis in Chapter 4.

2.4.1. Final devoicing and voicing assimilation

As seen in §2.1, the voicing contrast of obstruent consonants is neutralized under certain phonological conditions, such as in word-final positions and clusters, in Slavic languages. The final devoicing in some languages is exemplified in (36): voiced obstruents lose their voicing word-finally except in Serbo–Croatian (Townsend and Janda 1996).

(36) Final devoicing

a. Russian

naro**d**-ə	‘people (gen.sg.)’	naro**t**	**(**nom.sg.)
stav^{j}-i-t^{j}	‘to put’	staf^{j}	**(**imp.)
daro**g**-ə	‘road’	daro**k**	(gen.pl.)

b. Polish

i**d͡ʑ**-e	‘go (3sg)’	i**t͡ɕ**	**(**imp.)
gzi̯**b**-a	‘mushroom (gen.sg.)’	gzi̯**p**	**(**nom.sg.)
no**g**-a	‘leg’	nu**k**	(gen.pl.)

c. Czech

ko**z**-a	‘goat’	ko**s**	**(**gen.pl.)
l**v**-a	‘lion (gen.sg.)’	le**f**	**(**nom.sg.)
bje**ɦ**-u	‘run (gen.sg.)’	bje**x**	(nom.sg.)

d. Bulgarian

mla**d**-a	‘young (fem.sg.)’	mla**t**	**(**masc.sg.)
gro**b**-ət	‘coffin (def.)’	gro**p**	**(**indef.)
dra**g**-a	‘dear (fem.sg.)’	dra**k**	(masc.sg.)

cf.

e. Serbo–Croatian
gra:**d** ‘city’; no**v** ‘new’; sne**g** ‘snow’

In contrast, as illustrated in (37), regressive voicing assimilation is observed in all Slavic languages: obstruent consonants emerge with the same voicing specification as the following obstruent. Although these types of phenomena are widespread across languages and have been well-documented, one point specific to Slavic languages should be noted: the behavior of /v/. As shown in (37), this consonant undergoes devoicing like other voiced obstruents, while it does not trigger voicing on the preceding consonant. Hence, either voiceless or voiced consonants can precede [v] in many languages, as seen in (38).

(37) Voicing assimilation

a. Russian

pro**s**ʲ-i-t	‘request (3sg)’	proz**ʲ**-b-ə	‘request’
zagru**z**ʲ-i-tʲ	‘to load’	zagru**s**-k-ə	‘loading’
markə**v**ʲ-i	‘carrot (gen.sg.)’	marko**f**-k-ə	**(**dim.)
k-lʲes-u	‘to forest’	**g**-zapəd-u	‘to west’

b. Polish

li**tʂ**-i	‘count (3sg)’	li**dʐ**-b-a	‘number’
ri**b**-a	‘fish’	ri**p**-k-a	**(**dim.)
posta**v**-mi	‘put (imp.1pl)’	posta**f**-tɕe	**(**imp.2pl)
z-lublin-a	‘from Lublin’	**s**-krakov-a	‘from Krakow’

c. Czech

osa**d**-a	‘settlement’	osa**t**-k-a	**(**dim.)
se-sestr-ou	‘with sister’	**z**-brat-em	‘with brother’
ara:**b**-ij-e	‘Arabia’	ara**p**-sk-i:	‘Arabian’
v-berli:ɲ-e	‘in Berlin’	**f**-praz-e	‘in Prague’

d. Bulgarian

o**t**-otets	‘from father’	o**d**-brat	‘from brother’
ara**b**-ij-a	‘Arabia’	ara**p**-skʲ-i	‘Arabian’
v-europ-a	‘in Europe’	**f**-sofij-a	‘in Sofia’

e. Serbo–Croatian

te**ʒ**ak	‘heavy’	te**ʃ**k-a	(fem.sg.)
sr**b**-in	‘Serb’	sr**p**-sk-i	‘Serbian’
trgo**v**ats	‘merchant’	trgo**f**ts-a	(gen.sg.)

(38) Behavior of /v/ in voicing assimilation

a. Russian

vam	‘you (dat.pl.)’	**k**-vam / *__g__-vam	‘to you’

dva ‘two’ vs. **t**vaj-a ‘your (fem.sg.)’

b. Czech

va:mi	‘you (inst.pl.)’	**s**-va:mi / *__z__-va:mi	‘with you’

zvjetʃ-i: ‘increase (3sg)’ vs. **s**vjet ‘world’

c. Bulgarian

dvor ‘yard’ vs. **t**vorʲ-a ‘create (1sg)’

d. Serbo–Croatian

zva-ti ‘call (inf.)’ vs. **s**vadb-a ‘wedding’

A different pattern is observed in Polish: as seen in (39), this consonant not only fails to trigger voicing but also undergoes progressive devoicing. This process also applies to /r/, which emerges as [ʐ] under palatalizing conditions (see §2.2.3).

(39) Progressive devoicing in Polish

a.	/v/				
	tsɛrkʲe**v**-n-i	‘Orthodox’	tsɛrk̲**f**ʲ-i / *tsɛr**g**vʲ-i		‘church (gen.sg.)’
b.	/r/				
	vʲat**r**	‘wind’	vʲɛt̲ʂ̲-ɛ / *vʲɛ**d**ʐ̲-ɛ		(loc.sg.)
	cf.				
	pʲu**r**-o	‘feather’	pʲu**ʐ̲**-ɛ		(loc.sg.)

In Slavic linguistics, /v/ has been regarded as /w/, which should not trigger voicing due to its sonorant status (Padgett 2003; for historical background, see Townsend and Janda 1996). This account can also be extended to the Polish alternation of /r/, which was originally categorized as a sonorant. We can thus assume that the behavior of /v/ can be attributed to a certain phonological difference from other voiced obstruents. I leave it open to discussion what properties condition these patterns.

2.4.2. Another coronalization and iotation

Several other alternations triggered by front vocoids are also observed among Slavic languages, but their occurrence is restricted to certain morphological processes.

In §2.2.3 (see also §2.2.1), we saw two types of velar palatalizations: primary palatalization and secondary palatalization. The former is in fact not consistent in some

languages. As seen in (40), velar consonants alternate not only with palatoalveolar/retroflex ones but also with alveolar affricates/fricatives.

(40) Velar primary palatalization

a. Polish

kro**k**	‘step’	krot**ʂ**-i-tɕ	‘to step’
swu**g**-a	‘servant’	swu**ʐ**-i-tɕ	‘to serve’
pʲje**k**-w	‘bake (p.masc.3sg)’	pʲje**tʂ**-e	(3sg)
mu**g**-w	‘can (p.masc.3sg)’	mo**ʐ**-e	(3sg)
but			
pola**k**	‘Polish man’	pola**ts**-i	(nom.pl.)
dro**g**-a	‘dear (fem.nom.sg.)’	dro**dz**-i	(masc.human.nom.pl.)
ʐe**k**-a	‘river’	ʐe**ts**-e	(loc.sg.)
no**g**-a	‘leg’	no**dz**-e	(loc.sg.)

b. Czech

nau**k**-a	‘science’	nau**tʃ**-i-t	‘to teach’
slu**ɦ**-a	‘servant’	slou**ʒ**-i-t	‘to serve’
tʃlovje**k**	‘man’	**tʃ**lovje**tʃ**-e	(voc.sg.)
mo**ɦ**-u	‘can (1sg)’	mu:**ʒ**-e	(3sg)
but			
kro**k**	‘step’	kro**ts**-i:x	(loc.pl.)
dra**ɦ**-a:	‘dear (fem.nom.sg.)’	dra**z**-i:	(masc.anim.nom.pl.)
ru**k**-a	‘hand’	ru**ts**-e	(nom.pl.)
no**ɦ**-a	‘leg’	no**z**-e	(loc.sg.)

c. Serbo–Croatian

ru**k**-a	‘hand’	ru**tʂ**-itɕ-a	(dim.)
slu**g**-a	‘servant’	slu**ʒ**-i-ti	‘to serve’
ti**x**	‘silent’	ti**ʃ**-in-a	(n.)
but			
te**k**-u	‘flow (3pl)’	te**ts**-i	(imp.2sg)
va**g**-a	‘weight’	va**z**-i	(loc.sg.)
mu**x**-a	‘fly’	mu**s**-i	(loc.sg.)

The change to alveolar affricates or fricatives has been interpreted as the fossilization of historical change[12] in several morphological processes (Townsend and Janda 1996). At the very least, this alternation is phonologically non-productive among the contemporary

[12] This process has been called *second (velar) palatalization*, which was triggered by front vowels originating from diphthongs (Shevelov 1964; Townsend and Janda 1996).

languages. Although the mechanism for this pattern will not be pursued in what follows, I assume for the present that a certain morpheme-specific property may trigger this sound alternation in a manner similar to the change in palatoalveolars/retroflexes discussed later (see §4.4.1).

Another palatalization-like alternation is conditioned by following [j], though it is not so obvious:

(41) Iotation

a. Russian

pi**s**-a-t^{j}	'to write'	pi**ʂ**-u /*pis^{j}-j-u	(1sg)
xa**d**^{j}-i-t^{j}	'to walk'	xa**ʐ**-u /*xad^{j}-j-u	(1sg)
cf.			
zna-t^{j}	'to know'	zna-**j**-u	(1sg)

b. Polish

xo**dʑ**-i-ɕ	'walk (2sg)'	xo**dʑ**-e /*xodʑ-j-e	(1sg)

In historical phonology, these patterns have been regarded as sound changes triggered by [j], rather than by front vowels, which vary from language to language (Shevelov 1964; Townsend and Janda 1996). In synchronic terms, however, it is unclear whether [j] actually conditions these alternations. First, as exemplified in (42), palatalized consonants preceding [j] are attested in contemporary languages.

(42) Emergence of [j]

a. Russian
stat^{j}**j**-a 'article'; l^{j}ubov^{j}**-j**u 'love (inst.sg.)'

b. Polish
kome**d**^{j}**j**-a 'comedy'; xe**m**^{j}**j**-a 'chemistry'

Moreover, the mutation patterns are inconsistent in some derivations. See (43) for the Russian cases.

(43) Variable iotation (Russian)

prʲiglaʂʲ-i-tʲ	‘to invite’	prʲiglaʂ-u	(1sg)
		prʲiglaʂ-enʲ-ij-e	‘invitation’
but			
raʣʲ-i-tʲ	‘to bear’	raʐ-u	(1sg)
		raʐʣʲ-enʲ-ij-e	‘birth’

These facts suggest that this mutation is no longer phonological, but specific to certain morphological processes. Because this study concerns itself primarily with phonological alternations, this issue will not be elaborated in detail in the following discussion.

3. THEORETICAL BACKGROUND

This chapter reviews the theoretical frameworks proposed in previous research on sound patterns. Generative approaches to phonology as well as other linguistic areas have been developed for more than half a century, and are adopted in this study.

In generative phonology, observed sound patterns are regarded as a result of *grammatical* generation from certain *underlying forms* (UFs) stored in lexicon. The goal of the research is, then, to reveal what UFs and grammar(s) correctly account for phonological phenomena in languages. In the course of generative formalization, linguistic sounds have been abstracted in various ways. Section 3.1 sheds light on this issue, discussing how appropriate *representations* should be assumed for sounds. Section 3.2 in turn reviews grammar models proposed in previous studies, especially focusing on Optimality Theory approaches. Although this study is concerned with phonology, other areas should also be considered to correctly predict some sound alternations. Section 3.3 thus devotes itself to this issue, overviewing several approaches to interfaces between phonology and other linguistic aspects. Finally, Section 3.4 concludes the chapter.

3.1. Generative approaches and underlying representation

This section devotes itself to discussing representations for linguistic sounds. It has been assumed in generative phonology that sound patterns are generated from UFs stored in speakers'

lexicon by a certain grammar. Thus, one of the main questions is what underlying sound forms are stored.

The remainder of this section is organized as follows. First, §3.1.1 introduces the major theory of phonological representation, *distinctive features*. Next, the discussion turns to how appropriate UFs are determined by reviewing some representational approaches to phonological processes. Some researchers have proposed highly abstract underlying representations completely unattested on the surface. This is called *absolute neutralization*; its problems are considered in §3.1.2. In contrast, §3.1.3 discusses incomplete representation or *underspecification* in UFs, where some categories specified in surface forms (SFs) are unspecified. Finally, §3.1.4 summarizes the discussion.

3.1.1. Featural representation for sounds

Sounds are abstracted and categorized at the underlying level in generative phonology: researchers have assumed several types of representations for them. One widely adopted theory assumes that sounds consist of *distinctive features* specifying certain phonological properties. For instance, voiced consonants have [(+)voice] and high vowels have [(+)high],[13] etc.

[13] Some researchers have claimed that phonological features should be binary and have positive (+) and negative (−) values, and others claimed that they should be monovalent or privative; the following analysis mainly adopts the latter approach. See the following discussion.

What features are assumed is, however, still under debate. One issue is the distinction between consonants and vowels (Rubach 2007). While earlier theories (Chomsky and Halle 1968; Sagey 1986; Halle et al. 2000) have assumed that vowels are represented by specific features not specified for consonants in general,[14] some recent theories (Clements and Hume 1995; Harris and Lindsey 1995) have attempted to represent consonants and vowels uniformly by the same set of features (or "elements," as they were called later). In the former approach, in general, vowel height is represented by [±high] and [±low], backness by [±back], and roundedness by [±round]. In contrast, Clements and Hume (1995) assumed that vowel backness and roundedness should be represented by the same features as consonantal place of articulation (i.e., [coronal(, −anterior)] for front vowels, [dorsal] for back ones, and [labial] for rounded ones). The difference between consonants and vowels can then be attributed to the nodes governing these features: as schematized in Figure 1, they are governed by C-place nodes on consonants, while by V-place nodes on vowels.[15]

[14] Secondary articulation on consonants is represented by vocalic features (Ní Chiosáin and Padgett 1993; Halle et al. 2000; Rubach 2000, 2007).
[15] Node distinction does not necessarily imply the unified representation of consonants and vowels: for example, Ní Chiosáin and Padgett (1993).

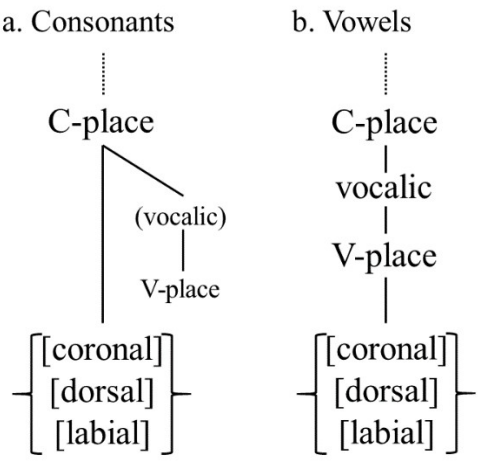


Figure 1 Clements and Hume's (1995) representation model

Note that consonants may have features under V-place nodes, which specify secondary articulation.

Harris and Lindsey (1995) adopted a similar concept, though they utilized another type of phonological unit, elements. In this approach, [a]-like vocalic and coronal consonantal properties are represented by an element |A|, [i]-like vocalic and palatal consonantal properties by |I|, and [u]-like vocalic and labial consonantal properties by |U|. Unlike features, these elements denote certain sounds by themselves. Like features, however, they can represent the other sounds by being combined with each other. For instance, [o] is represented as |A, U|.

The benefit of representing consonants and vowels by common phonological units is that such representations can directly account for consonant–vowel interactions, which are observed across languages. Palatalization, for instance, is a phonological process that can be regarded as spreading of a [coronal] feature or an |I| element on front vowels to adjacent consonants.

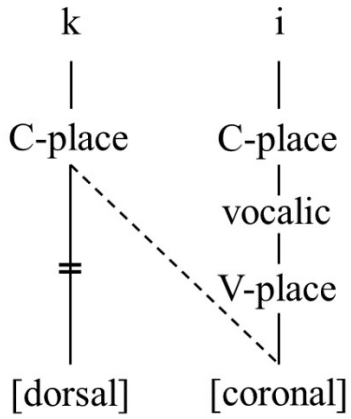


Figure 2 Representation for velar coronalization

Figure 2 illustrates how the coronalization of a velar consonant /k/ is represented in the featural model (for detailed analyses of Slavic languages, see Clements and Hume 1995; Rubach 2007 for a featural approach, and Gussmann 2007 for an elemental approach).

Rubach (2007) argued against this type of representation (which he called the UFT model) by suggesting that it cannot fully account for Slavic velar palatalization. Note that his discussion was based on the assumption that velar palatalization is accompanied by the retraction of [i], i.e., a change to [ɨ]. As noted in §2.2.4, however, the emergence of [ɨ] is questionable. Rubach (2007) gave the additional counterargument that velar coronalization may result in the emergence of anterior coronals, i.e., dental/alveolar affricates. What should be considered is that this pattern occurs exclusively in a few morphological processes, as mentioned in §2.4.2. Moreover, in the theoretical framework Rubach adopted (OT, which will be introduced in §3.2.1), phonological patterns are predicted to result from the interaction of multiple constraints, rather than as an automatic reflex of the featural structure. For this reason,

this paper does not adopt Rubach's (2007) objection to the UFT model, but follows Clements and Hume's (1995) unified representation of consonants and vowels, which can directly account for consonant–vowel interactions. Although it remains unresolved whether features or elements are more appropriate, the following discussion will adopt the former approach. One reason is that the featural approach can account for consonantal categories or consonant–vowel interactions more precisely than the element theory. For instance, retroflex and prepalatal/palatalized consonants emerge as a result of the palatalization processes, but only the latter causes the following [a] to emerge as [i] in unstressed syllables (§2.3.1). These patterns can be explained as follows: [+distributed] along with [coronal, −anterior] is involved in the agreement in vowel reduction, whereas only adjacent consonants and vowels agree only in [coronal, −anterior] in the palatalization process (see §4.2.1 and §4.2.2). In the element approach, such a distinction is not possible.

While consonants and vowels share phonological properties as noted above, some properties should be specific to consonants or vowels. One factor to consider is vowel height. As briefly mentioned earlier, this property has been represented by the binary features [±high] and [±low] (Chomsky and Halle 1968; Sagey 1986). In this framework, mid vowels are represented as the negative value of both features, i.e., [−high, −low]. The implication of this representation is that these vowels share the *non-high* property with low vowels and the *non-low* property with high ones. This is actually the case in Slavic languages, as can be seen in

Chapter 2: only non-high vowels can undergo vowel reduction or non-low mid vowels can trigger palatalization. With regard to the latter, however, palatalization should be related to highness, because high vowels are more likely to trigger this process than mid ones. It is thus assumed that mid vowels (at least front ones) are specified for [+high] as well as [+low] (Kostakis 2017). Kostakis (2017) argued for this representation on the basis of vowel coalescence and unpacking, in which the sequences of high and low vowels are unified into a single mid vowel and vice versa. However, all mid vowels do not share phonological properites with high and/or low vowels: the schwa emerges because of the vowel reduction and does not trigger palatalization. This phenomenon suggests that the schwa should be represented as a non-high and non-low vowel, similar to that in the literature. The problem here is that it is unclear whether *non-high* or *non-low* denotes the absence of a certain high or low property or the presence of the reverse (i.e., [low] for *non-high* or [high] for *non-low*) property. Recently, the absence of phonological properties has been regarded as an underspecification (§3.1.3), rather than the negative value, of relevant features (Steriade 1995). By adopting this framework, mid vowels that are not related to the aforementioned phonological patterns (e.g., schwa) should be represented as the absence of height features. From these points, I assume that there are two representations for mid vowels: as combinations of (privative) [high] and [low] (e.g., [o, e]) and as the complete absence of height features (e.g., schwa). §4.1.1 discusses the featural specifications of segments in Slavic languages in detail.

3.1.2. A representational approach and absolute neutralization

Since *underlying representations* (URs) are abstract sound forms that cannot be directly observed, they have been assumed on the basis of phonological patterns. This implies that URs can be more or less different from surface sound forms. In this sense, any UR is possible for a given surface form if an appropriate phonological grammar can be assumed.

Practically, however, URs are determined to some extent lexically or morphologically. Let us consider one of the palatalization cases (§2.2.1) in which a root-final consonant is palatalized when followed by an affix beginning with a front vowel:

(44) Palatalization in the singular locative of a noun (Russian, see also 2a)
va**d**-a ‘water’ va**d**^{j}-e (loc.sg.)

One question is whether the palatalized consonant in question is really generated from its non-palatalized counterpart. In other words, why can the consonant not be palatalized in the UR? A key to the answer lies in nouns whose stems end in palatalized consonants throughout the declension, as shown in (45b). Note that the nouns shown in (45a) end in non-palatalized consonants unless the front vowels follow.

(45) Nominal singular declension in Russian (= 1)

a. ‘desk’		b. ‘handlebar’	
sto**l**	(nom./acc. sg.)	ru**l**^{j}	(nom./acc. sg.)
sta**l**-a	(gen.sg.)	ru**l**^{j}-a	(gen.sg.)
sta**l**-u	(dat.sg.)	ru**l**^{j}-u	(dat.sg.)
sta**l**-om	(inst.sg.)	ru**l**^{j}-om	(inst.sg.)
sta**l**^{j}-e	(dat./loc.sg.)	ru**l**^{j}-e	(loc.sg.)

To summarize these declension patterns, we can conclude that stem-final consonants are always palatalized before a front vowel, but can be either palatalized or not elsewhere. We can therefore conclude that the stem of (45a) is non-palatalized in the UR and emerges as its palatalized counterpart if it precedes a front vowel, while the stem of (45b) is palatalized in the UR.

Likewise, the generative framework has assumed appropriate URs to account for sound patterns. However, some of them seem to be ad hoc, since they never emerge as these underlying forms on the surface (*absolute neutralization*; Kiparsky 1968). Previous research on Slavic phonology has also assumed such URs. One example is non-palatalizing [e]. In Polish, as shown in (9b), while consonants palatalize before [e] in most cases, they do not do so in all cases (§2.2.2). Rubach (1984) assumed that the UR of the problematic vowel that emerges as [e] but does not trigger palatalization is the unrounded back mid vowel (/ɤ/), which is completely unattested in Polish. Gussmann (2007) also assumed a specific UR for non-palatalizing [e] under a framework of Element Theory.

Another instance concerns the variation in velar palatalization. As shown in and (11), velar consonants palatalize in various ways before a front vowel (§2.2.3). Morén (2006) analyzed the Serbian patterns, in which a velar consonant preceding [i] changes to a prepalatal affricate or fricative in some cases, but to a dental affricate in others, as illustrated in (46).

(46) Velar palatalization before [i] in Serbian (see Morén 2006)

junak ‘hero’ ~ junaʦ-iʨe (dim.) vs. junaʦ-i (pl.)

According to this account, while the front high vowel has the feature [coronal] under both V-place and C-place nodes in the diminutive formation, the feature only appears under the C-place node in plural declension. When [coronal] on the vowels spreads to a preceding velar consonant, the consonant may change to a prepalatal consonant, in which [coronal] is specified under the V-place, or to a dental one, in which [coronal] is specified under the C-place node. This argument is similar to the preceding analyses of Polish non-palatalizing [e]: the underlying differences in the front vowel are not reflected by any surface pronunciation.

Finally, vowel–zero alternation (§2.3.4) has also been accounted for by specific URs. Previous studies have assumed specific URs for the alternating vowels. Rubach (1984), for instance, assumed a certain lax vowel in his analysis of Polish. Gussmann (2007) and Scheer and Ziková (2009), in contrast, proposed empty nuclei as the UR of the alternating vowels. A crucial difference between these two approaches should be mentioned. While an unattested segment was assumed in the former approach, the latter suggests an incomplete autosegmental structure with no specific segments. In other words, empty nuclei are not *neutralized*, but rather *implemented* so that they could emerge phonetically. This approach should thus be regarded as a type of incomplete specification or *underspecification*, which is discussed in the next subsection.

Thus far, we have overviewed several studies on phonological irregularity that assumed special URs. What they have in common is that unpredictability in terms of surface sound patterns is attributed to covert phonological properties. Although this approach derives the correct results, it cannot be supported by any evidence independent of the given phonological patterns. I claim that phonological unpredictability should be analyzed by considering factors beyond bare phonology (e.g., lexical or morphological properties) as well. This issue will be discussed again in §3.3.

3.1.3. Underspecification

While phonological segments have been represented by features or elements, it remains debatable whether all phonological categories should be specified. For instance, since sonorants are all phonetically voiced, voicing is a *redundant* specification for them. Moreover, it is controversial whether voiceless consonants are specified as such (e.g., [−voice]) or represented as the absence of voicing. Lombardi (2001) argued for the latter approach by focusing on the fact that voiced coda can be devoiced, and not completely deleted. She formalized this situation as deletion of [voice], uniformly accounting for deletion of coda consonants with marked place features and final devoicing.

Steriade (1995) asserted two main conditions under which underspecification should be assumed: phonological predictability (or redundancy) and inertness (or inactiveness). Sonorant

voicing in Slavic languages holds true for these conditions: all sonorants are voiced and never trigger voicing assimilation (§2.4.1). This situation is not universal across languages. By contrast, sonorants cause adjacent obstruent consonants to be voiced (i.e., intervocalic and postnasal voicing) in many languages. In rule-based models from the literature, Steriade (1995) indicated that such variations have been formalized as the difference in the order of *redundancy* rules, in which underlyingly underspecified features are specified, compared with that of relevant phonological rules. Analyses in this line are based on *full-specification* hypothesis: segments must be specified for each of the universal set of binary distinctive features at the surface. One assumption is that it should be the *unmarked* value of each feature underspecified in the underlying representation and is specified by redundancy rules.

Steriade (1995) casts doubt on these assumptions as follows. First, some segments should be underspecified for some features also in the surface representations (see also Keating 1988). Such a permanent or phonetic underspecification is suggested for schwa (for backness and height features) or glottal consonants (for place features). Moreover, the value that is marked or unmarked for some features is unclear. Steriade (1995) studied [ATR] harmony with regard to whether [+ATR] or [−ATR] is spread and varies by language. In a similar manner, voiceless and voiced consonants may also be phonologically active (see also Wetzels and Mascaró 2001; Bennett and Rose 2017). In Polish, vowel raising can occur when voiceless consonants follow, but not before nasals (§2.3.2).

This discussion suggests that some segments do not have some phonological features and that some features play certain phonological features in both values. This phenomenon led Steriade (1995) to assume that phonological features are *privative* rather than binary, which is discussed in the current dissertation. For instance, dental/alveolar, labial, and velar consonants are specified for [coronal], [labial], and [dorsal], respecitively, and not for [±coronal], whereas glottal consonants are completely unspecified for any place features. By contrast, voiceless consonants cannot be underspecified for [voice] but can be specified for a certain feature, for example, [−voice]. Therefore, the *voiceless* feature is assumed as a phonologically active property rather than the negative value of a binary feature as proposed in the earliest Generative Phonology (e.g., Chomsky and Halle 1968).

Regarding the featural specifications of vowels (§3.1.1), vowel height also has two main representations: by assuming binary features, such as [±high] and [±low], or privative features, such as [high] and [low]. I assert that [−high] or [−low] plays no roles in phonological terms; phonological processes can only be related to [high] (e.g., for palatalization), [low] (e.g., for vowel reduction), or underspecification (e.g., for schwa). In other words, [−high] or [−low] should be differentiated from [−voice] and should not be required. In summary, only phonologically active features should be assumed as privative rather than binary (cf. Clements and Hume 1995; see also Harris and Lindsey 1995 for an Element model).

In addition to *underspecification* for predictable or inactive properties, some researchers have proposed that even phonologically indispensable categories should be *lexically* underspecified in the URs to account for some sound patterns. Inkelas (1994), for instance, argued that idiosyncratically alternating units should be underspecified for the given alternating features. In her analysis of Turkish data, shown in (47), root-final plosive consonants are underspecified for voicing in the presence of coda devoicing, while underlyingly voiced or voiceless consonants do not undergo the alternation. In other words, this approach attributes the occurrence of the given alternations to the specific underlying properties.

(47) Voicing specification in Turkish (Inkelas 1994:288)
   a. voiceless
      /sanat**t**/: sana**t**-lar ‘art (pl.)’ ~ sana**t**-ɨ (acc.)
   b. voiced
      /etü**d**/: etü**d**-lar ‘etude (pl.)’ ~ etü**d**-ɨ (acc.)
   c. underspecified
      /kana**D**/: kana**t**-lar ‘wing (pl.)’ ~ kana**d**-ɨ (acc.)

Recall that some Slavic vowel alternations mentioned in the last chapter are also restricted to certain morphemes, which suggests that specific underlying representations are required to correctly account for the phenomena. In §4.4.2 and §4.4.3, I will analyze the vowel alternations concerned with assuming underspecification for the given alternating features.

3.1.4. Interim summary

This section has discussed the formal representation for linguistic sounds. First, sounds were categorized by phonological features (or elements). Specifically, as noted in §3.1.1, I argued

for a unified representation of consonants and vowels to better account for assimilation processes such as palatalization. Next, several previous studies on UR were reviewed. Even though UR is more or less abstract and can differ from the actual pronunciation, arbitrary representations absolutely unattested on the surface, as exemplified in §3.1.2, are doubtful. In contrast, as noted in §3.1.3, some features can be phonologically absent, which accounts for some idiosyncratic alternations.

Based on the discussion so far, I will propose a featural representation for the segments observed in Slavic languages in §4.1.

3.2. Phonological grammar and Optimality Theory

The core of the generative formalization of sound patterns lies in phonological *grammar*, which generates (or predicts) surface sound patterns from the given UFs. The following subsections thus review previous studies on how appropriate phonological grammar should be assumed.

While phonological processes have long been generalized as certain rules, constraint-based grammar has been developed in the recent decades. The main approach of the latter type is Optimality Theory (hereafter OT: Prince and Smolensky 1993), which is overviewed in §3.2.1. Under this framework, observed sound patterns are regarded as the optimal candidates according to the language-specific rankings of the universal constraints. §3.2.2 reviews two main models in OT. One of the most important principles in earlier OT is that a surface form

is generated in one step, which is called *Parallelism*. This clearly contrasts with previous rule-based models, in which rules are applied in a certain order, rather than simultaneously. Recently, however, gradual derivation or *Serialism* has also been adopted by OT analyses (e.g., Rubach 2000, 2003) to account for so called *opaque* sound patterns, in which the triggers of phonological processes are covert on the surface. As some researchers have suggested, it is hard for the parallel OT, which refers exclusively to surface forms, to explain *Opacity* cases. However, the serial OT has empirical and theoretical problems. This subsection thus argues against this approach, discussing resolution of Opacity under the parallel OT. Finally, §3.2.3 concludes the section.

3.2.1. Outline of the framework

The main goal of OT is to account for cross-linguistic universality and variation in a uniform framework. The former is guaranteed by the universal set of constraints. In other words, it is assumed that phonological constraints are common to human languages. Constraints in the OT framework are violable, unlike rules in earlier theory, so that even if a candidate of an SF or *output* violates a constraint, it can be selected as an optimal output. Candidates are evaluated according to the ranking of constraints; a candidate violating lower-ranked constraints is preferable to another violating higher-ranked ones. An output is thus selected from the theoretically infinite set of the candidates according to how they violate the ranked constraints.

In other words, some exceptions to a phonological rule (e.g., A → B) can be reanalyzed as violations of a corresponding constraint (e.g., *A: "A must not be attested") that are permitted under the condition that constraints ranked higher than this constraint are violated by other candidates. Needless to say, sound patterns vary with constraint rankings, which can account for cross-linguistic (synchronic) and diachronic variation.

Now, let us see some examples of OT analysis. As introduced in §2.1, dental stops (/t, d/) preceding front vowels change to their palatalized counterparts ([tʲ, dʲ]) in Russian, while they change to alveopalatal affricates ([tɕ, dʑ]) in Polish. First, these processes, i.e., palatalization, can be generalized as the assimilation of a consonant to the following front vowel, as mentioned earlier. Following an OT-based approach, assimilation can be formalized by a certain *markedness* constraint on disagreeing sound sequences (e.g., AGREE). On the other hand, some blocking constraints should also be assumed, taking into account that the palatalization of dentals is unattested in some languages such as Serbo–Croatian. In order to predict palatalization, AGREE must be ranked higher than the *faithfulness* constraint, which prohibits changes in a consonantal quality (e.g., FAITH-C). Next, the variation in palatalization between these languages can be explained by assuming the markedness constraints on consonants. We can hypothesize that while the markedness constraints eliminating alveopalatals (*tɕ, *dʑ) are ranked higher than those on palatalized dentals (*tʲ, *dʲ) in Russian, the ranking is reversed in Polish. The constraint rankings among Slavic languages can be summarized as (48), where ">>"

denotes that the preceding constraints are ranked higher than the following ones. The analysis of the variation in palatalization is demonstrated by the *tableaux* in (49).

(48) Constraint ranking regarding palatalization
   a. Russian: AGREE >> FAITH-C; *tɕ, *dʑ >> *tʲ, *dʲ
   b. Polish: AGREE >> FAITH-C; *tʲ, *dʲ >> *tɕ, *dʑ
   c. Serbo–Croatian: FAITH-C >> AGREE (*tʲ, *dʲ, *tɕ, *dʑ are tie)

(49) Variation in palatalization: summary tableaux
   a. Russian: /ti/ → [tʲi]

/ti/	AGREE	FAITH-C	*tɕ, *dʑ	*tʲ, *dʲ
ti	*W	L		
☞ tʲi		*		*
tɕi		*	*W	L

   b. Polish: /ti/ → [tɕi]

/ti/	AGREE	FAITH-C	*tʲ, *dʲ	*tɕ, *dʑ
ti	*W	L		
tʲi		*	*W	L
☞ tɕi		*		*

   c. Serbo–Croatian: /ti/ → [ti]

/ti/	FAITH-C	AGREE	*tʲ, *dʲ	*tɕ, *dʑ
☞ ti		*		
tʲi	*W	L	*	
tɕi	*W	L		*

In tableaux,[16] a UR or an *input* is shown in top line in the leftmost row, and the candidates of the SR or *output* appear below the input. "W" denotes the violation of the constraint in the top line by non-optimal candidates in the leftmost row, which eliminates them (i.e., such constraints prefer the "winner" indicated by "☞"). The violation by the winner, in contrast, is denoted by an asterisk. "L" indicates that the non-optimal candidates do not violate the

[16] This dissertation adopts McCarthy's (2008) "combination tableaux."

constraint when it is violated by the winner (i.e., such constraints prefer the "losers"). To correctly select the winner, therefore, the "W" constraints need to be ranked higher than the "L" ones, which are schematically denoted by a solid line between them. Constraints in the same ranking are, in contrast, divided by a dotted line. Besides, constraints are divided by a double line when their hierarchy cannot be determined. As can be seen in each tableau in (49), while the non-palatalized candidate [ti] violates AGREE, palatalized ones violate IDENT-C. Since the former constraint is ranked higher than the latter in (49a, b), the non-palatalized candidates are eliminated. With regard to the type of palatalization, secondary palatalization violates *tʲ, whereas primary violates *tɕ. Since the latter is ranked higher than the former in (49a), secondary palatalization is preferred to primary. In (49b), in contrast, primary palatalization is optimal because the ranking is reversed. Finally, both processes are eliminated in (49c) because FAITH-C outranks AGREE.

Thus far, I have reviewed parallel OT, in which outputs are generated directly from inputs. Although this theory can successfully account for cross-linguistic similarity and variation, it has also raised some concerns. One of the main concerns is that phonological processes cannot be predicted unless certain triggers emerge on the surface, because OT analysis evaluates possible outputs without considering generation processes themselves. Indeed, a number of phonologically *opaque* cases, in which triggers for given processes are covert, have been documented in previous studies. To account for such phenomena, some researchers (e.g.,

Rubach 2003) have abandoned the parallelism proposed in the earlier OT framework. The next subsection sheds light on this issue and addresses how to account for phonological *Opacity*.

3.2.2. Parallelism vs. Serialism: how to account for Opacity?

As noted above, parallel or output-based models, such as earlier versions of OT, cannot account for phonological processes in the absence of certain overt triggers. Let us begin the discussion by considering one example from Slavic languages.

As exemplified in §2.2.1, palatalization can occur before back vowels or consonants despite being triggered by front vowels in general. Some examples are repeated in (50).

(50) Opaque palatalization in Slavic languages (see also 3, 4)

[Russian]			
i**d**-u	‘go (1sg)’	i**dʲ**-o-t	(3sg)
ru**k**-a	‘hand’	ru**ʧ**-n-ajə	(adj., fem.nom.sg.)
[Polish]			
gwo**s**	‘voice’	gwo**ɕ**-n-a	‘loud (fem.nom.sg.)’

In other words, no palatalizing triggers emerge on the surface; these palatalization cases cannot be distinguished from many other cases in which palatalization does not occur before back vowels or consonants. Even if a front vowel were assumed as the UR, parallel OT could not predict palatalization because the constraint forcing palatalization refers only to the output candidates. The failure of the analysis is demonstrated in (51), with the constraint ranking being equal to that in (49). Note that vowel backing is not discussed here.

(51) Opaque palatalization in Russian:[17] i/de/t ⁇→ i[dʲo]t ‘go (sg3)’ (see 3 in §2.2.1)

/de/	AGREE	FAITH-C	*tʲ, *dʲ
☠ do			
💣 dʲo	*	*	*

The palatalizing candidate violates all the constraints, while the non-palatalizing one violates none. In other words, the former candidate is *harmonically bound* by the latter, which means that it cannot be optimal regardless of constraint ranking.

Serial models, in contrast, can correctly predict opaque patterns. In generative phonology, complicated sound patterns have long been formalized by the application of ordered rules. Halle (1959), for instance, analyzed Russian sound patterns by assuming that language-specific rules are applied to given UFs in a certain order. The rule-based approach has further developed to account for phonological processes in word derivation: one dominant theory is lexical or cyclic phonology. This theory assumes that *cyclic* rules are applied at every stage of word formation, after which *post-cyclic* ones are automatically applied. In his analysis of Polish, Rubach (1984) assumed that while the rule for velar coronalization is cyclic, that for vowel backing (he calls it “retraction”) is post-cyclic. As a result, root-final velar consonants change to retroflexes before the verbal affix /-i/ due to the coronalization rule. After word formation is complete, the affix undergoes retraction triggered by the post-cyclic rule. This derivation process can be schematized as (52).

[17] “☠” denotes the undesirable output predicted by the given grammar, and “💣” denotes the desirable output that was not predicted.

(52) Opaque velar palatalization in Polish:
e.g. /krok+i+tɕ/ 'step+(v.)+ (inf.)' → [krotʂitɕ] (Rubach 1984:112 revised by the author)

Cyclic		
1st cycle:	<krok>	No change
2nd cycle:	<krok+i>	Palatalization (k → tʂ)
3rd cycle:	<krotʂi+tɕ>	No change
Postcyclic	/krotʂitɕ/	Retraction (i → ɨ)
Surface	[krotʂitɕ]	

Note that his analysis is based on the traditional description that [ɨ], and not [i], follows "hard" consonants. This approach can still be applied to the Russian opaque palatalization in (50) if the retraction is extended to mid vowels and the vowel deletion is added to the post-cyclic rules.

Recently, to resolve the problem of parallel OT, serialism has also been adopted in the OT framework. Rubach (2000, 2003, 2007) analyzed Polish and Russian in a framework of serial OT, called "derivational OT," in which constraints are evaluated at each derivational stage and constraint ranking may vary among the stages. The variation in velar palatalization mentioned in §2.2.1, for instance, is formalized as follows according to his (2003) analysis. First, as can be seen in (53a), the constraint on palatalized velars (*SOFTDOR) is ranked higher than that prohibiting coronalization (IDENT (Dor)) at the first level, which results in coronalization. However, as shown in (53b), the ranking of these two constraints is reversed at the next stage, and secondary palatalization defeats coronalization.

(53) Velar palatalization in Polish (Rubach 2003)
a. Level 1: *SOFTDOR >> IDENT (Dor) e.g. //k+i// → /ʧi/
b. Level 2: IDENT (Dor) >> *SOFTDOR e.g. /ki/ → [kʲi]

It thus seems that the serial-derivation models are superior to the parallel mapping model in terms of the capacity to account for phonological processes. This type of approach, however, has empirical and theoretical problems. As McCarthy (2007) noted, the core of the analysis in serial models is "to isolate the opaquely interacting processes into different strata […]" (McCarthy 2007:39). In the above cited analysis of Polish, for instance, palatalization before front vowels and vowel retraction blocking palatalization interact, each of which is predicted by different constraint rankings in different strata. One question is, then, whether all opaque patterns can be divided in this manner. However, if derivation could be divided into theoretically infinite levels to account for Opacity, as suggested by McCarthy (2007), this theory would also predict unattested patterns.

Rubach (2003), in fact, restricted the level distinction to three stages of word formation: first, a stem level, in which word stems are derived by affixation to roots; second, a word level, in which whole words are derived; and finally, a sentence level or post-cyclic level for lexical phonology. This restriction fails to account for some opaque cases, however. As illustrated in §2.2.3, two types of velar palatalization (primary, i.e., coronalization, and secondary) are observed among Slavic languages; the choice of process that occurs is primarily determined morphologically. If these cases are analyzed according to Rubach's (2003) level distinction, then each type of palatalization needs to be predicted at different levels. A remarkable counterexample from Russian, however, is verbal conjugation. As can be seen in (54),

coronalization is observed in present personals, while secondary palatalization occurs in imperatives.

(54) Velar palatalization in Russian verbal conjugation
a. Present personals: coronalization
bʲirʲig-u ‘preserve (1sg)’ bʲirʲiʐ-o-t (3sg)
b. Imperatives: secondary palatalization
bʲirʲig-u ‘preserve (1sg)’ bʲirʲigʲ-i (imp.)

Moreover, it is doubtful that the deletion of a palatalizing trigger such as vowel backing occurs at a later level than palatalization. First, the back vowel [o] in (54a) alternates with [i] depending on stress, as shown below.

(55) Vowel alternation in the verbal affix

tʲik-ú-t	‘strem (3pl)’	tʲitʃ-**ó**-t	(3sg)
ví-tʲik-u-t	‘strem outwards (3pl)’	ví-tʲitʃ-**i**-t	(3sg)

It can be assumed that the UR of the affix should be a front vowel that palatalizes preceding consonants. However, vowel backing is not necessarily conditioned by stress, which is confirmed by the observation that stressed front vowels are widely attested in affixes as illustrated in (56).

(56) Stressed front vowels in verbal affixes

lʲit-á-tʲ	‘to fly’	lʲitʲ-**é**-tʲ	‘to fly somewhere’
		lʲitʲ-**í**-t	(3sg)

This suggests that vowel backing cannot be predicted at the word-formation level, which follows the stem-formation level that should predict palatalization.

Another problem raised by serialism is locality. As suggested by Kimper (2011) (see also McCarthy 2002), serial OT predicts phonological patterns locally, while parallel OT predicts them globally. This difference is especially crucial in the analysis of *outward-sensitive* word formation processes, in which the sound pattern concerned cannot be correctly predicted without referring to a whole word (e.g., Bonet and Lloret 2005: see §3.3.2). One more global effect is Paradigm Uniformity (Burzio 1996; Steriade 2000; McCarthy 2005). As noted in §2.3.2 and §2.3.4, some of the vowel alternations involve phonological uniformity within the inflectional paradigm. Since serial OT considers word formation locally, i.e., at each level, it cannot account for such global effects. I will return to this issue in §3.3.2.

In the analyses of Opacity, various attempts have also been made under the framework of parallel OT. Interestingly, some opaque patterns can be accounted for by *containment*, a core principle in the earliest OT (Prince and Smolensky 1993). Note that most recent OT approaches have adopted a different principle, *correspondence*: the OT grammar refers to the correspondence between the output phonological units and their input counterparts (McCarthy and Prince 1995). Unlike this approach, Containment Theory simply considers whether input information is preserved. This makes accounting for opaque alternations when the process is directly related to the trigger in inputs possible. One instance is the aforeconsidered palatalization before back vowels or consonants. Given that a palatalizing trigger, that is, front vowels, exists in the input, palatalization can be interpreted as the preservation of front/palatal

feature, that is, [coronal] (§3.1.1). In other words, [coronal] on the front vowel emerges as the palatal feature on the consonant. In this study, I assume that MAX[18] is a constraint on featural preservation. If this constraint is ranked higher than the constraint blocking palatalization or an addition of the palatal feature to consonants (tentatively assumed as DEP-C), as observed in (57), the palatalization can be accounted for under the parallel OT.

(57) Opaque palatalization in Russian: *i*/de/*t* → *i*[dʲo]*t* 'go (sg3)' (= 51)

/de/	MAX	DEP-C	*tʲ, *dʲ
do	*W	L	
☞ dʲo		*	*

Note that all opaque patterns cannot be accounted for in this manner: the relevant trigger does not emerge at all on the surface in some cases. However, under the framework of Containment Theory, the information in inputs is preserved in or carried over to the outputs even when not phonetically reaized, that is, pronounced; outputs contain all properties specified in the inputs. *Counter-feeding* Opacity can thus be accounted for by assuming that the component triggering a given process that is absent in an input (i.e., inserted, invisible, or not referred to by the constraint(s) concerned). Goldrick (2001) proposed such representation (he called "Turbid Representations") that distinguishes inserted units from underlying ones (see

[18] This is the abbreviation of "maximization," which demands that input information be realized in the outputs. This type of constraint and DEP ("dependence"), which demands that phonological units in outputs be specified in the inputs, have been proposed mainly under the framework of Correspondence Theory. Although this work adopts Containment Theory, I name the assumed constraints in this manner. IDENT ("identity" in terms of phonological features) will not be adopted because this type of constraint cannot work without assuming any correspondence.

also Oostendorp 2008). Following this approach, Tanaka (2014, 2015) more strikingly asserted that properties (practically, features) in output should be distinguished by constraints according to whether they are preserved, deleted, or inserted, as summarized in Table 21.

	Input	Output	
X	present	present	"preserved"
<X>	present	absent	"deleted"
[X]	absent	present	"inserted"

Table 21 Turbid Representations (Tanaka 2014, 2015)

In his (2015) analysis of Japanese sequential voicing (*rendaku*), for instance, voicing in sonorants or added by preceding nasals was distinguished from underlying [voice] in obstruents, which was originally specified.

As long as outputs that mismatch the actual emergence (pronunciation) are assumed, as noted by McCarthy (2007) in his critique, Containment Theory can be differentiated as parallelism in a strict sense. On the other hand, at least in the course of analyzing Opacity, input properties such as phonological features contained by outputs are assumed at the level of representation. As discussed in §3.1.1, phonological representation should be divided into several levels. In particular, featural information is not directly reflected by actual pronunciation; features are phonetically realized in linguistic sounds by their connection to a certain timing slot. Returning to the discussion of parallel OT grammar, the resolution of Opacity in terms of Containment Theory, especially distinguishing underlying, inserted, and deleted features, can be said to be a parallel grammar referring to multiple-level representation.

From the discussion thus far, this work adopts Containment Theory with Turbid Representations to account for phonologically opaque patterns.

3.2.3. Interim summary

This section has discussed which phonological grammar should be considered appropriate. The first subsection reviewed OT, which has resolved many problems posed by previous rule-based approaches. On the other hand, as discussed in §3.2.2, parallel OT has been criticized for its problems accounting for Opacity. Serial OT, in contrast, seems to resolve this problem; however, it raises other theoretical and empirical problems.

The failure to explain Opacity by parallel OT lies primarily in its strict dependence upon outputs, which may not maintain the underlying properties. As discussed earlier, such problems can be resolved by the earliest assumption in OT, *containment*. In Chapter 4, I will attempt to account for some of the opaque phonological processes among Slavic languages by reducing them to the maintenance of underlying featural representation, i.e., specific faithfulness. In addition, some cases will be formalized by assuming Turbid Representations, which clearly distinguishes preserved, deleted, and inserted units from each other.

3.3. Interface of phonology with other areas

Some sound alternations cannot be analyzed in terms of phonology alone. As noted in chapter 2, patterns beyond pure phonology are also observed among Slavic languages. This makes it necessary to consider various factors in order to correctly predict the given alternations.

This section thus devotes itself to reviewing the previous research on the interface between phonology and other linguistic areas such as the lexicon and morphology. First, §3.3.1 discusses phonological alternations sensitive to morphological derivation in word formation, which have been known as *Derived Environment Effects* (DEEs). Next, §3.3.2 addresses locality and globalism in sound patterns related to word formation. While some phonological variations are local, phonological alternations may show global effects in word formation. The latter involves cases in which a sound pattern within a morphological domain is sensitive to phonological properties outside the domain (*outward sensitivity*) or in which a sound pattern in a morphological form is affected by another from in the same paradigm (*Paradigm Uniformity*). §3.3.3, in contrast, considers sound alternations specific to certain lexical items. Formal classification or "stratification" of the lexicon (apart from lexical idiosyncrasies or exceptions) has been proposed by many researchers (e.g., Ito and Mester 1995). In particular, *loanword phonology* has provoked much concern. Before concluding this section, §3.3.4 briefly reviews stochastic OT approach to phonological varaiations. Finally, §3.3.5 summarizes the discussion.

3.3.1. Morphological motivations for sound alternations

Some sound alternations are motivated not only phonologically but also morphologically. Among Slavic languages, as has been laid out in §2.2.2–§2.2.3, palatalization strikingly shows this point.

Łubowicz (2002) took up several velar palatalization patterns observed in Polish. First, as noted in §2.2.2, palatalization can be avoided among loanwords. In addition, it is questionable why /g/ changes to a fricative [ʐ] ([ʒ] in her interpretation), while /k/ to an affricate [tʂ]. Note that the voiced retroflex affricate [dʐ] is attested in Polish. This is a type of Opacity, as Łubowicz also observed, has been explained in the framework of lexical phonology (Rubach 1984). In contrast, Łubowicz attempted to account for the processes concerned by parallel OT with *Local Conjunction* (hereafter LC; Smolensky 1993) of constraints. First, let us consider her generalization of DEEs in Polish velar palatalization. As summarized below, non-palatalized velar consonants and the voiced retroflex affricate are attested within (primarily loanword) roots, while they do not emerge across morpheme boundaries, i.e., as a result of derivations.

(58) DEEs in Polish velar palatalization (cf. Łubowicz 2002[19])
  a. Within roots
    a**ge**nt ‘agent’; **dʐ**em ‘jam’
  b. Across morpheme boundaries
    ro**g**-u ‘horn (gen.sg.)’ ro**ʐ**-ek /*ro**g**-ek, *ro**dʐ**-ek (dim.)

[19] IPA transcription is implemented by the author because it was not adopted by Łubowicz (2002).

Noting the mismatch between syllable and morpheme boundaries in the derived environments, she assumed the constraint on non-palatalized velars (PAL) conjoined with that on this boundary mismatch (R-ANCHOR (stem; σ)). As (59) demonstrates, the conjoined constraints are violated only in derivational cases; if it is ranked higher than the constraint on the featural change, i.e., coronalization (IDENT (coronal)), palatalization is predicted in this context. PAL, in contrast, is ranked lower than IDENT (coronal) in general, which results in the resistance to palatalization in non-derived contexts. The spirantization of [dz̨] can be analyzed more simply; the constraint on this consonant conjoined with that on the coronalization was ranked higher than the faithfulness constraint on spirantization.

(59) DEEs in Polish velar palatalization (cf. Łubowicz 2002)
i. /agent/ → [agent] 'agent'
ii. /rog-ek/ → [roz̨ek] 'horn (dim.)'

	PAL & R-ANCHOR (stem; σ)	IDENT (coronal)	PAL
i. /agent/			
a. ☞ agent	✓		*
b. az̨ent	✓	W	L
ii. /rog-ek/			
a. rogek	W	L	*
b. ☞ roz̨ek		*	

Note that palatalization is not necessarily conditioned by derivation. As mentioned in §2.2.2, consonants other than [k, g] remain non-palatalized in some morphological contexts. Moreover, velar stops may undergo secondary palatalization as well as coronalization. In other words, the palatalization depends on not only whether derivation occurs at all but also what kind of derivation occurs: the palatalization patterns cannot be reduced to DEEs, but must still be

strongly related to each morphological process. In fact, Łubowicz defined certain morphological domains of LC in her analysis of Polish. Besides, as briefly noted above, the avoidance of velar palatalization and the emergence of [dʐ] should be regarded as loanword-specific patterns. The current analysis thus does not focus on DEEs themselves. First, morphologically conditioned processes should simply be addressed by referring to certain morpheme-specific properties, rather than viewing them in terms of a certain morpho-phonological condition such as a boundary mismatch. In addition, loanword phonology should be regarded as lexical specificity, which is also considered by phonological grammar. This topic is discussed in §3.3.3.

A more direct approach to morpho-phonological alternations is to assume phonological constraints that are active exclusively under certain morphological conditions. Beckman (1997) assumed faithfulness constraints on roots and affixes respectively, accounting for the cross-linguistic tendency wherein affixes are more likely to undergo sound alternations than roots. Theoretically, this approach can be extended to any morphological categories, such as nouns or verbs or feminine or masculine nouns.

Note that the morphologically specific constraints are also violable; therefore, non-absolute or variable patterns can emerge. Non-OT approaches to morphology–phonology interfaces are problematic regarding this point. Scheer (2003) proposed moraic templates for some morphological categories in Czech. According to his analysis, three morae are weighed

to nominal diminutives or verbal infinitives, feminine nouns cannot exceed three morae, and so on. In §2.3.3, we have observed that Czech length alternations are variable; therefore, they cannot be generalized simply by any moraic template. Regarding OT constraints, their violability can account for the variability. §4.4.3 argues that relevant morphologically-specific constraints on vowel length are active only when the vowels concerned are underspecified for length; such constraints should be dominated by the faithfulness constraint on vowel length in this language.

This section has discussed how morphological conditions should be considered to account for sound alternations and argued for OT constraints exclusively on certain morphological units. §3.3.2 presents morpho–phonology topic, namely, word formation.

3.3.2. Localism vs. Globalism

In § 3.2.2, global morpho-phonological effects were introduced as an argument for parallel OT. It has been shown that the sound pattern of an allomorph cannot be determined without considering that of a whole word (Boneta and Lloret 2005; Kimper 2011; Yu 2017).

Bonet and Lloret (2005) examined a domain effect that serial OT fails to account for in the behavior of Catalan pronominal clitics. In brief, the position of epenthetic vowels varies from the affixation of one clitic to that of multiple ones. In other words, the concerned vowel epenthesis cannot be correctly predicted without referring to a whole word. Such *outward-*

sensitive word formation is also observed in Bulgarian. As documented by Zec (1988), schwa follows [r] after an obstruent consonant in word-final positions, but precedes [r] when another morpheme follows. Notably, this pattern is restricted to several lexical items. See (60) for examples.

(60) Floating schwa in Bulgarian

	grəb 'back'	gərbove	(pl.) (Zec 1988:555)
cf.	krək 'circle'	krəgove	(pl.)

The position of the schwa should be determined to improve syllabification in whole wordforms. Considering that complex codas are restricted in Bulgarian (§2.3.4), the schwa must follow [r] word-finally. When a vowel follows, the complex codas can be broken by the new syllable boundaries. Therefore, the schwa precedes [r] to avoid complex onsets, which are relatively disfavored.

One more global effect is, as noted in §3.2.2, Paradigm Uniformity. In Russian, for instance, vowel deletion is blocked in verbal prefixes (see §2.3.4; Gouskova 2012). As illustrated in (61), this blocking occurs when the deletion is phonologically unmotivated in other inflected forms of an identical verb.

(61) Vowel preservation in Russian verbal prefixes[20]

	v**a**-ʂ-l-á	'enter (p.fem.sg.)'	v**a**-ʂó-l / *f-ʂó-l	(p.masc.sg.)
cf.	v**a**-rt-u	'in (the) mouth'	*v**a**-rot / v-rot	'into (the) mouth'

[20] Some verbal prefixes and prepositions have a common form and meaning. For example, [v(a)-] 'in, into': ʂol 'walked (masc.sg.)' ~ va-ʂol 'entered (masc.sg.)' // rot 'mouth' ~ v-rot 'into mouth.'

As noted earlier, this can be regarded as Paradigm Uniformity (McCarthy 2005, hereafter PU). McCarthy (2005) analyzed such cases in the OT framework through evaluation of the paradigm as a whole, rather than word by word. This model assumes the PU constraint, which is violated when members of a paradigm phonologically vary. In the vowel preservation in (61), a candidate of the given paradigm whose prefix vowel is deleted in the past masculine singular would violate this constraint. Needless to say, local evaluations, in which the phonological pattern of each inflectional form is predicted, cannot account for PU effects. Later in §4.3.1 and §4.3.2, I will discuss the PU in vowel raising and in vowel–zero alternation, respectively.

In contrast, the localism of morpho-phonology has also been shown to be superior to the globalism. However, to my knowledge, most examples involve allomorph selection, or more precisely, suppletion. In other words, they involve not the phonological alternation of an allomorph, but the selection of allomorphs for a given morpheme. For this reason, I assert here that phonological grammar should be parallel and global. Since this dissertation focuses primarily on phonological alternation, I will not discuss lexical allomorphy further.

3.3.3. Lexical strata and loanword phonology

Many researchers have suggested that the sound patterns of foreign words or loanwords are different from those of native ones. The case is similar among Slavic languages (see Chapter

2). To formalize this situation, researchers have proposed that lexical items should be classified into several types.

In their analysis of Japanese, Ito and Mester (1995) assumed several lexical *strata* among which phonological behavior varies. For instance, while some sound sequences such as [ti] or [ɕe] are unattested in native words, they are observed in some loanwords in this language. Under the OT framework, Ito and Mester (1999, 2001) assumed that some faithfulness constraints are indexed to each stratum so that they would be active exclusively in certain strata. With regard to the above mentioned patterns, for instance, the markedness constraints on [ti] or [ɕe] are ranked higher than the general faithfulness constraint, while dominated by the loanword-specific faithfulness constraint (Ito and Mester 1999). This approach has been extended to lexical idiosyncrasies other than loanword phonology (Pater 2007, 2010; Gouskova 2012 among others). Gouskova (2012), for instance, analyzed the Russian vowel–zero alternation (see §2.3.4) by assuming constraints indexed to the lexical class in which the alternation occurs. As shown in (62), the constraint on mid vowels (*MID) is ranked higher than that on vowel deletion (MAX-V) only if it is indexed to the lexical class (L) but is ranked lower in general. Thus, as can be seen in (63), the non-deletion candidates violate *MID$_L$ only in the alternating word and are thus eliminated.

(62) Lexical indexation in the analysis of the Russian vowel–zero alternation
*MID$_L$ >> MAX-V >> *MID

(63) Russian vowel–zero alternation: demonstration
i. /rotL-a/ → [rtá] 'mouth (gen.sg.)'
ii. /vorot-a/ → [varótə] 'gate'

	*MIDL	MAX-V	*MID
i. /rotL-a/			
a. rota	W	L	*
b. ☞ rta		*	
ii. /vorot-a/			
a. ☞ varotə			*
b. varta		W	L

Next, we need to consider whether any lexical idiosyncrasy can be attributed to the lexical stratification. To discuss this issue, let us return to loanword phonology. Ito and Mester (1995) suggested that while loanwords show specific phonological patterns unattested in native words, some of them may cease to do so, being assimilated to native words or *nativized*. In other words, lexical items can move to another stratum (the direction is uniform in loanword phonology). Nativization is also observed in Slavic languages: as noted in Chapter 2, many phonological alternations extend to loanwords, albeit infrequently. This suggests that lexical strata should not be static, and it could be possible for any lexical item in a stratum to move to another one. From this perspective, it is appropriate to assume a certain stratum in which vowel–zero alternation occurs, because this process can extend to etymologically unmotivated words including foreign words. In other words, lexical strata are theoretically unrelated to etymology but are exclusive to phonological grammar: "phonological lexicon" (Ito and Mester 1995) is stratified according to whether certain phonological constraints are active. In the aforementioned vowel–zero alternation, the lexical strata are defined in terms of whether the constraint on mid vowels (*MID) dominates the faithfulness constraint on vowel deletion

(MAX-V). In the same manner, the aforementioned Japanese *loanword-specific* patterns (Ito and Mester 1995, 1999) are not attributed to etymology but to the phonological stratification of a lexicon: the relevant markedness constraints are dominated by the faithfulness constraint in certain (non-etymological) lexical strata. This is why phonological variations among foreign words are observed. Any lexical item can be affiliated with any lexical stratum, and the affiliation can vary synchronically and diachronically. In other words, any lexical item can theoretically undergo stratum-specific sound patterns. §4.3 uses lexical stratification to account for loanword phonology and some other *productive* (see §4.1.3) alternations such as vowel–zero alternation and Polish vowel raising.

By contrast, alternations that are restricted to certain lexical items, such as vowel fronting in Polish (§2.2.4), should not be explained under the framework of lexical stratification. Unlike the patterns discussed above, such restrictive alternation patterns would not be extended within the phonological lexicon. Therefore, the occurrence of these alternations should not be determined by a stratum that is affiliated with a given morpheme but by a certain property specific to the morpheme. One possible lexically specific property is special representation, such as underspecification (§3.1.2–§3.1.3). For instance, the vowel fronting in Polish can be attributed to an underspecification for backness on the vowels concerned exclusively with alternating morphemes. In other words, most morphemes in which vowels are specified for backness cannot undergo alternation regardless of which lexical stratum they are indexed to.

This section argued that sound patterns that are phonologically variable, but can be extended within the phonological lexicon, should be accounted for by assuming the stratification of the phonological lexicon. Before concluding this section, a brief review of another approach to phonological variability is presented in §3.3.4.

3.3.4. Weighted constraints and Stochastic OT

The lexical stratification discussed in §3.3.3 attempts to account for phonological variations categorically. Other researchers proposed theoretical frameworks under which observed variability is formalized as such (i.e., in accordance with the frequencies). The core of this *stochastic* model is to regard variable data as the distribution of *harmonic values* calculated according to the *weights* of constraints. In other words, this model no longer selects a certain winner from output candidates by considering categorical constraint ranking, but constructs grammar that predicts how well-formed each candidate is by assuming the gradual significance (i.e., *weights*) of constraints. This section briefly reviews this framework on the basis of Boersma and Hayes (2001).

This model and normal OT have common points. First, output candidates are generated from a certain input, and these candidates are evaluated on the basis of the violation of each of the universal constraints. The evaluation process differenciates the stochastic model from standard OT. One significant point is that the constraints are not categorically ranked, which

would not prefer one candidate over another, but are *weighted* in a certain manner. The aim of candidate evaluation is to calculate the value of well-formedness (or harmonic value) by summing up each constraint violation multiplied by the weights; a lower value indicates a less favored or well-formed candidate. Observed data are not regarded as a set of *optimal* candidates but as a *stochastic* distribution of several attested forms. Boersma and Hayes (2001) assumed that the distribution of variable patterns is formalized as the difference in the values. Therefore, the main goal in the analysis is to calculate the weights of each constraint that fit into the observed distributional patterns.

One of the main goals in this model is to determine how language learners manage or keep in touch with the online data of observed sound patterns. In this sense, the aim of this approach is different from that of the theories reviewed earlier and of the current work in general. In the next chapter, I attempt to provide generalizations of the *tendencies* of the sound patterns in question, excluding the stochastic data of actually observed sound patterns.

3.3.5. Interim summary

This section has considered the interaction of sound patterns with several properties that cannot be generalized in terms of phonology alone. While morphological derivation shows specific phonological effects (DEEs) as noted in §3.3.1, they cannot be reduced to a certain phonological generalization, but should be explained by directly referring to the given

morphological conditions. The globalism of phonological processes was discussed in §3.3.2: besides the locality of allomorphy, accounts of phonological patterns should make global reference to word formation. In contrast, §3.3.3 considered lexical specificity, such as loanword phonology, and argued for lexical stratification. It was emphasized that such variable patterns cannot be attributed to etymology, but to *phonologically* defined lexical stratification. Finally, §3.3.4 briefly reviewed stochastic OT, under which phonological variations are formalized as distribution of harmonic values in accordance with the weights of the violated constraints.

In the next chapter, I will attempt to account for the sound alternations laid out in Chapter 2 under the theoretical framework introduced in this chapter.

4. ANALYSIS

The aim of this chapter is to account for the sound alternations laid out in Chapter 2 according to the theoretical framework discussed in Chapter 3. The remainder of the chapter is organized as follows. First, Section 4.1 considers several basic assumptions required for the current analysis. Next, an analysis of the phenomenon is conducted in the following three sections (see §4.1.3 as for this division). First, Section 4.2 addresses primarily *phonological* alternations, which almost unexceptionally occur under certain phonological conditions. Next, Section 4.3 accounts for variable alternations that are not completely phonologically predictable, but still *productive* in that the patterns are extended to new or foreign words. Finally, Section 4.4 considers phonologically non-productive and lexically specific alternations. Section 4.5 summarizes the discussion.

4.1. Basic assumptions

Before analyzing the alternation patterns in detail, this section briefly introduces the basic assumptions on which the current formalization will be based. First, §4.1.1 considers how sounds are represented by the phonological features discussed in §3.1.1. Next, §4.1.2 assumes the phonological constraints in the OT framework introduced in §3.2.1. Finally, §4.1.3 examines the phonological *productivity* of sound alternations.

4.1.1. Featural representation

Segments observed among Slavic languages were laid out in §2.1. In the framework of generative phonology, this subsection proposes their representation in terms of phonological features.

Let us begin with the featural organization of sounds. Following Clements and Hume (1995), as mentioned in §3.1.1, it is assumed that vowels and consonants are represented by the same set of features, especially with regard to the place features. First, as discussed in §3.1.1, vowel backness is represented by the same place features as consonants, i.e., [dorsal] (for backness) and [coronal] (for frontness). In this way, [labial] represents roundedness, which is not contrastive among Slavic languages. Next, secondary articulation on consonants is represented by place features under the V-place node. In particular, as laid out in §2.2, secondary palatalization is phonologically common to prepalatal consonants, which leads to the assumption that it should be represented as [coronal, −anterior]. The featural organization can be schematized as Figure 3 (cf. Figure 1). Since the complete discussion of featural representation is beyond the scope of this study, other types of features (e.g., laryngeal) are not discussed in detail.

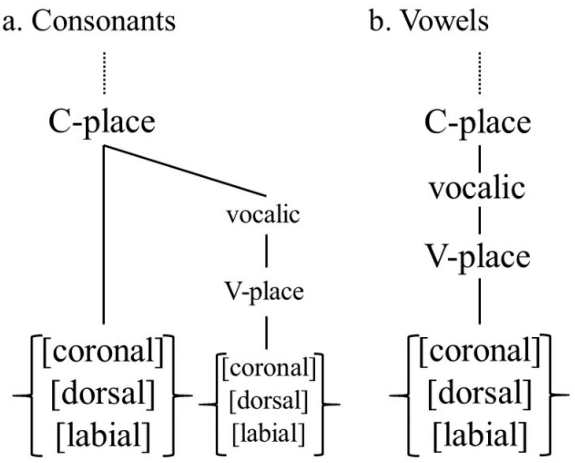


Figure 3 Organization of place features

Now, let us move on to the vowels in Slavic languages. One point is that, as discussed in §3.1.1, height is represented by the privative features [high] and [low]. On one hand, mid vowels are more marked than others and should have complex structures. Moreover, especially in several Slavic languages, the mid front vowel ([e]) shares the palatalizing property with the high vowel ([i]), which is thus attributed to [high]. However, schwa results from vowel reduction in unstressed syllables, which should be relatively unmarked. For this reason, I propose that [o, e] should be represented as the combination of [high] and [low], while [ə] is underspecified.

Several assumptions about Slavic phonology should be noted. One regards /ɨ/, which has traditionally been documented as a high non-palatalizing vowel, despite emerging as front on the surface (Padgett 2001; Ćavar 2004). Even though this is a front vowel, it should not be fully merged with [i]. Since it is lexically contrastive with /i/, it should be distinguished from the latter in the underlying form regardless of its surface frontness. I thus propose

underspecification of [coronal] (and of [dorsal]) for /ɨ/. Similarly, non-palatalizing [e] in Polish, which is also lexically contrastive, should also be differentiated from normal [e]. I propose underspecification of height features for this non-palatalizing vowel (transcribed as /ɛ/), taking into account the non-high and non-low properties of the mid vowel. This assumption is supported by the typological tendency that palatalization is more likely to be triggered by higher vowels (§2.2). The vowel [i] or [e] varies phonetically and depends on whether the preceding consonants are palatal(ized) (Ćavar 2004), that is, the differences in the URs are more or less reflected by the surface realizations.

Another note involves a *central* low vowel [a]: it varies in the specification for [dorsal]. As discussed in §4.2.2, this vowel should be underspecified for [dorsal] (and [coronal]) in Bulgarian, where [a] alternates with [ə] in unstressed syllables. By contrast, this vowel can also behave as *back* (e.g., Polish vowel backness alternation: see §4.4.2). Note that this vowel cannot be specified for [coronal] (or categorized as front).

Finally, roundedness is not contrastive among Slavic languages. The assumed featural specification is summarized in Table 22, in which "●" denotes specification for the given features.

	a	i	‘ɨ’	u	e	‘ɛ’	ẽ[21]	o	õ	ə
[high]		●	●	●	●			●		
[low]	●				●			●		
[coronal, −anterior]		●			●	●	●			
[dorsal]	(●)			●				●	●	
[labial]				(●)				(●)	(●)	
[nasal]							●		●	

Table 22 Featural representation for vowels in Slavic languages

Next, let us consider the consonants. Based on previous research (Sagey 1986; Keating 1990; Rubach 1994; Clements and Hume 1995), the featural specification is summarized as Table 23. Note that voicelss and voiced obstruent consonants are placed in the same cells: the upper one in each cell is voiceless (specified for [−voice]), while the lower is voiced (specified for [+voice]). For the sake of simplicity, featural specification is not illustrated in the table. Although “●” denotes the specification for the given features, “+” and “–” represent the counterparts of the given features: regarding [anterior], “+” stands for [+anterior], whereas “–” [−anterior]. I emphasize again that “+” or “–” is different from the positive or negative value of binary features assumed in the literature: the plus and minus counterparts of each feature have their own phonological activities.

[21] Since only mid nasal vowels are observed, height is not constrastive for these vowels.

	Feature	p b	f v	m	w	t d	ʦ ʣ	s z	n	r	l	ɾ̥ ɾ	ʧ ʤ	ʃ ʒ	ʈʂ ɖʐ	ʂ ʐ	ʨ ʥ	ɕ ʑ	c ɟ	ɲ	ʎ	j	k g	x ɣ	ʔ	h ɦ
C-Place	[coronal]					●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
	[anterior]					+	+	+	+	+	+	−	−	−	−	−	−	−	−	−	−	−				
	[distributed]					−	−	−	−	−	−	+	+	+	−	−	+	+	+	+	+	+				
	[dorsal]				●																		●	●		
	[labial]	●	●	●	●																					
Root	[nasal]			●					●											●						
	[sonorant]				●					●	●	●									●	●				
	[lateral]										●										●					
Other	[continuant]	−	+			−	−	+					−	+	−	+	−	+	−				−	+	−	+
	[strident]		●				●	●				●	●	●	●	●	●	●								

Table 23 Featural representation for consonants in Slavic languages

Several comments are added in order. First, because [anterior] and [distributed] represent the articulation of the tongue tip or blade (Keating 1990), they are relevant exclusively to coronal consonants. Thus, the cells for these features are shaded in non-coronal consonants. Second, [sonorant] is not specified for nasal consonants; this feature is redundant because all nasal consonants are sonorant. In phonological terms, nasal consonants do not share any properties with liquids or glides among Slavic languages. For instance, nasal consonants never trigger vowel raising in Polish compared with non-nasals (§2.3.2). Third, [continuant] is relevant exclusively to obstruent consonants: [+continuant] represents fricatives, whereas [−continuant] stops and affricates. This feature is at least noncontrastive for the other consonants: non-nasals are all [+continuant], whereas nasals [−continuant]. Thus, the cells for this feature are shaded for non-obstruent consonants. For the same reason, the cells for [lateral], which is a subcategory of sonorant consonants, are also shaded for the other consonants. Finally, [strident] has been assumed primarily for obstruents, but this analysis tentatively assumes that Czech trill-fricative consonants ([r̝] and its devoiced counterpart) are also specified for this feature. This feature is not contrasitive for fricatives among Slavic languages, but such a contrast has been documented for several languages (e.g., Utman and Blumstein 1994).

An additional fact to be noted is that palatoalevolar and alveopalatal consonants cannot be distinguished by the feature as given in Table 23; both are specified as [coronal, −anterior, +distributed, strident]. On the other hand, these consonants do not contrast with each other

within a language (Hall 1997; see also Zygis 2003). The current analysis thus tentatively assumes that the type of consonants that emerge are determined by language-specific properties, whose detailed mechanisms remain open to discussion.

In addition to the contrasts in primary articulation, as mentioned earlier, consonants may be accompanied by secondary articulation, which is represented by the place features under V-place. Significant for some Slavic languages is secondary palatalization with [i]-like articulation, which should be specified as [coronal, −anterior] under the V-node accompanied by [high], as schematized in Table 24, like the vowel [i] (Zubritskaya 1995). This representation is consistent with the tendency for palatalization to be triggered by higher front vowels, as noted earlier. Note that this contrast is not observed for (pre)palatal and retroflex consonants, which may emerge as a result of primary palatalization. Although further research is required, I assume for the present that these consonants are specified for these features under the C-place node, which cannot be affected by the same features under the V-place.

	p, b, f, v	p^j, b^j, f^j, v^j
C-place	[labial]	[labial]
V-place	n/a	[coronal, −anterior]
height	n/a	[high]

Table 24 Representational contrast in secondary palatalization (e.g., labials)

4.1.2. Phonological constraints

This subsection introduces significant phonological constraints relevant to sound alternations in Slavic languages.

First, as laid out in Chapter 2, many sound alternations can be generalized as assimilation. To account for this process, the following constraint has been proposed especially for voicing assimilation.

(64) AGREE (Lombardi 1999, 2001 among others):
Assign a violation mark for each segment that disagrees with the adjacent segment (in a certain feature specification).

Palatalization and vowel fronting can be accounted for by this type of constraint(s). What should be considered first is directionality: assimilation can be either regressive or progressive. With regard to Slavic languages, both palatalization and vowel fronting are regressive: preceding consonants assimilate to following vowels in palatalization, while preceding vowels assimilate to following consonants in vowel fronting. These processes are also common when CV sequences agree: [coronal] spreads to the preceding segment in both patterns. The two alternations, therefore, can be formalized by the markedness constraint (64) and the faithfulness constraint on [coronal] as shown below.

(65) MAX (coronal):
Assign a violation mark for each feature [coronal] that is present in the input and absent in the output.

These constraints must dominate the faithfulness constraint on the spreading of [coronal] to the adjacent segment(s) as shown below.[22] (67) demonstrates the ranking argument.

(66) DEP-SEG (coronal):
Assign a violation mark for each feature [coronal] on segments that is absent in the input and present in the output.

(67) Ranking argument: palatalization and vowel fronting
i. Palatalization: e.g. /ti/ → [tɕi]
ii. Vowel fronting: e.g. /otɕ/ → [etɕ]

	AGREE	MAX (coronal)	DEP-SEG (coronal)
i. /ti/			
ti	*W		L
tu		*W	L
☞ tɕi			*
ii. /otɕ/			
otɕ	*W		L
ot		*W	L
☞ etɕ			*

Thus far, I have shown that palatalization and vowel fronting can be analyzed in the same manner. However, as noted in §2.2, while palatalization frequently occurs before front vowels, vowel fronting is rarely attested. Moreover, the frequency of palatalization depends on the height of the following front vowels; this process is more likely to occur before [i] than before [e]. These facts suggest that the constraints such as (64) and (66) should be sensitive to phonological contexts. We will return to this detail in §4.2.1.

Next, let us examine vowel alternations unrelated to assimilation to adjacent consonants. First, vowel reduction is generalized as a restriction on the emergence of certain unstressed

[22] Palatalization or vowel fronting would not violate DEP (coronal) because these processes involve the spreading of [coronal] underlying in the input.

vowels. In the Slavic languages in which vowel reduction is observed, mid vowels undergo this process. Thus, the emergence of unstressed mid vowels is restricted and can be formalized as a markedness constraint, as seen in (68).

(68) *[high, low]/σ̆ (*UNSTRMID):
Assign a violation mark for each unstressed vowel with both [high] and [low] (i.e., mid vowel).

Another pattern is for high vowels to never undergo reduction. In other words, vowels with the feature [low] are more marked than the other vowels in unstressed positions. This situation can be formalized by assuming the markedness constraints in (69), ranked according to (69c).

(69) Constraints on height features in unstressed syllables
a. *[low]/σ̆ (*UNSTRNONHIGH):
Assign a violation mark for each feature [low] in unstressed syllables.
b. *[high]/σ̆:
Assign a violation mark for each feature [high] in unstressed syllables.
c. *[low]/σ̆ >> *[high]/σ̆

Since vowel reduction is accompanied by change in height, the faithfulness constraints in (70) should be dominated by the markedness constraint(s) concerned.

(70) Faithfulness constraints on height features
a. MAX (high):
Assign a violation mark for each feature [high] that is present in the input and absent in the output.
b. MAX (low):
Assign a violation mark for each feature [low] that is present in the input and absent in the output.

Now, let us see the basic constraint rankings relevant to vowel reduction. (71) demonstrates two reduction patterns: all non-high vowels are to be deleted in (71i), and only mid vowels in (71ii).

(71) The ranking argument for vowel reduction

i. Reduction of all non-high vowels
e.g., /CeCe/ → [CiCé]; /CaCe/ → [CəCé]

	*UNSTRMID	*UNSTRNONHIGH	MAX (low)
/CeCe/			
CeCé	*W	*	L
☞ CiCé			*
/CaCe/			
CaCé		*W	L
☞ CəCé			*

ii. Reduction of only mid vowels
e.g., /CeCe/ → [CiCé]; /CaCe/ → [CaCé]

	*UNSTRMID	MAX (low)	*UNSTRNONHIGH
/CeCe/			
CeCé	*W	L	*
☞ CiCé		*	
/CaCe/			
☞ CaCé			
CəCé		*W	L

Another very widespread alternation is deletion or alternation with zero. While the choice of vowel(s) that can be deleted varies from language to language, several points are common to Slavic languages. First, vowel deletion is conditioned by a following vowel or a change from a closed to an open syllable. In other words, sequences of CCV are preferred to CVCV. This situation can be formalized as a markedness constraint (72).

(72) *V/…V:
Assign a violation mark for each vowel preceding a vowel.

If this constraint dominates the faithfulness constraint on vowel deletion such as (73), the vowel–zero alternation can be predicted.

(73) MAX-V:
Assign a violation mark for each vowel that is present in the input and absent in the output.

Another important point is that only morpheme-final vowels can be deleted. This can be formalized by assuming a positional faithfulness (Beckman 1997) on vowel deletion; the faithfulness constraint on deletion of non-morpheme-final vowels as in (74) should dominate (72). The basic ranking argument is demonstrated in (75).

(74) MAX-V/NONFINAL:
Assign a violation mark for each non-morpheme-final vowel that is present in the input and absent in the output.

(75) The ranking argument for vowel–zero alternation
e.g., /CVC**V**C-V/ → [CVCCV]

/CVC**V**C-V/	MAX-V/NONFINAL	*V/…V	MAX-V
CVC**V**CV		**W	L
☞ CVCCV		*	*
CC**V**CV	*W	*	*
CCCV	*W	L	**

First of all, the third and last candidates violate MAX-V/NONFINAL because the non-final vowel in the preceding morpheme is deleted, which are eliminated. Next, the first candidate violates *V/…V for the two vowels, while the second candidate for only the one vowel. As a result, the second candidate, in which only the morpheme-final vowel is deleted, is selected as the output.

Next, the variation in alternating vowels can be accounted for by splitting the faithfulness constraint (73) into those on each vowel[23] and reranking them. In other words, the deletion of certain vowels can be predicted by the domination of (72) over the faithfulness constraint on these vowels. The rankings among Slavic languages are schematized in (76). Note that MAX-V/NONFINAL dominates *V/…V regardless of the underlying vowel quality.

(76) Reranking of the constraints relevant to vowel–zero alternation
   a. Russian: /o, e/ can be deleted.
      MAX-a, MAX-i, MAX-ɨ, MAX-u >> *V/…V >> MAX-o, MAX-e
   b. Polish, Czech: /e/ can be deleted.
      MAX-a, MAX-i, MAX-ɨ, MAX-u, MAX-o >> *V/…V >> MAX-e
   c. Serbo–Croatian: /a/ can be deleted.
      MAX-i, MAX-u, MAX-o, MAX-e >> *V/…V >> MAX-a
   d. Bulgarian: /e, ə/ can be deleted.
      MAX-a, MAX-i, MAX-u, MAX-o >> *V/…V >> MAX-e, MAX-ə

One may suspect that vowel deletion should be attributed to the markedness of certain vowels (Gouskova 2012). However, I argue against this account for two reasons: first, markedness scales among vowels have been regarded as universal across languages. In particular, mid vowels have been documented as more marked than the others on the basis of their distributional patterns among languages. This tendency, however, is not true of the Slavic vowel–zero alternation; for instance, mid vowels cannot undergo the deletion in Serbo–Croatian. The other counterargument is that the surface vowel quality is irrelevant to the alternation in some languages. In Russian, for instance, while [i, ə] as well as [o, e] may be

[23] These constraints should also be defined in terms of the phonological features (e.g., MAX-V (high, low, dorsal) = MAX-o), but they are simplified in (76).

deleted at the surface, underlying /i/ cannot. In fact, alternating [i, ə] are each /e, o/ in the underlying form. This situation must be accounted for by the faithfulness, rather than markedness, constraint on certain vowels.

Some other vowel alternations are conditioned by syllable structure. In Polish, as noted in § 2.3.2, [o] in open syllables alternates with [u] and nasal vowels emerge as back in closed syllables. These situations can be formalized by the following markedness constraints:

(77) Markedness constraints for closed syllables
  a. *V[high, low, dorsal]/_C)$_\sigma$ (*o/_C)$_\sigma$):
     "Assign a violation mark for each [o] in closed syllables."
  b. *V[coronal, nasal]/_C)$_\sigma$ (*ẽ/_C)$_\sigma$):
     "Assign a violation mark for each [ẽ] in closed syllables."

These constraints may be supported independently of the alternations concerned. First, closed syllables have been regarded as more marked typologically than open ones (Ladefoged and Maddieson 1996; Gordon 2016). For this reason, phonological contrast should be restricted in this context. On the other hand, mid vowels have been considered more marked than the other vowels (Ladefoged and Maddieson 1996; Beckman 1997; Gordon 2016). Although the universal markedness scale for nasal vowels is unclear, a front vowel is less likely to emerge than a back vowel in Polish. It has been well documented that the front nasal vowel especially tends to lose its nasality in word-final positions (Gussmann 2007 among others). In summary, the constraints in (77) can be generalized as restrictions on marked segments in marked positions. If these constraints dominate the faithfulness constraints on vowel change (e.g., 70;

simplified as MAX/V (F) here), the given alternations are predicted. Basic ranking arguments are summarized below.

(78) Ranking arguments
i. Vowel raising: e.g. /tot/ → [tut]
ii. Nasal vowel backing: e.g. /tẽt/ → [tõt]

	*o/_C)σ	*ẽ/_C)σ	MAX/V (F)
i. /tot/			
tot	*W		L
☞ tut			*
ii. /tẽt/			
tẽt		*W	L
☞ tõt			*

Finally, Czech has vowel length alternations. As noted in §2.3.3, however, these processes are related to morphology, and thus, cannot be formalized by any phonological constraint. For the present, I assume that the alternations can be blocked by the faithfulness constraint below:

(79) Faithfulness constraints on vowel length (unified as FAITH-V-μ):
a. MAX-V-μ
Assign a violation mark for each mora on vowels that is present in the input and absent in the output.
b. DEP-V-μ
Assign a violation mark for each mora on vowels that is absent in the input and present in the output.

Later in §4.4.3, I will propose some morphologically driven constraints.

4.1.3. Phonological productivity

Before presenting a detailed analysis of the sound alternations, this subsection briefly discusses the issue of variation or exceptionality. As discussed in Chapter 2, while some sound

alternations almost unexceptionally occur under certain phonological conditions, others show exceptions. Thus, to predict the alternation patterns, as discussed in §3.3, properties beyond pure phonology should also be considered.

The occurrence of phonological exceptions is not uniform. First, the frequency of alternations varies from process to process. In Polish, for instance, while the raising of vowels preceding underlyingly voiced consonants frequently occurs, backness alternation of nasal vowels does not, even though both processes are conditioned by change in syllable structure (see §2.3.2). It is, however, difficult to directly account for the difference in the frequency of the given patterns by phonological grammar, which only categorizes sound patterns. However, it is also inappropriate to define arbitrary boundaries between frequent and infrequent processes.

Putting aside the issue of numerical frequency, what should be considered is whether the given patterns *can* be applied to *any* lexical items. This investigation of Slavic phonology (see Chapter 2) has suggested that some alternations can extend their range to loanwords, while others are restricted to several lexical items. I thus conclude that the former processes are phonologically *productive* since they can potentially occur under certain phonological conditions with other (e.g., lexical) factors set aside. In theoretical terms, phonological grammar must be able to predict such patterns for any lexical item unless a certain factor blocks them. Previous research has proposed lexically specific faithfulness constraints (see §3.3.3) as a blocking factor. The other type of alternations, in contrast, are no longer purely phonological

in that they are not completely motivated by any phonological condition, but rather by lexical factors. Such lexical specificity has been formalized as a special type of underlying representation (see §3.1.2–§3.1.3) in previous phonological studies. In summary, the difference in phonological productivity can be accounted for by adopting different approaches. Note that productivity is in principle irrelevant to frequency. For instance, the vowel–zero alternation, which is not very frequently attested, is also observed among some loanwords in many Slavic languages.

In the following sections, I will show the theoretical analysis conducted for the sound alternations in Slavic languages, classifying them by productivity. First, §4.2 addresses unexceptional phonological processes. Next, §4.3 accounts for phonologically productive processes that show exceptions by assuming lexical stratification and certain faithfulness constraints specific to each lexical stratum. In contrast, §4.4 explains lexically restrictive phenomena by assuming *underspecification* for the alternating phonological categories in the underlying forms.

4.2. Analysis of primarily phonological alternations

This section analyzes purely phonological alternations under the framework of OT. §4.2.1 addresses the palatalization that unexceptionally occurs under certain phonological conditions, and §4.2.2 discusses vowel reduction in unstressed syllables.

4.2.1. Phonological palatalization

As noted in §2.2, phonological or obligatory palatalization is attested in Russian, Polish, and Bulgarian. In Russian and Polish, while non-velar consonants preceding front vowels [i, e] can be non-palatalized, velars[24] cannot. Velars preceding front vowels are always palatalized in Bulgarian as well, while other consonants cannot be palatalized in this context.

Palatalization (along with vowel fronting triggered by palatal(ized) consonants) is regarded as an assimilation process that should be explained by the markedness constraint AGREE (see 64) assumed in §4.1.2. In addition, two more assumptions are required to precisely account for the palatalization patterns among Slavic languages. One is that palatalization is more likely to occur on velar consonants than on others. This suggests that the ranking of the markedness constraint varies with the place of articulation: the constraint on velar consonants is ranked consistently higher than that on the other consonants. The AGREE constraint should thus be split as shown in (80). Note that the features in which CV sequences are to agree are [coronal, −anterior], for which prepalatal or retroflex consonants are specified (see §4.1.1; see also Clements and Hume 1995).

[24] The velar fricative [x] can remain non-palatalized in Polish (§2.2.1 and §2.2.3).

(80) AGREE constraints sensitive to the place of articulation on consonants
   a. AGREE-LABIAL/_V (coronal, −anterior) (hereafter AGREE-P):
      Assign a violation mark for each labial consonant that does not agree with the following vowel in [coronal, −anterior].
   b. AGREE-CORONAL/_V (coronal, −anterior) (hereafter AGREE-T):
      Assign a violation mark for each coronal consonant that does not agree with the following vowel in [coronal, −anterior].
   c. AGREE-DORSAL/_V (coronal, −anterior) (hereafter AGREE-K):
      Assign a violation mark for each dorsal (i.e., velar) consonant that does not agree with the following vowel in [coronal, −anterior].
   d. Ranking
      AGREE-K >> AGREE-P, AGREE-T

In addition, palatalization is more likely to occur before [i] than before [e]; the occurrence of palatalization depends on the height of triggering vowels. As noted in §2.2, this tendency is cross-linguistically observed (Chen 1973), which should be formalized as a fixed ranking of the markedness constraints concerned, as illustrated in (81) (see also Rubach 2003). Since this difference is related to positional effects and loanword phonology, it will be discussed later.

(81) Palatalization: constraint ranking
   a. AGREE-C/_i (coronal, −anterior):
      Assign a violation mark for each consonant that does not agree with the following [i] in [coronal, −anterior].
   b. AGREE-C/_e (coronal, −anterior):
      Assign a violation mark for each consonant that does not agree with the following [e] in [coronal, −anterior].
   c. Ranking
      AGREE-C/_i (coronal, −anterior) >> AGREE-C/_e (coronal, −anterior)

Note that these constraints are to be violated by non-palatal(ized) consonants preceding [i] derived from /ɨ/ or [e] from /ɛ/, though these vowels are not completely merged with the palatalizing counterparts. Hence, splitting the markedness constraints is not enough to account for the absence of palatalization. Since non-palatalizing [i] from /ɨ/ is still a high vowel, palatalization before mid-front vowels cannot be predicted due to the ranking in (81c) if the

constraint on consonants preceding [i] is inactive. Therefore, palatalization avoidance can be attributed to differences in underlying forms. I assume the faithfulness constraints on the insertion of the features lacking in /ɨ/ and /ɛ/, i.e., either [coronal] or [high], as shown in (82). The assumption that palatal(ized) consonants are specified also for [high] is consistent with the typological tendency for higher vowels to be more likely to trigger palatalization, as noted in §4.1.1.

(82) Constraints on *non-palatalizing* front vowels
  a. DEP (coronal):
     Assign a violation mark for each feature [coronal] that is absent in the input and present in the output.
  b. DEP (high):
     Assign a violation mark for each feature [high] that is absent in the input and present in the output.

If these constraints dominate the markedness constraints as in (81), palatalization is blocked. Note that the markedness constraints should be slightly modified so that CV sequences can agree in [high] along with [coronal, −anterior]:

(83) Constraints regarding palatalization (modified)
  a. AGREE-C/_i (coronal, −anterior, high) (hereafter AGREE-C/_i):
     Assign a violation mark for each consonant that does not agree with the following [i] in [coronal, −anterior, high].
  b. AGREE-C/_e (coronal, −anterior, high) (hereafter AGREE-C/_e):
     Assign a violation mark for each consonant that does not agree with the following [e] in [coronal, −anterior, high].

Remember here that velar consonants undergo palatalization even if they precede the non-palatalizing front vowels.[25] Therefore, AGREE-K (80c) should be ranked still higher than the faithfulness constraints in (82). The ranking arguments are schematized below.

(84) Ranking argument: non-palatalizing front vowels (e.g., Polish)

a. /ɨ/ (high front vowel without [coronal])

i. /tɨ/ → [ti] e.g. /kot-ɨ/ → [koti] 'cat (nom.pl.)'

ii. /kɨ/ → [kʲi] e.g. /krok-ɨ/ → [krokʲi] 'step (nom.pl.)'

	AGREE-K/_i	DEP (coronal)	AGREE-C/_i
i. /tɨ/			
☞ ti			*
tɕi		*W	L
ii. /kɨ/			
ki	*W	L	*
☞ kʲi		*	

b. /ɛ/ (mid front vowel without [high])

i. /tɛ/ → [te] e.g. /kot-ɛm/ → [kotem] 'cat (inst.sg.)'

ii. /kɛ/ → [kʲe] e.g. /krok-ɛm/ → [krokʲem] 'step (inst.sg.)'

	AGREE-K/_e	DEP (high)	AGREE-C/_e
i. /tɛ/			
☞ te			*
tɕe		*W	L
ii. /kɛ/			
ke	*W	L	*
☞ kʲe		*	

One thing to be added is that this distinction in the underlying representation should be inappropriate for Czech, at least for [e]. First, palatalization is restricted to several consonants in this language, unlike Russian or Polish. Another, more crucial piece of evidence is that while

[25] As noted earlier, the non-palatalized velar fricative [x] can precede front vowels in Polish.

non-palatalized velars can precede front vowels in Czech, unlike the pattern demonstrated in (84), coronalization is triggered by [e] in several affixes:

(85) Variable palatalization in Czech (see also 9b in §2.2.2)

ko**t**	'cat'	ko**t**-em	(inst.sg.)
j**d**-u	'go (1sg)'	j**d**-e	(3sg)
kro**k**	'step'	kro**k**-em	(inst.sg.)
dra**ɦ**-a:	'dear (fem.sg.)'	dra**ɦ**-e:	(fem.pl.)
cf.			
svje**t**	'world'	svje**c**-e/*svje**t**-e	(loc.sg.)
tvr**d**-a:	'hard (fem.sg.)'	tvr**ɟ**-e/*tvr**d**-e	(adv.)
pe**k**-l	'bake (p.p.masc.sg.)'	pe**ʧ**-e/*pe**k**-e	(3sg)
mo**ɦ**-u	'can (1sg)'	mu:**ʒ**-e/*mu:**ɦ**-e	(3sg)

This observation leads to the claim that palatalization in Czech should be triggered by certain lexical properties specific to certain morphemes rather than phonologically by front vowels. Such lexical palatalization in Czech as well as Serbo–Croatian, in which only velar coronalization is observed before certain morphemes while non-palatalized consonants preceding front vowels are generally attested, will be discussed later in §4.4.1.

Now let us consider the variation among Slavic languages. This can be accounted for by re-ranking the relevant constraints with the fixed rankings in (80d, 81c) preserved, as summarized in (86). MAX (coronal) should be active to eliminate vowel backing as discussed in §4.1.2 (see 67). Note that only native phonology is addressed here (palatalization avoidance in loanwords will be discussed in §4.3.3).

(86) Palatalization: constraint ranking[26]

a. Russian
AGREE-K/_i >> DEP (coronal) >> AGREE-C/_i
AGREE-K, AGREE-P, AGREE-T, MAX (coronal) >> DEP-C (coronal)

b. Polish
AGREE-K/_i >> DEP (coronal) >> AGREE-C/_i
AGREE-K/_e >> DEP (high) >> AGREE-C/_e
AGREE-K, AGREE-P, AGREE-T, MAX (coronal) >> DEP-C (coronal)

c. Bulgarian
AGREE-K, MAX (coronal) >> DEP-C (coronal) >> AGREE-P, AGREE-T

d. Czech, Serbo–Croatian[27]
MAX (coronal), DEP-C (coronal) >> AGREE-K, AGREE-P, AGREE-T

(87) demonstrates how the current OT grammar works (only consonants preceding /i/ are targeted; the full demonstration is shown in Appendix 3).

(87) Ranking argument:

a. Russian (similar to Polish)

i. /pi/ → [pʲi] e.g. /lʲubʲ-i-tʲ/ → [lʲubʲitʲ] 'to love'
ii. /ti/ → [tʲi] e.g. /zontʲ-ik/ → [zontʲik] 'umbrella (dim.)'
iii. /ki/ → [kʲi]/[ʧi] e.g. /pʲekʲ-i/ → [pʲikʲi] 'bake (imp.)'

	AGREE-K/_i	AGREE-P/_i	AGREE-T/_i	MAX (coronal)	DEP-C (coronal)
i. /pi/					
pi		*W			L
☞ pʲi					*
pu				*W	L
ii. /ti/					
ti			*W		L
☞ tʲi					*
tu				*W	L
iii. /ki/					
ki	*W				L
☞ kʲi					*
☞ ʧi					*
ku				*W	L

[26] Precisely speaking, the current ranking does not consider that some coronal consonants cannot undergo palatalization, which should be explained by assuming other markedness constraints on certain consonants.

[27] Considering that velar palatalization is attested in these languages, AGREE-K (place) should still be active for some derivation patterns. See §4.4.1.

b. Bulgarian

i. /pi/ → [pi] e.g. /grup-i/ → [grupi] ‘group (pl.)’
ii. /ti/ → [ti] e.g. /vrat-i/ → [vrati] ‘door (pl.)’
iii. /ki/ → [kʲi]/[ʧi] e.g. /lek-i/ → [lekʲi] ‘light (pl.)’

	AGREE-K/_i	MAX (coronal)	DEP-C (coronal)	AGREE-P/_i	AGREE-T/_i
i. /pi/					
☞ pi				*	
pʲi			*W	L	
pu		*W		L	
ii. /ti/					
☞ ti					*
tʲi			*W		L
tu		*W			L
iii. /ki/					
ki	*W		L		
☞ kʲi			*		
☞ ʧi			*		
ku		*W	L		

c. Serbo–Croatian (also for Czech)

i. /pi/ → [pi] e.g. /lep-i/ → [lepi] ‘nice (masc.pl.)’
ii. /ti/ → [ti] e.g. /zlat-ima/ → [zlatima] ‘gold (dat.pl.)’
iii. /ki/ → [ki] e.g. /srb-sk-i/ → [srpski] ‘Serbian’

	MAX (coronal)	DEP-C (coronal)	AGREE-K/_i	AGREE-P/_i	AGREE-T/_i
i. /pi/					
☞ pi				*	
pʲi		*W		L	
pu	*W			L	
ii. /ti/					
☞ ti					*
tʲi		*W			L
tu	*W				L
iii. /ki/					
☞ ki			*		
kʲi		*W	L		
ʧi		*W	L		
ku	*W		L		

Note that the type of palatalization (i.e., primary or secondary) that occurs is not discussed here.

So far, this section has only discussed assimilatory palatalization (agreement between consonants and the following front vowels). As noted in §2.2, however, palatalization can occur even if no front vowels follow on the surface (see 3 and 4). Nevertheless, we can observe an underlying front vowel in this type of cases:

(88) Emergence of front vowels in opaque palatalization (Russian)
a. Palatalization before back vowels
id-u ‘go (1sg)’ id^{j}-**ó**-t (3sg)
cf. ví-id^{j}-**i**-t ‘go out (3sg)’
b. Palatalization before consonants
s^{j}il-a ‘power’ s^{j}il^{j}-**n**-ə ‘powerfully, strongly’
cf. s^{j}il^{j}-**in** ‘powerful (decl.)’

As seen in (88a), the palatalizing vowel emerges as [i] in unstressed syllables. Note that this vowel alternation is one of the reduction patterns introduced in §2.3.1 (see 18b[28]). In (88b), a front vowel [i] emerges at the beginning of the palatalizing morpheme in word-final positions. This pattern reminds us of the vowel–zero alternation mentioned in §2.3.4. More concretely, we can assume that this morpheme begins with the front alternating vowel, i.e., /e/. Given that a certain front vowel underlyingly remains, such opaque palatalization can be regarded as a type of preservation of the feature [coronal], as discussed in §3.2.2. In other words, MAX (coronal) is violated when neither palatalization nor the emergence of a front vowel occurs. The current grammar can still predict this pattern, as can be seen in (89). In other words, the seemingly *opaque* phonological process can in fact be accounted for under the parallel OT.

[28] I will discuss why the backness alternation occurs in §4.2.2.

This type of palatalization leads to a disagreement between adjacent consonants and vowels: palatal(ized) consonants precede back vowels. However, this situation does not contradict the current constraint ranking assumed in (86) because the markedness constraints act exclusively on consonants preceding front vowels, that is, the markedness constraints on consonants preceding back vowels should be ranked low, or at least dominated by MAX (coronal). This topic, specifically vowel backness alternations, is discussed again in §4.4.2.

(89) Opaque palatalization (Russian: see also 57 in §3.2.2)
i. /id-e-t/ → [idʲot] 'go (3sg)'
ii. /sʲil-en-o/ → [sʲilʲnə] 'powerfully'

	MAX (coronal)	DEP-C (coronal)
i. /d-e/		
do	*!	
☞ dʲo		*
ii. /l-en-o/		
lnə	*!	
lʲnə		*

Another factor the preceding discussion has not addressed is the type of consonants that emerge in palatalization. As noted in §2.2.3, velar and coronal consonants can undergo either primary or secondary palatalization. Although clear cross-linguistic preferences for one over another have not been documented (Bhat 1978; Bateman 2007; Kochetov 2011), secondary palatalization is more restricted than primary among Slavic languages (see §2.2.1). The following markedness constraint can thus be assumed.

(90) *Cʲ (cf. Takatori 1997):
Assign a violation mark for each consonant specified for [coronal, −anterior] under V-place node.
"Assign a violation mark for each secondarily palatalized consonant."

Secondary palatalization occurs only when this constraint is dominated by the faithfulness constraints on primary palatalization as below:

(91) Faithfulness constraints on place features (cf. Rubach 2003)
a. MAX (dorsal):
Assign a violation mark for each feature [dorsal] that is present in the input and absent in the output.
b. MAX (+anterior):
Assign a violation mark for each feature [+anterior] that is present in the input and absent in the output.
c. MAX (labial):
Assign a violation mark for each feature [labial] that is present in the input and absent in the output.

Next, we consider the rankings that predict each process. With regard to velar palatalization, for instance, the constraint rankings vary as in (92).

(92) Velar palatalization: re-ranking
a. Primary palatalization (coronalization)
*Cʲ >> MAX (dorsal)
b. Secondary palatalization
MAX (dorsal) >> *Cʲ

Velar palatalization is, however, more complicated because of the intra-language variations related to morphology noted in §2.2.3. This issue will be discussed in detail later in §4.4.1. Coronal palatalization is, in contrast, phonologically predictable. The variation among languages can be accounted for as follows:

(93) Coronal palatalization: re-ranking

a. Primary palatalization (Polish[29])

*Cʲ >> MAX (+anterior)

/te/ → [t͡ɕe] e.g., /kot-e/ → [kot͡ɕe] ‘cat (loc.sg.)’

	AGREE-T/_e	*Cʲ	MAX (+anterior)	DEP-C (coronal)
/te/				
te	*W		L	L
tʲe		*W	L	*
☞ t͡ɕe			*	*

b. Secondary palatalization (Russian)

MAX (+anterior) >> *Cʲ

/te/ → [tʲe] e.g., /krasat-e/ → [krəsatʲe] ‘beauty (loc.sg.)’

	AGREE-T/_e	MAX (+anterior)	*Cʲ	DEP-C (coronal)
/te/				
te	*W		L	L
☞ tʲe			*	*
t͡ɕe		*W	L	*

Besides, as noted in §2.2.1, labial palatalization is only secondary across languages (Bateman 2007). This situation is formalized by the universal ranking below:

(94) Blocking of primary labial palatalization

MAX (labial) >> *Cʲ

Finally, let us consider positional effects. As mentioned in §2.1–§2.2, the emergence of palatal(ized) consonants is restricted under some phonological conditions. First, secondarily palatalized consonants are unattested in some languages unless a vowel follows. In Polish (§2.1.2) and Bulgarian (§2.1.5), for instance, secondarily palatalized consonants do not emerge

[29] The palatal lateral [ʎ] is unattested and should be accounted for by the markedness constraint on this consonant. See also §4.4.1.

unless they precede a vowel. This suggests that the constraints on these consonants not preceding vowels, such as (95), is ranked higher than MAX (coronal).

(95) Positional markedness of secondarily palatalized consonants
a. *CʲC[30] (see also Kochetov 2002):
"Assign a violation mark for each secondarily palatalized consonant preceding another consonant."
b. *Cʲ#:
"Assign a violation mark for each secondarily palatalized consonant in word-final positions."

(96) demonstrates that underlyingly palatalized labial consonants emerge as non-palatalized when no vowel follows.

(96) Depalatalization (e.g., Polish)
i. /pʲes-a/ → [psa] 'dog (gen.sg.)' cf. [pʲes] (nom.sg.)
ii. /karpʲ/ → [karp] 'carp (nom.sg.)' cf. [karpʲa] (gen.sg.)

	*CʲC	*Cʲ#	MAX (coronal)
i. /pʲes-a/			
pʲsa	*W		L
☞ psa			*
ii. /karpʲ/			
karpʲ		*W	L
☞ karp			*

The positional avoidance of palatalized consonants is also observed in derivations. One example is the adjectivizing affix /-en/, whose vowel is deleted when another vowel follows (see 4 in §2.2.1). When root-final consonants are labial, however, palatalization is blocked due to constraint (95), as seen in (97) (this vowel deletion is not discussed here).

[30] The acceptability of this type of cluster depends on the preceding palatalized consonant. In particular, [lʲ] preceding another consonant is widely observed (e.g., sʲilʲnə 'strongly').

(97) Palatalization avoidance (e.g., Polish)

i. /pʲev-en/ → [pʲevʲen] ‘certain (masc.sg.)’

ii. /pʲev-en-a/ → [pʲevna] ‘certain (fem.sg.)’

cf.

iii. /ruk-en-a/ → [ruʦna] ‘hand (adj., fem.sg.)’

	*CʲC	AGREE-P/_e	MAX (coronal)	DEP-C (coronal)
i. /pʲev-en/				
pʲeven		*W		L
☞ pʲevʲen				*
ii. /pʲev-en-a/				
☞ pʲevna			*	
pʲevʲna	*W		L	*
iii. /ruk-en-a/				
rukna			*W	L
☞ ruʦna				*

This restriction partially holds in Russian as well: secondarily palatalized consonants are unlikely to precede consonants but can emerge word-finally. In terms of the constraint ranking, (95a) is ranked higher than MAX (coronal), while (95b) lower than this faithfulness constraint. (98) shows the ranking arguments.

(98) Depalatalization (Russian)

i. /pʲos-a/ → [psa] ‘dog (gen.sg.)’ cf. [pʲos] (nom.sg.)

ii. /ʦepʲ/ → [ʦepʲ] ‘chain (nom.sg.)’ cf. [ʦipʲax] (loc.pl.)

	*CʲC	MAX (coronal)	*Cʲ#
i. /pʲos-a/			
pʲsa	*W	L	
☞ psa		*	
ii. /ʦepʲ/			
☞ ʦepʲ			*
ʦep		*W	L

Depalatalization occurs before a consonant because *CʲC dominates MAX (coronal). In contrast, word-final palatalized consonants are preserved due to MAX (coronal) which dominates *Cʲ#. The restriction can also be observed in the adjectivizing affix /-en/ as in Polish:

(99) Palatalization avoidance (e.g., Russian)
i. /svabod-en/ → [svabodʲin] 'free (masc.sg.)'
ii. /svabod-en-a/ → [svabodna] 'free (fem.sg.)'
cf.
iii. /dolg-en-a/ → [dalzna] 'obliged (fem.sg.)'

	*CʲC	AGREE-T/_ i	MAX (coronal)	DEP-C (coronal)
i. /svabod-en/				
svabodin		*W		L
☞ svabodʲin				*
ii. /svabod-en-a/				
☞ svabodna			*	
svabodʲna	*W		L	*
iii. /dolg-en-a/				
dalgna			*W	L
☞ dalzna				*

Another positional restriction involves word boundaries. As discussed in §2.2.2 and §2.2.3, while palatalization is unattested across word boundaries in Russian, only word-initial [i] triggers secondary palatalization in Polish. This suggests that the faithfulness constraint on palatalization in word-final positions (100) should be assumed.

(100) DEP-C/_# (coronal):
Assign a violation mark for each feature [coronal] on word-final consonants that is absent in the input and present in the output.

This constraint dominates the markedness constraints (see 83) in Russian. In Polish, in contrast, only the markedness constraint on consonants preceding [e], and not that on consonants

preceding [i], is dominated by (100). The Polish pattern thus clearly reflects the universal hierarchy in (81c). The variation in the rankings is as follows:

(101) Palatalization of word-final consonants
  a. Russian
     DEP-C/_# (coronal) >> AGREE-C/_i, AGREE-C/_e >> DEP-C (coronal)
  b. Polish
     AGREE-C/_i >> DEP-C/_# (coronal) >> AGREE-C/_e >> DEP-C (coronal)

One more thing to be considered for Polish is that only secondary palatalization is attested, in contrast to other positions. For this reason, the faithfulness constraints on primary palatalization assumed in (91) should also be sensitive to word-final position. The constraint ranking for coronal consonants is as follows:

(102) Secondary palatalization in word-final positions (Polish)
     MAX/_# (+anterior) >> *C^j >> MAX (+anterior)

The ranking arguments can be summarized as below (only coronal consonants are demonstrated).

(103) Ranking argument:

a. Russian

i. /t#i/ → [ti] e.g. /brat#irʲin-ɨ/ → [bratirʲini] 'Irina's brother'

ii. /t#e/ → [te] e.g. /at#et-ovo/ → [atetəvə] 'from this'

	DEP-C/_# (coronal)	AGREE-T/_i	AGREE-T/_e	DEP-C (coronal)
i. /t#i/				
☞ ti		*		
tʲi	*W	L		*
tɕi	*W	L		*
ii. /t#e/				
☞ te			*	
tʲe	*W		L	*
tɕe	*W		L	*

b. Polish

i. /t#i/ → [tʲi] e.g. /brat#ir-ɨ/ → [bratʲiri] 'Ira's brother'

ii. /t#e/ → [te] e.g. /brat#ev-ɨ/ → [bratevi] 'Eva's brother'

	AGREE-T/_i	MAX/_# (+anterior)	DEP-C/_# (coronal)	*Cʲ	AGREE-T/_e	MAX/ (+anterior)
/t#i/						
ti	*W		L	L		
☞ tʲi			*	*		
tɕi		*W	*	L		
/t#e/						
☞ te					*	
tʲe			*W	*W	L	
tɕe		*W	*		L	*

This subsection has addressed obligatory palatalization patterns. In contrast, as noted in §2.2, many variable patterns are also observed, and are conditioned primarily by following morphemes. This topic will be discussed in §4.4.1.

4.2.2. Vowel reduction

This subsection analyzes the reduction of unstressed (or unaccented, in a wider sense) vowels, which is observed in several Slavic languages. Similar processes with almost no variations or exceptions occur across languages.

First, vowel reduction is motivated by the avoidance of certain vowels in unstressed syllables, which is formalized as the markedness constraints assumed in §4.1.2 (see 68 or 69). These constraints should be ranked higher than faithfulness constraints on vowels such as (70) in the languages in which the reduction occurs. A simple ranking as shown in (104) is assumed for Bulgarian, in which non-high vowels undergo reduction in unstressed syllables.

(104) Constraint ranking in Bulgarian (see 71i)
*[low]/σ̆ (*UNSTRNONHIGH) >> MAX (low)

This ranking is, however, not enough to account for the reduction patterns: since vowel backness is unchanged, some additional faithfulness constraints should be active. In the same spirit that the blocking of vowel backing has been accounted for, along with the preservation of palatal(ized) consonants in the last subsection (see also 65 in §4.1.2), the failure of fronting should be accounted for by the following faithfulness constraint. This constraint also plays a role in the blocking of coronalization (discussed in §4.4.1).

(105) MAX (dorsal) (=91a):
Assign a violation mark for each feature [dorsal] that is present in the input and absent in the output.

Note that this constraint would not prevent /a/ from changing to a back or front vowel (i.e., [u] or [i]), since this vowel is unspecified for any place feature. I assume that DEP (place) eliminates the emergence of high vowels from /a/. In other words, specification of the place features is fully faithful to inputs. The full analysis of Bulgarian is demonstrated in (106).

(106) Vowel reduction in Bulgarian

i. /Co/ → [Cu] e.g., /vod-a/ → [vudá] 'water'
ii. /Ce/ → [Ci] e.g., /del-a/ → [dilá] 'matter (pl.)'
iii. /Ca/ → [Cə] e.g., /dad-eʃ/ → [dədéʃ] 'give (2sg)'

	*UNSTR NONHIGH	MAX (low)	MAX (coronal)	MAX (dorsal)	DEP (place)
i. /Co/					
a. Co	*W	L			
b. ☞ Cu		*			
c. Cə		*		*W	
ii. /Ce/					
a. Ce	*W	L			
b. ☞ Ci		*			
c. Cə		*	*W		
iii. /Ca/					
a. Ca	*W	L			
b. Cu, Ci		*			*W
c. ☞ Cə		*			

First, non-high vowels are eliminated by *UNSTRNONHIGH, which dominates MAX (low). Next, the choice of vowel is determined by other faithfulness constraints. Since /o/ and /e/ are underlyingly specified for the place (backness) features, the change to schwa is eliminated by MAX (dorsal) or MAX (coronal). On the other hand, since /a/ is unspecified for any place feature,

the emergence of [u, i] is eliminated by DEP (place). Note that the choice of the constraint that is dominated by the faithfulness constraints on the place features remains undetermined.

The situation is more complicated in Russian due to the preservation of [a] in pretonic positions. Moreover, the effect of the preceding consonant needs to be considered: as noted in §2.3.1, the reduction pattern depends on whether a palatal(ized) consonant precedes the vowel. The former fact suggests that the markedness constraint on unstressed vowels should be split. Crosswhite (2000) claimed that only stressed and pretonic syllables, which are parsed into (disyllabic iambic) feet, have morae and assumed a markedness constraint on *non-moraic* vowels. The constraints can be summarized as (107).

(107) Markedness constraints on unstressed vowels (cf. Crosswhite 2000)
  a. *[high, low]/$\breve{\sigma}_{(\mu)}$ (*UNSTRMID) (cf. 68):
  Assign a violation mark for each unstressed vowel with both [high] and [low] (i.e., mid vowel).
  b. *[low]/σ (*NONMORAICNONHIGH):
  Assign a violation mark for each vowel with [low] (i.e., non-high vowel) that bears no morae.

These constraints must be undominated given the reduction patterns: (108) indicates that they dominate the faithfulness constraints on vowel height (see 70 in §4.1.2), which would block reduction.

(108) Vowel reduction in Russian

i. /CoCV/ → [CaCV́] e.g., /vod-a/ → [vadá] 'water'

ii. /CoCV/ → [CəCV] e.g., /gorod-a/ → [gəradá] 'city (nom.pl.)'

	*UNSTRMID	*NONMORAICNONHIGH	MAX (high)	MAX (low)
i. /CoCV/				
a. CoCV́	*W		L	L
b. ☞ CaCV́			*	
c. CəCV́			*	*
ii. /CoCV/				
a. CoCV	*W		L	L
b. CaCV		*W	*	L
c. ☞ CəCV			*	*

Next, let us consider the effect of preceding consonants. In particular, all non-high vowels following palatal(ized) consonants change to [i], which can be regarded as an assimilation to the preceding consonants. However, the vowel fronting cannot be fully attributed to the assimilation because unstressed [u] can follow palatalized consonants. This leads to the assumption that the AGREE-type constraint for unstressed syllables should be divided in a manner similar to the constraint on non-palatalized consonants: the constraint on unstressed [u] is dominated by MAX (dorsal), whereas that on the other unstressed vowels is ranked higher than this faithfulness constraint. What should be considered next is that, as mentioned in §2.3.1, the fronting of /o/ is in fact slightly different from that of /a/: while unstressed /o/ emerges as [i] when it follows retroflex consonants ([ʂ, ʐ]), /a/ appears as [a] or [ə] under this condition. Moreover, the preceding palatal(ized) consonants seem to be derived, i.e., triggered by the vowel alternating between [o] and [i], in some cases such as (109).

(109) Palatalization before /o/ (see also 55 in §3.2.2)

i**d**-u	‘go (1sg)’	i**dʲ**-ó-t	(3sg)	~ ví-i̯**dʲ**-i-t	‘go out (3sg)’
nʲi**s**-u	‘carry (1sg)’	nʲi**sʲ**-ó-t	(3sg)	~ ví-nʲi**sʲ**-i-t	‘carry outwards (3sg)’

This suggests that the alternating vowel should be underlyingly specified for frontness, which triggers the palatalization. I assume that the vowel alternating between [o] and [i] is underlyingly specified for both [coronal] and [dorsal], which is transcribed tentatively as /ë/. Given this assumption, the difference between /o/ (actually /ë/) and /a/ in the reduction patterns can be explained as follows: /ë/ emerges as [i] due to its underlying frontness[31] (i.e., feature [coronal]), whereas /a/ does so for consonant–vowel assimilation. This account implies that retroflex consonants are differentiated from palatalized consonants and [ʧ, ɕ:], which have been regarded as soft (see §2.2.5), in that they do not assimilate the following vowel. In terms of featural theory, this situation can be formalized as the agreement of [coronal, −anterior, +distributed]. This assimilation should thus be formalized by the following constraints:

(110) AGREE-type constraints on unstressed vowels

a. AGREE-ă/C_ (coronal, −anterior, +distributed):
Assign a violation mark for each unstressed [a] that does not agree with the preceding consonant with [coronal, −anterior, +distributed].

b. AGREE-ə̆/C_ (coronal, −anterior, +distributed):
Assign a violation mark for each unstressed [ə] that does not agree with the preceding consonant with [coronal, −anterior, +distributed].

c. AGREE-ŭ/C_ (coronal, −anterior, +distributed):
Assign a violation mark for each unstressed [u] that does not agree with the preceding consonant with [coronal, −anterior, +distributed].

[31] The vowel that emerges as back (i.e., [o]) in stressed syllables should be explained by assuming that the constraint on stressed [e] is ranked higher than that on stressed [o]. Notably, the former constraint is dominated by DEP (dorsal) in order for /e/ to emerge as such in stressed syllables.

As noted earlier, (110c) should be dominated by MAX (dorsal) to block the fronting of unstressed /u/. Since /a/ is unspecified for the place feature, in contrast, (110a, b) need not dominate this faithfulness constraint. To predict the emergence of [i], these constraints should be ranked higher than MAX (low). The reduction of /o/ following palatal(ized) consonants, in contrast, should be attributed to the faithfulness constraint MAX (coronal). If this constraint is ranked higher than MAX (dorsal), the emergence of [i] can be predicted. The ranking arguments are schematized in (111) (all the candidates are unstressed syllables). First, as can be seen in (111i), since /a/ is unspecified for place features, it cannot violate MAX (coronal) or MAX (dorsal). [a] following palatal(ized) consonants are outranked by [i] due to the AGREE-type constraint dominating MAX (low). The fronting of /u/, in contrast, is eliminated because MAX (dorsal) ranks higher than the relevant markedness constraint, as shown in (111ii). The alternation of /ë/ is, as noted earlier, not conditioned by assimilation, but by its underlying features. As can be seen in (111iii), therefore, [i] emerges even after retroflex consonants because MAX (coronal) dominates MAX (dorsal). /a/ following retroflexes, in contrast, does not emerge as [i] due to the absence of [coronal], as demonstrated in (111iv).

(111) Fronting in Russian vowel reduction: OT analysis

i. /Cʲa/ → [Cʲi]
ii. /Cʲu/ → [Cʲi]
iii. /ʂë/ → [ʂi]
iv. /ʂa/ → [ʂa]

	MAX (coronal)	MAX (dorsal)	AGREE-ŭ	AGREE-ă	MAX (low)
i. /Cʲa/					
Cʲa				*W	L
☞ Cʲi					*
ii. /Cʲu/					
☞ Cʲu			*		
Cʲi		*W	L		
iii. /ʂë/					
ʂa	*W	L			
☞ ʂi		*			
iv. /ʂa/					
☞ ʂa					
ʂi					*W

An additional assumption needed to account for the Russian reduction patterns is that back vowels change to [a] or [ə], and never to [u], unlike in Bulgarian. This pattern needs to be divided into the emergence of [a] and that of [ə]. First, the former should be regarded as the preservation of [low] (see also 111): MAX (low) is ranked higher than MAX (high) or MAX (dorsal). Note that MAX (low) is violated for the reduction of a front vowel /e/, which suggests that this constraint is dominated by MAX (coronal). The constraint ranking can be summarized as (112).

(112) MAX (coronal) >> MAX (low) >> MAX (high), MAX (dorsal)

The emergence of [ə], in contrast, cannot be explained in the same way: [low] is lost regardless of whether [u] or [ə] emerges. Even worse, [ə] violates MAX (dorsal) if the input is /o/. I propose that [u] should be defeated by [ə] due to the markedness hierarchy; [ə] is the least-marked vowel. What should be considered is that underlying /u/ (and /i/) is (are) always preserved as such. The markedness constraints are thus dominated by the faithfulness constraint exclusively on high vowels. The relevant ranking is illustrated in (113).

(113) MAX (high)/u(, i) >> *u(,*i) >> MAX (high), MAX (dorsal), *ə

Such faithfulness constraints can be regarded as a kind of positional faithfulness (Beckman 1997: see also §4.1.2), which is also supported by other alternation processes. As mentioned in §2.3.4, only a few vowels can undergo deletion (or vowel–zero alternation) among Slavic languages, which should be accounted for by faithfulness constraints on certain vowels, as discussed in §4.1.2.

Now, let us see how the current grammar works.

(114) Behavior of unstressed vowels in Russian

i.	/CoCV, CaCV/ → [CaCV́]	e.g., /v**o**d-a/ → [v**a**dá]		‘water’
ii.	/CoCV, CaCV/ → [CəCV]	e.g., /g**o**rod-a/ → [g**ə**radá]		‘city (nom.pl.)’
iii.	/Cu/ → [Cu]	e.g., /r**u**k-a/ → [r**u**ká]		‘hand’
iv.	/Cʲa/ → [Cʲi]	e.g., /svʲ**a**z-i/ → [svʲ**i**zí]		‘connection (loc.sg.)’
v.	/Cʲu/ → [Cʲu]	e.g., /sʲ**u**da/ → [sʲ**u**dá]		‘(to) here’

	*NonMoraicNonHigh	*UnstrMid	Max (cor)	Agree-ă	Agree-ə̆	Max (high)/ i,u	Max (low)	*i, *u	Max (dor)	Max (high)	*ə	Agree-ŭ
i. /CoCV, CaCV/												
CoCV́		*W							(L)	(L)		
CuCV́							*W	*	(L)	(L)		
☞ CaCV́									(*)	(*)		
CəCV́							*W		(*)	(*)	*	
ii. /Co(CV), Ca(CV)/												
Co(CV)	*W	*W					L					
Cu(CV)							*	*W	(L)	(L)	L	
Ca(CV)	*W						L		(*)	(*)		
☞ Cə(CV)							*		(*)	(*)	*	
iii. /Cu/												
☞ Cu								*				
Cə						*W		L	*	*	*	
iv. /Cʲa/												
Cʲa	(*W)			*W			L					
Cʲə					*W		*	L			*	
☞ Cʲi							*	*				
v. /Cʲu/												
☞ Cʲu								*				*
Cʲi								*	*W			L
Cʲə					*W	*W		L	*	*	*	

(114) Behavior of unstressed vowels in Russian (cont.)

vi. /C$^{(j)}$ë, ʂë, zʐë/ → [C^{j}i, ʂi, zʐi] e.g., /zʐëna/ → [zʐiná] ‘wife’

vii. /C$^{(j)}$e/ → [C^{j}i] e.g., /r^{j}ek-a/ → [r^{j}iká] ‘river’

	*NonMoraicNonhigh	*UnstrMid	Max (cor)	Agree-ă	Agree-ə̆	Max (high)/ i,u	Max (low)	*i, *u	Max (dor)	Max (high)	*ə	Agree-ŭ
vi. /C$^{(j)}$ë, ʂë/												
☞ C^{j}i, ʂi							*	*	*			
C^{j}u, ʂu			*W				*	*	L			(*)
C^{j}a, ʂa	(*W)		*W	(*W)			L		*			
C^{j}ə, ʂə			*W		(*)		*	L	*		*	
vii. /C$^{(j)}$e/												
☞ C^{j}i							*	*				
C^{j}u			*W				*	*				*
C^{j}a	(*W)		*W	*W			L					
C^{j}ə			*W		*		*	L			*	

First, (114i–iii) address the cases in which back vowels are preceded by non-palatal(ized)[32] consonants. When the syllable concerned immediately precedes a stressed syllable, as seen in (114i), [a] does not violate *NonMoraicNonhigh, so [o] is eliminated by *UnstrMid. Since [u, ə] violates Max (low), which is ranked higher than Max (high), or Max (dorsal) violated by [a], [a] is selected as the optimal output. In the other unstressed syllables, as shown in (114ii), [a] is eliminated by *NonpretonicNonhigh. [u] is defeated by [ə] due to dominance of the markedness constraint over the faithfulness constraints Max (high) and Max (dorsal). The change in height of /u/ is eliminated by Max (high)/u, as indicated by (114iii). Next, (114iv–vi) address the cases in which back vowels are preceded by a palatal(ized) consonant. As can

[32] Retroflex consonants are included except when /ë/ follows as shown in (114vi).

be seen in (114iv), /a/ emerges as [i] regardless of whether a stressed syllable immediately follows, because [a] or [ə] is eliminated by the relevant AGREE-type constraints. In contrast, as shown in (114v), /u/ avoids fronting (or assimilation) because the AGREE-type constraint on unstressed [u] is dominated by MAX (dorsal). Since this type of markedness constraint does not target retroflex consonants, /a/ following retroflexes does not emerge as [i], but as [a] or [ə], likewise in (114i, ii). /ë/, in contrast, still emerges as [i] even if it follows retroflexes, because non-front vowels are eliminated by MAX (coronal), as (114vi) demonstrates. Finally, as seen in (114vii), front vowels merge into [i] due to MAX (coronal).

This subsection has provided an analysis of vowel reduction in Slavic languages. The basic mechanism of this alternation is that unstressed mid or non-high vowels are eliminated by the markedness constraints (see 68 and 69 in §4.1.2) dominating the faithfulness constraints on vowel height (see 70 in §4.1.2). While vowels change in height, vowel backness tends to be preserved, which is guaranteed by the relevant faithfulness constraint (see 65 in §4.1.2 and 105 in this subsection). Bulgarian is a typical case of this pattern, as demonstrated in (106). In contrast, vowel backness can be affected by preceding consonants in Russian, where these patterns should be divided into the assimilation of unstressed [a] to the preceding palatal(ized) consonants, accounted for by the AGREE-type constraints (110), and the alternation of the specific mid vowel underlyingly specified for both [dorsal] and [coronal].

4.2.3. Interim summary

This section showed an analysis conducted for the phonologically predictable alternations in Slavic languages. As demonstrated above, these patterns can be accounted for by assuming certain constraint hierarchies. The following two sections, in contrast, will consider variable sound alternations.

4.3. Analysis of lexically specific phonological alternations

This section addresses sound alternations that are not completely phonologically predictable, but still phonologically productive in that the pattern can be extended within the lexicon. As noted in §4.1.3, such processes should be accounted for by assuming lexical stratification.

This section begins with an analysis of two cases: §4.3.1 focuses on vowel raising in Polish, and §4.3.2 sheds light on vowel–zero alternation, which is widely observed among Slavic languages. Afterwards, §4.3.3. discusses loanword phonology, which is distinct from native phonology. Finally, §4.3.4 summarizes the discussion.

4.3.1. Vowel raising in Polish

This subsection analyzes the Polish vowel raising outlined in §2.3.2. This process is conditioned by closed syllables, which can be formalized as the constraint on [o] in this position as assumed in §4.1.2 (see 77a).

Another phonological tendency of this alternation involves the voicing of following consonants. As noted in §2.3.2, the alternation is more likely to occur before voiced or sonorant consonants than before voiceless ones. This generalization, however, cannot be simply formalized in terms of OT due to devoicing of the following voiced obstruents where the raising occurs, i.e., in closed syllables. In other words, as shown in (115), the underlying difference is neutralized in the position concerned.

(115) Voicing neutralization in closed syllables

ko**z**-a	'goat'	ku**s**	(gen.pl.)
ko**s**-a	'scythe'	ko**s**	(gen.pl.)

To account for this Opacity, I propose a kind of Turbid Representation introduced in §3.2.2. That is, underlying [+voice] should still be referred to by a certain markedness constraint even if it is deleted. I assume the following constraint on [o] preceding codas with underlying [+voice]:

(116) *o/_<[+voice]>)$_{\sigma}$:
Assign a violation mark for each [o] preceding <[+voice]> in closed syllables.
i.e., "No [o] preceding consonants specified for [+voice] in the input in closed syllables regardless of whether the [+voice] is realized in the output."

This constraint along with that on pre-sonorant [o] (*o/_[sonorant])$_{\sigma}$) should be ranked higher than the general constraint on [o] in closed syllables (*o/_C)$_{\sigma}$: see 77a in §4.1.2).

As noted in §2.3.2, the alternation is also observed when underlyingly voiceless consonants follow, but not when nasal consonants follow. Two points should be suggested from this observation. First, nasal consonants must not be specified for [+voice], though

phonetically voiced. Second, the alternation can occur when phonetically voiceless consonants follow regardless of whether they are underlyingly voiced. In OT terms, the constraint on [o] preceding voiceless consonants in closed syllables (117a) dominates that the constraint on [o] preceding nasal consonants (117b). Thus, the ranking of the markedness constraints is summarized as (118).

(117) Contraints on [o] in closed syllalbles (added)
  a. *o/_[−voice])$_\sigma$:
     Assign a violation mark for each [o] preceding [−voice] in closed syllables.
  b. *o/_[nasal])$_\sigma$:
     Assign a violation mark for each [o] preceding [nasal] in closed syllables.

(118) *o/_<[+voice]>)$_\sigma$, *o/_[sonorant])$_\sigma$ >> *o/_[−voice])$_\sigma$ >> *o/_[nasal])$_\sigma$

What should be considered next is the exceptionality of this process. As noted in §2.3.2, while many phonological exceptions are observed, this process extends to several loanwords, which suggests its productivity. As reviewed in §3.3.3, lexical stratification (Ito and Mester 1995) is valid for this type of lexical idiosyncrasy. I assume the lexical strata in accordance with the occurrence of the alternation in each phonological context, as given in Table 25. This suggests that many native words belong to LS2, while loanwords are initially adapted into LS1, where several native words are also found. In the course of loanword adaptation, items can move to LS2. In a similar manner, native words can move to LS3, though this process is not yet widespread. Note that other lexical strata (LS4–8) are theoretically possible, though unattested.

Lexical stratum	Following consonants (underlying)			Examples
	Voiced/Sonorant	Voiceless	Nasal	
LS1	×	×	×	xudoba ‘poverty’
LS2	✓	×	×	koza ‘goat’ vs. kosa ‘scythe’
LS3	✓	✓	×	robota ‘labor’
LS4	✓	✓	✓	(Unattested)
LS5	×	✓	×	(Unattested)
LS6	✓	×	✓	(Unattested)
LS7	×	✓	✓	(Unattested)
LS8	×	×	✓	(Unattested)

Table 25 Lexical stratification in accordance with the vowel raising patterns

This lexical stratification can be formalized as that in Table 26 in terms of the activity of the relevant markedness constraints (ON denotes that the markedness constraint concerned dominates the relevant faithfulness constraint, and OFF donotes the reversed ranking).

	*o/_<[+voice]>)$_\sigma$, *o/_[sonorant])$_\sigma$	*o/_[−voice])$_\sigma$	*o/_[nasal])$_\sigma$
LS1	OFF	OFF	OFF
LS2	**ON**	OFF	OFF
LS3	**ON**	**ON**	OFF
LS4	**ON**	**ON**	**ON**
LS5	OFF	**ON**	OFF
LS6	**ON**	OFF	**ON**
LS7	OFF	**ON**	**ON**
LS8	OFF	OFF	**ON**

Table 26 Phonological lexicon in terms of the constraint on [o] in closed syllalbles

By looking at the attested patterns, we can deduce the following implicature: *o/_<[+voice]>)$_\sigma$ and *o/_[sonorant])$_\sigma$ are active if *o/_[−voice])$_\sigma$ is also active. Given that this implication is

consistent with the ranking in (118), only the faithfulness constraint must be indexed to each lexical stratum. The full constraint ranking is thus summarized as below (cf. 78i in §4.1.2):

(119) full constraint ranking
MAX**LS1** (low) >>
*o/_<[+voice]>)$_{\sigma}$,
*o/_[sonorant])$_{\sigma}$ >>
MAX**LS2** (low) >>
*o/_[−voice])$_{\sigma}$ >>
MAX**LS3** (low) >>
*o/_[nasal])$_{\sigma}$ >>
(MAX**LS4** (low))

LS4 is also theoretically possible in the current analysis: some lexical items in which /o/ precedes nasal consonants can undergo the alternation. By contrast, LS5–8 contradict the constraint ranking in (118) and are theoretically eliminated.

(120) demonstrates how the current grammar correctly predicts the given patterns. First, as seen in (120i), the raising is eliminated by the faithfulness constraint for morphemes indexed to LS1 regardless of which consonants follow, because MAX$_{LS1}$ (low) dominates all the markedness constraints on [o] in closed syllables. For morphemes indexed to LS2, in contrast, the faithfulness constraint (MAX$_{LS2}$ (low)) is dominated by the constraint *o/_<[+voice]>)$_{\sigma}$ (116). Raising before underlyingly voiced (and sonorant) consonants is thus preferred to the emergence of [o], which violates this constraint, as shown in (120ii). Raising is still blocked before underlyingly voiceless consonants, as (120iii) indicates. Finally, as can be seen in (120iv), raising occurs when voiceless consonants follow in morphemes indexed to LS3 because the faithfulness constraint (MAX$_{LS3}$ (low)) is dominated by *o/_[−voice])$_{\sigma}$ (117a).

(120) Ranking arguments

i. /xudob$_{LS1}$/ → [xudop] 'poverty (gen.pl.)'
ii. /koz$_{LS2}$/ → [kus] 'goat (gen.pl.)'
iii. /kos$_{LS2}$/ → [kos] 'scythe (gen.pl.)'
iv. /robot$_{LS3}$/ → [robut] 'labor (gen.pl.)'

	MAX$_{LS1}$ (low)	*o/_<[+voi]>)$_{\sigma}$	MAX$_{LS2}$ (low)	*o/_[−voi])$_{\sigma}$	MAX$_{LS3}$ (low)
i. /xudob$_{LS1}$/					
xudop		*			
xudup	*W	L			
ii. /koz$_{LS2}$/					
kos		*W	L		
☞ kus			*		
iii. /kos$_{LS2}$/					
☞ kos				*	
kus			*W	L	
iv. /robot$_{LS3}$/					
robot				*W	L
robut					*

This grammar can correctly eliminate LS4 patterns by making the ranking of the markedness constraints fixed (this is omitted in the tableaux). The current result is consistent with Ito and Mester's (1999, 2001) claim that markedness constraints should not be lexically indexed, contrary to the claims of Pater (2007, 2010) or Gouskova (2012).

Another thing to be considered is that regardless of the lexical properties, as noted in §2.3.2, this alternation is blocked when a diminutive affix /-ek/ follows. Because the affix-initial vowel is deleted in most inflected forms, paradigm uniformity (PU) can be assumed to be relevant to this process. As introduced in §3.3.2, PU is accounted for in the OT framework by treating whole paradigms as candidates. The constraint on paradigms regarding vowel raising can be assumed as (121):

(121) PU (low):
Assign a violation mark if a form within a paradigm is different from another in specification for [low] on a segment.

Note that I tentatively assume that this constraint is categorically violated: the seriousness of the violation remains uniform regardless of the number of forms that undergo or resist the alternation concerned. If this constraint dominates the faithfulness constraints for the strata in which raising is attested, as demonstrated in (122), [u] emerges in all inflected forms of the diminutives.

(122) Ranking arguments
i. /voz$_{LS2}$-ek/ → <[vuzek], [vusku],...> 'wagon (dim.)'
cf.
ii. /krok$_{LS2}$-ek/ → <[krotʂek], [krotʂku],...> 'step (dim.)'

	PU (low)	*o/_<[+voi]>)$_\sigma$	MAX$_{LS2}$ (low)	*o/_C)$_\sigma$
i. /voz$_{LS2}$-ek-/				
<vozek, vosku,...>		*12W[33]	L	*12
<vozek, vusku,...>	*W		*12L	
☞ <vuzek, vusku,...>			*14	
ii. /krok$_{LS2}$-ek-/				
☞ <krotʂek, krotʂku,...>				*12
<krotʂek, krutʂku,...>	*W		*12	L
<krutʂek, krutʂku,...>			*14W	L

First, as can be seen in (122i), raising before underlying voiced consonants cannot be avoided for LS2 morphemes when the initial vowel of the following affix is deleted, because the markedness constraint (*o/_<[+voice]>)$_\sigma$) dominates MAX$_{LS2}$ (low) (see also 120). Preservation of [o] in the presence of the following vowel is defeated by the raising across the whole

[33] **n* denotes *n*-time violation. There are 14 (7 cases for each of singular and plural numbers) declensional forms in Polish.

paradigm required by PU-[low], which also outranks MAX$_{LS2}$ (low). Note that non-alternating morphemes still resist this raising, as shown in (122ii), because the faithfulness constraint dominates the general markedness constraint (*o/_C)$_{\sigma}$). One thing to note is that PU is not always preserved: the alternation patterns laid out in Chapter 2 may cause inconsistency among wordforms within a paradigm. For instance, palatalization before several case/number suffixes violates PU in stem-final consonants. This suggests that the relevant constraints (e.g., AGREE) should dominate the PU constraints, e.g., PU (coronal). This issue will be discussed again in the next subsection.

4.3.2. Vowel–zero alternation

As discussed in §4.1.2, vowel–zero alternation is formalized as follows: the markedness constraint on vowels preceding another vowel is ranked higher than the faithfulness constraint on deletion of the alternating vowel. However, as noted in §2.3.4, this phonological generalization is insufficient to completely account for the given phenomena due to lexical exceptions.

While whether vowel–zero alternation occurs is lexically determined, this process is phonologically productive to such extent that its range of application extends within the lexicon. As overviewed in §2.3.4, this alternation is not fully predictable in terms of etymology: the occurrence in an etymologically indentical word can vary from language to language (see 31).

Moreover, the alternation is also observed in several loanwords in many langauges (see 30). These facts suggest that the deletion process should not be attributed to a certain property such as speical representation specific to several lexical items, but accounted for by lexical stratification. In the same manner as in the last subsection, the following lexical strata can be assumed.

Lexical stratum	Vowel–zero alternation	Examples (Russian)
LS1	×	palʲot ‘flight’
LS2	✓	lʲot ‘ice’

Table 27 Lexical stratification in accordance with the vowel–zero alternation patterns

To predict these patterns, the faithfulness constraint(s) on deletion indexed to LS1 should be ranked higher than the markedenss constraint (72) (see §4.1.2). The ranking for Russian is exemplified in (123).

(123) The full ranking relevant to vowel–zero alternation (e.g., Russian: cf. 76a)
MAX-a, MAX-i, MAX-i, MAX-u, MAX$_{\mathbf{LS1}}$-o, MAX$_{\mathbf{LS1}}$-e >> *V/…V
>> MAX$_{\mathbf{LS2}}$-o, MAX$_{\mathbf{LS2}}$-e

Let us see how the current grammar works (vowel reduction is not considered below).

(124) The ranking argument for vowel–zero alternation

i. /l^{j}**o**d$_{LS2}$-a/ → [l^{j}da] ‘ice (gen.sg.)’
ii. /d^{j}**e**n^{j}$_{LS2}$-i/ → [dn^{j}i] ‘day (nom.pl.)’
iii. /urov^{j}**e**n^{j}$_{LS2}$-a/ → [urovn^{j}a] ‘level (gen.sg.)’
iv. /**ro**d$_{LS1}$-a/ → [**ro**da] ‘kin (gen.sg.)’
v. /t^{j}**e**n^{j}$_{LS1}$-i/ → [t^{j}en^{j}i] ‘shadow (gen.sg.)’
vi. /s**a**d-a/ → [s**a**da] ‘garden (gen.sg.)’

	MAX-V/ NONFINAL	MAX-a	MAX$_{LS1}$-o	MAX$_{LS1}$-e	*V/…V	MAX$_{LS2}$-o	MAX$_{LS2}$-e
i. /l^{j}od$_{LS2}$-a/							
l^{j}oda					*W	L	
l^{j}da						*	
ii. /d^{j}en^{j}$_{LS2}$-i/							
d^{j}en^{j}i					*W		L
dn^{j}i							*
iii. /urov^{j}en^{j}$_{LS2}$-a/							
urov^{j}en^{j}a					*W		L
urovn^{j}a							*
urv^{j}en^{j}a	*W					*	
iv. /rod$_{LS1}$-a/							
roda					*		
rda			*W		L		
v. /t^{j}en^{j}$_{LS1}$-i/							
t^{j}en^{j}i					*		
tn^{j}i				*W	L		
vi. /sad-a/							
sada					*		
zda		*W			L		

First, as seen in (124i, ii), vowel deletion violates only the faithfulness constraint (MAX$_{LS2}$-o or MAX$_{LS2}$-e) outranked by *V/…V for morphemes indexed to LS2. These morphemes thus undergo the deletion. Note that non-initial vowels cannot be deleted due to MAX-V/NONFINAL, as shown in (124iii) (see also 75). In contrast, as seen in (124iv, v), the vowel deletion is eliminated by the faithfulness constraint on LS1 morphemes (MAX$_{LS1}$-o or MAX$_{LS1}$-e). Finally, as indicated by (124vi), the deletion of vowels other than /o, e/ is blocked regardless of which

stratum given morphemes are affiliated with because the faithfulness constraints on these vowels (e.g., MAX-a) dominate *V/…V. As for the variation among Slavic languages, see Appendix 4.

While the vowel–zero alternation is lexically conditioned, as laid out in §2.3.4, some phonological or morpho-phonological factors are relevant to this process. First of all, deletion is blocked if unacceptable consonant clusters would emerge otherwise. This suggests that the markedness constraints on such clusters assumed tentatively as in (125) should be ranked higher than *V/…V.

(125) *COMPLEX:
"Assign a violation mark for each complex consonant cluster."

An example from Russian is demonstrated in (126), in which the cluster [bvʲj] is avoided.

(126) Phonological blocking of vowl-zero alternation
i. /lʲubovʲ$_{LS2}$-ju/ → [lʲubovʲju] 'love (inst.sg.)'
cf.
ii. /lʲubovʲ$_{LS2}$-i/ → [lʲubvʲi] 'love (gen.sg.)'

	*COMPLEX	*V/…V	MAX$_{LS2}$-o
i. /lʲubovʲ$_{LS2}$-ju/			
lʲubovʲju		*	
lʲubvʲju	*W	L	*
ii. /lʲubovʲ$_{LS2}$-i/			
lʲubovʲi		*W	L
lʲubvʲi			*

Another blocking factor is, as mentioned in §2.3.4, the following of another alternating vowel: the vowel deletion does not occur if the following vowel undergoes deletion. As briefly noted earlier, this situation can be conditioned by preservation of Paradigm Uniformity: the

wordform concerned assimilates to the forms in which the deletion is blocked in the absence of the affix-initial vowel. As assumed for raising in Polish in §4.3.1 (see 121), the following constraint can thus be assumed:

(127) PU-V:
Assign a violation mark if a form within a paradigm is different from another in the presence of a vowel.

This constraint, however, turns out to be insufficient to account for the derivation patterns. If (127) dominated the markedness constraint conditioning the vowel–zero alternation (*V/…V), the alternation of the vowel in the diminutive affix would also be blocked. As seen in (128), PU-V eliminates not only the alternation of the root-final vowel, but also that of the affix vowel.

(128) Failure of prediction regarding PU
e.g., /dʲenʲ$_{LS2}$-ok$_{LS2}$/[34] → <[dʲenʲok], [dʲenʲka],...> 'day (dim.)' (Russian)

	PU-V	*V/…V
i. /dʲenʲ$_{LS2}$-ok$_{LS2}$-/		
☠<[dʲenʲok], [dʲenʲoka],...>	L	*22W
<[dnʲok], [dʲenʲka],...>	**W	*10L
💣<[dʲenʲok], [dʲenʲka],...>	*	*12

One resolution is to restrict the PU constraint so that it could refer exclusively to *non-final* vowels. I thus assume the following constraint:

(129) PU-V/non-final:
Assign a violation mark if a form within a paradigm is different from another in the presence of a non-final vowel.

[34] There are 12 forms: 6 cases (nom., gen., dat., acc., inst. and loc.) * 2 numbers (sg. and pl.). The case/number suffix is zero in two forms (nom.sg. and acc. sg.). Constraint violation for suffix-internal vowels is not considered in the following tableaux.

This constraint should dominate *V/…V to block the vowel–zero alternation within roots, while (127) is outranked by *V/…V to correctly predict the alternation of the affix vowel. See (130) for the ranking arguments.

(130) Ranking arguments (Russian)
i. /vo$_{LS2}$-ʂol$_{LS2}$-/[35] → <[vaʂol], [vaʂla],...> 'enter (pp.)'
cf.
ii. /vo$_{LS2}$-rot$_{LS2}$/ → [vrot] 'into mouth'
iii. /vo$_{LS2}$-rot$_{LS2}$-u/ → [vartu] 'in mouth'

	*COMPLEX	PU-V /non-final	*V/…V	PU-V	MAX$_{LS2}$-o	MAX$_{LS2}$-e
i. /vo$_{LS2}$-ʂol$_{LS2}$-/						
<[vaʂol], [vaʂola],...>			*7W	L	L	
<[fʂol], [vaʂla],...>		*W	*3L	**	*4	*
☞ <[vaʂol], [vaʂla],...>			*4	*	*3	
ii. /vo$_{LS2}$-rot$_{LS2}$/						
varot			*W		L	
☞ vrot					*	
iii. /vo$_{LS2}$-rot$_{LS2}$-u/						
☞ vartu			*			
vrtu	*W		L		*	

As seen in (130i), vowel–zero alternation of the prefix vowel is eliminated by the constraint (129), whereas the vowel in the verbal stem, which is not targeted by (129), can be deleted due to *V/…V. In contrast, as mentioned in §2.3.4, vowels in prepositions undergo the alternation even if another alternating morpheme follows. The current OT grammar correctly predicts this pattern. Consider that prepositions do not involve any inflectional paradigms, which are not

[35] There are four conjugational forms (masc.sg., fem.sg., neut.sg., and pl.), one of which ends in a consonant (masc.sg.).

referred to by PU constraints. Hence, as demonstrated in (130ii, iii), whether the vowel emerges by other relevant constraints. As noted in in §2.3.4, however, prefixes do undergo the vowel–zero alternation in Polish while nominal stems avoid it. This situation reminds us of cross-linguistically observed morpho-phonological effects: affixes are more likely to undergo phonological processes than roots or stems (Beckman 1997 among others). I thus assume the following constraint, which involves positional faithfulness.

(131) PU-V/stem:
Assign a violation mark if a form within a paradigm is different from another in the presence of a vowel <u>that is an exponent of stems</u>.

This constraint should dominate *V/…V in Polish, while (129) not. The difference between Russian and Polish is demonstrated below:

(132) Ranking arguments (Russian)
i. /dʲenʲ$_{LS2}$-ok$_{LS2}$-/ → <[dʲenʲok], [dʲenʲka],...> 'day (dim.)'
ii. /vo$_{LS2}$-ʂol$_{LS2}$-/ → <[vaʂol], [vaʂla],...> 'enter (pp.)'

	PU-V /non-final	*V/…V	PU-V	MAX$_{LS2}$-o	MAX$_{LS2}$-e
i. /dʲenʲ$_{LS2}$-ok$_{LS2}$-/					
<[dʲenʲok], [dʲenʲoka],...>		*22W	L	L	
<[dnʲok], [dʲenʲka],...>	*W	*10L	**	*10	*
☞ <[dʲenʲok], [dʲenʲka],...>		*12	*	*10	
ii. /vo$_{LS2}$-ʂol$_{LS2}$-/					
<[vaʂol], [vaʂola],...>		*7W	L		
<[fʂol], [vaʂla],...>	*W	*3L	**	*4	
☞ <[vaʂol], [vaʂla],...>		*4	*	*3	

(133) Ranking arguments (Polish)

i. /pʲesLS2-ekLS2-/[36] → <[pʲesek], [pʲeska],...> 'dog (dim.)'

ii. /veLS2-ʂedLS2-w-/[37] → <[fʂedw], [veʂwa],...> 'enter (pp.)'

	PU-V /stem	*V/…V	PU-V /non-final	PU-V	MAXLS2-e
i. /pʲesLS2-ekLS2-/					
<[pʲesek], [pʲeseka],...>		*27W		L	L
<[psek], [pʲeska],...>	*W	*13L	*	**	*14
☞ <[pʲesek], [pʲeska],...>		*14		*	*13
ii. /veLS2-ʂedLS2-w-/					
<[veʂedw], [veʂedwa],...>		*13W	L	L	L
☞ <[fʂedw], [veʂwa],...>		*6	*	**	*7
<[veʂedw], [veʂwa],...>		*7W	L	*L	*6

This subsection has analyzed the vowel–zero alternation in Slavic languages. As has been discussed thus far, the lexical idiosyncracy is accounted for by assuming the ranking between lexically-indexed faithfulness constraints on certain vowels and the markedness constraint on prevocalic vowels (*V/…V). In addition, we have seen that the alternation may be blocked by the constraint on disfavored consonant clusters (*COMPLEX) or the PU constraints.

4.3.3. Loanword phonology

As can be seen in Chapter 2, phonological patterns in loanwords can be differentiated from those in native words (Ito and Mester 1995, 1999, 2001). However, the occurrence of specific patterns is not consistent among loanwords: variations are observed both among words and/or

[36] There are 14 forms: 7 cases (nom., gen., dat., acc., inst., loc. and voc.) * 2 numbers (sg. and pl.). The case/number suffix is zero in one form (nom.sg.).

[37] There are 7 forms (masc.sg., fem.sg., neut.sg., masc.human.pl., masc.non-human.pl., fem.pl. and neut.pl.), one of which ends in a consonant (masc.sg.).

speakers. For this reason, loanwords have also been considered to form a dedicated lexical stratum in which some phonological processes are blocked by specific faithfulness constraints (Ito and Mester 1999, 2001).

Let us begin by extending the current analysis of the variable patterns that have been addressed so far in this section to loanword phonology. The basic concept is quite simple: loanwords are originally affiliated with the stratum in which the given alternation is unattested. More concretely, most loanwords belong to "LS1" in terms of the alternations discussed in the previous subsections. As in native phonology, however, the boundaries among the lexical strata are unstable, which means that loanwords can also undergo the given phonological processes.

An interesting feature of loanword phonology is that some generalizations hidden in native phonology come to be transparent. In Russian, for instance, while all consonants preceding /e/ and /i/ are palatalized in native words, palatalization may be absent before /e/ in loanwords. This pattern is consistent with the cross-linguistic tendency for palatalization to be more likely to occur before [i] than before [e], which is formalized as the fixed ranking of the relevant markedness constraints (see 81c in §4.2.1). In addition, the palatalization avoidance varies with the place of articulation of consonants. As mentioned in §2.2.2, coronals are much more likely to resist palatalization than the other consonants.

The palatalization avoidance and the discussed patterns cannot be generalized on the basis of etymology alone. Given the discussion so far, I suggest that the Russian phonological

lexicon should be stratified in accordance with the occurrence of palatalization. Thus, I assume LS1, in which palatalization of coronal consonants is unattested and LS2, in which palatalization occurs without exception. In OT terms, the AGREE constraints on velars or labials (80a, c) dominate the relevant faithfulness constraint, and the AGREE constraint on coronals (80b) should be dominated by an LS1-specific faithfulness constraint, such as (134).

(134) DEP_{LS1}-C (coronal) (cf. 66 in §4.1.2):
Assign a violation mark for each feature [coronal] on a consonant that is absent in the input affiliated with LS1 and present in the output .

(135) demonstrates the ranking arguments (cf. 87a in §4.2.1).

(135) Palatalization avoidance in Russian loanwords
i. /te_{LS1}/ → [te] e.g., /$\text{antena}_{\text{LS1}}$/ → [antenə] 'antenna'
ii. /pe_{LS1}/ → [p^{j}e] e.g., /$\text{inspektsija}_{\text{LS1}}$/ → [$\text{insp}^{\text{j}}$ektsijə] 'inspection'
iii. /ke_{LS1}/ → [k^{j}e] e.g., /$\text{buket}_{\text{LS1}}$/ → [$\text{buk}^{\text{j}}$et] 'bouquet'

	AGREE-K/_e (place)	AGREE-P/_e (place)	DEP_{LS1}-C (coronal)	AGREE-T/_e (place)
i. /te_{LS1}/				
☞ te				*
t^{j}e			*W	L
ii. /pe_{LS1}/				
pe		*W	L	
☞ p^{j}e			*	
iii. /ke_{LS1}/				
ke	*W		L	
☞ k^{j}e			*	

First, as can be seen in (135i), the palatalization of coronal consonants is eliminated by DEP_{LS1}-C (coronal) being ranked higher than the relevant markedness constraint. In contrast, as shown

in (135ii, iii), palatalization of labial and velar consonants defeats avoidance because DEP$_{LS1}$-C (coronal) is dominated by the markedness constraints.

Although much less frequent than coronals, non-palatalized labial consonants are still attested. This can be formalized by assuming that *loanword* stratum is divided into two types: "assimilated" and "non-assimilated" loans (Ito and Mester 1999). Palatalization resistance in velars, in contrast, is almost unattested, although recent studies have documented several examples of this pattern. Note that, as mentioned in §2.2.2, the vowel concerned originates from English [æ] in most cases. Since this vowel is lower than the normal [e] in Russian, these vowels can be differentiated from each other in the underlying forms. In §4.2.1, I argued that *non-palatalizing* /e/ (/ɛ/) in Polish lacks [high], resulting in the absence of palatalization due to the faithfulness constraint, DEP (high). English [æ] can also be regarded as the same type of vowel, which is specified only for [low] in the underlying form. The palatalization avoidance can thus be accounted for by assuming that DEP (high) dominates AGREE-K/_e (place) in Russian. See (136) for the ranking argument.

(136) /æ/ in Russian loanwords from English: /kæ/ → [ke] (e.g., /kæt/ → [ket] 'cat boat')

/kæ/	DEP (high)	AGREE-K/_e (place)
☞ ke		*
kʲe	*W	L

Note that this analysis has in fact nothing to do with which stratum a given morpheme is affiliated with.

This subsection has considered loanword phonology, which may be distinguished from native phonology in various ways. As we have seen thus far, loanword-specific patterns can be accounted for by lexical stratification. While loanwords tend to avoid phonological processes, they may come to undergo some alternations, which suggests that boundaries among lexical strata are variable regardless of etymology. Moreover, loanword phonology also shows certain phonological tendencies, which are generalized as the rankings of relevant markedness constraints.

4.4. Analysis of lexically specific alternation

Other types of alternations to be considered are phonologically *non-productive* and lexically specific processes. In the following subsections, three cases from Slavic languages will be discussed in turn. First, §4.4.1 examines coronalization and morpheme-specific palatalizations triggered by certain morphemes, a clearly separate process from the phonological palatalization discussed in §4.2.1. Next, §4.4.2 examines vowel backness alternations in Polish, and §4.4.3 discusses vowel length alternations in Czech, both of which are restricted to certain morphemes.

4.4.1. Morpho-phonological palatalizations

As laid out in §2.2.3, the type of velar palatalization (i.e., coronalization or secondary palatalization) that occurs is determined by triggering morphemes in some languages. What

should be considered is that coronalization can also be attested in languages where phonological palatalization is completely absent. On the other hand, obligatory palatalization before *non-palatalizing* front vowels in Russian and Polish is only secondary. These facts thus suggest that coronalization is conditioned primarily by certain lexically specific properties.

In OT terms, this process should not be accounted for by phonological markedness constraints such as AGREE, but by lexically specific constraints. Note that lexical stratification is inappropriate in this case: coronalization is triggered by certain morphemes without variation. On the other hand, this process is not extended to other morphemes, unlike the alternations discussed in the last section. What is required is, therefore, a constraint exclusively targeting several morphemes. I assume here a kind of Generalized Alignment constraint (McCarthy and Prince 1993) such as (137).

(137) ALIGN ([coronal]$_{PAL}$, L, σ, L) (ALIGN-coronal):
"For every feature [coronal] on morphemes indexed as PAL,[38] its left edge must coincide with the left edge of a syllable."

A similar constraint was assumed by Zubritskaya (1995) or Takatori (1997), which was active regardless of the lexical properties.[39] This constraint should dominate the relevant faithfulness constraints (see also 66 and 91) as shown below:

[38] This indexation is not *phonological*, but lexically assigned to morphemes causing the preceding consonants to undergo primary palatalization. For the sake of simplicity, I utilize this index as *PAL*.
[39] Rubach (2000) criticized this general constraint for the failure of some palatalization patterns. By contrast, the current analysis assumes that the constraint is exclusive on certain morphemes. This assumption does not contradict the aforementioned discussion of *purely phonologial* palatalization.

(138) Coronalization: ranking argument

i. /k-i$_{PAL}$/ → [ʧi] e.g., /znak-i$_{PAL}$-tʲ/ → [znaʧitʲ] ‘to signify’ (Russian)

ii. /k-e$_{PAL}$/ → [ʧe] e.g., /pek-e$_{PAL}$/ → [peʧe] ‘bake (3sg)’ (Czech)

	ALIGN-coronal	MAX (dorsal)	DEP-C (coronal)
i. /k-i$_{PAL}$/			
ki	*W*	L	L
kʲi	*W	L	*
☞ ʧi		*	*
ii. /k-e$_{PAL}$/			
ke	*W*	L	L
kʲe	*W	L	*
☞ ʧe		*	*

Note that this prediction does not depend on whether DEP-C (coronal) dominates the AGREE-type constraints (cf. §4.2.1). This implies that coronalization is conditioned by front vowels in certain morphemes regardless of whether palatalization is generally triggered by front vowels in that language. This is consistent with the empirical facts.

Another factor to consider is that the choice of consonant that emerges in this pattern varies from language to language: either palatoalveolars or retroflexes are observed, as summarized below (cf. §2.2.1, §2.2.3).

	palatoalveolars	retroflexes
Russian	k→ʧ	g→ʐ; x→ʂ
Polish, Serbo–Croatian	n/a	k→ʈʂ; g→ʐ; x→ʂ
Bulgarian	k→ʧ; g→ʒ; x→ʃ	n/a
Czech	k→ʧ; ɦ→ʒ; x→ʃ	n/a

Table 28 Variation in coronalization among Slavic languages.

Needless to say, these variations should be formalized as the differences in the rankings of the relevant markedness constraints, as shown below:

(139) Markedness hierarchy of prepalatal consonants

a. Russian:[40] *t͡ɕ, *ʃ, *ʒ >> *t͡ʃ, *ɕ, *ʑ
b. Polish, Serbo–Croatian: *t͡ʃ, *ʃ, *ʒ >> *t͡ɕ, *ɕ, *ʑ
c. Czech, Bulgarian: *t͡ɕ, *ɕ, *ʑ >> *t͡ʃ, *ʃ, *ʒ

Note that /g/ undergoes spirantization, emerging as a fricative consonant. Since voiced palatoalveolar or retroflex affricates are almost unattested in Slavic languages,[41] the following constraint ranking should be fixed:

(140) *d͡ʑ >> MAX (−continuant)

Apart from when [d͡ʑ] emerges, the faithfulness constraint on [±continuant] cannot be violated.

The palatalization of several coronal consonants in Czech can be accounted for in the same manner as coronalization. What should be considered is that coronal palatalization has a different range of application from velar palatalization. As noted in §2.2.2 (see 9b), some morphemes trigger palatalization exclusively on velar consonants. For this reason, palatalizing morphemes should be classified into two types, and the alignment constraint should be split as assumed in (141). I tentatively assume here that *PAL1* morphemes trigger both velar and coronal palatalizations, whereas *PAL2* ones trigger only velar palatalizations, as shown below:

[40] A voiceless alveopalatal fricative is also attested in this language but only as long (i.e., [ɕː]: see §2.1.1). This consonant is avoided in coronalization probably because of its long articulation, which violates a certain faithfulness constraint on the change in consonantal duration. This issue remains open to discussion.

[41] As noted in §2.1, this consonant emerges as a result of voicing assimilation, which should be accounted for by other constraints.

(141) Constraints on 'palatalizing' morphemes in Czech

a. ALIGN ([coronal]$_{PAL1}$, L, σ, L) (ALIGN-coronal $_{PAL1}$):
"For every feature [coronal] on morphemes indexed as PAL1, its left edge must coincide with the left edge of a syllable."

b. ALIGN ([coronal]$_{PAL2}$, L, σ, L) (ALIGN-coronal $_{PAL2}$):
"For every feature [coronal] on morphemes indexed as PAL2, its left edge must coincide with the left edge of a syllable."

The first constraint should dominate MAX (+anterior) as well as MAX (dorsal), while the latter only MAX (dorsal). See (142) for the ranking arguments.

(142) Palatalization in Czech: ranking arguments

i. /t-i$_{PAL1}$/ → [ci] e.g., /ʧist-i$_{PAL1}$-t/ → [ʧiscit] 'to clean'
ii. /d-e$_{PAL1}$/ → [ɟe] e.g., /vod-e$_{PAL1}$/ → [voɟe] 'water (loc.sg.)'
cf.
iii. /d-e$_{PAL2}$/ → [de] e.g., /jd-e$_{PAL2}$/ → [jde] 'go (3sg)'
iv. /k-e$_{PAL2}$/ → [ʧe] e.g., /pek-e$_{PAL2}$/ → [peʧe] 'bake (3sg)'

	ALIGN-coronal$_{PAL1}$	MAX (+anterior)	ALIGN-coronal$_{PAL2}$	MAX (dorsal)
i. /t-i$_{PAL1}$/				
ti	*W*	L		
☞ ci		*		
ii. /t-e$_{PAL1}$/				
de	*W*	L		
☞ ɟe		*		
ii. /d-e$_{PAL2}$/				
☞ de			**	
ɟe		*W	L	
ii. /k-e$_{PAL2}$/				
ke			*W*	L
☞ ʧe				*

Note that the analysis above did not consider the fact that some consonants never undergo palatalization, which should be accounted for by assuming markedness constraints on unattested palatal consonants, such as [ç, ʝ, ʎ], outranking the alignment constraints.

In the discussion thus far, one morpheme-specific palatalization has remained unresolved: a diminutive affix /-Vk/ triggers velar coronalization, but not palatalization of the other consonants, in Russian, Polish and Czech. Some examples are given below:

(143) Coronalization in diminutive derivation

a. Russian

base		dimimutive		
		(nom.sg.)	(gen.sg.)	(gen.pl.)
zna**k**	‘sign’	zna**ʧ**-ok	zna**ʧ**-k-a	zna**ʧ**-k-of
dru**g**-ə	‘friend (gen.sg.)’	dru**ʐ**-ok	dru**ʂ**-k-a	dru**ʂ**-k-of
ru**k**-a	‘hand’	ru**ʧ**-k-ə	ru**ʧ**-kʲ-i	ru**ʧ**-ik
mu**x**-ə	‘fly’	mu**ʂ**-k-ə	mu**ʂ**-kʲ-i	mu**ʂ**-ik
cf.				
si**n**	‘son’	si**n**-ok	si**n**-k-a	si**n**-k-of
karo**v**-ə	‘cow’	karo**f**-k-ə	karo**f**-kʲ-i	karo**v**-ək

b. Polish

base		dimimutive		
		(nom.sg.)	(gen.sg.)	(gen.pl.)
kro**k**	‘step’	kro**ʈʂ**-ek	kro**ʈʂ**-k-u	kro**ʈʂ**-k-uf
oʐe**x**	‘nut’	oʐe**ʂ**-ek	oʐe**ʂ**-k-u	oʐe**ʂ**-k-uf
ʐe**k**-a	‘river’	ʐe**ʈʂ**-k-a	ʐe**ʈʂ**-kʲ-i	ʐe**ʈʂ**-ek
no**g**-a	‘leg’	nu**ʂ**-k-a	nu**ʂ**-kʲ-i	nu**ʐ**-ek
cf.				
pʲe**s**	‘dog’	pʲe**s**-ek	pʲe**s**-k-a	pʲe**s**-k-uf
so**v**-a	‘owl’	su**f**-k-a	su**f**-kʲ-i	su**v**-ek

c. Czech

base		dimimutive		
		(nom.sg.)	(gen.sg.)	(gen.pl.)
obla**k**	‘cloud’	obla:**ʧ**-ek	obla:**ʧ**-k-u	obla:**ʧ**-k-u:
smi:**x**	‘laugh’	smi:**ʃ**-ek	smi:**ʃ**-k-u	smi:**ʃ**-k-u:
kɲi**ɦ**-a	‘book’	kɲi:**ʃ**-k-a	kɲi:**ʃ**-k-i	kɲi:**ʒ**-ek
plo**x**-a	‘space’	plo**ʃ**-k-a	plo**ʃ**-k-i	plo**ʃ**-ek
cf.				
va:**z**-a	‘vace’	va:**s**-k-a	va:**s**-k-i	va:**z**-ek
kle**p**	‘rumor’	kli:**p**-ek	kli:**p**-k-u	kli:**p**-k-u:

Since this affix affects only velar consonants, it seems to be a PAL2 morpheme in Czech. However, the ranking assumed in (142) contradicts that in Polish (see 93a in §4.2.1), in which

MAX (+anterior) is dominated by *Cʲ, which is ranked lower than MAX (dorsal) to predict secondary palatalization of velars, as shown in (144).

(144) Failure of the analysis of the diminutive derivation in Polish (cf. 93a)
i. /pʲes-ek$_{PAL2}$/ → [pʲesek] 'dog (dim.)'
ii. /krok-ek$_{PAL2}$/ → [krotʂek] 'step (dim.)'

	ALIGN-coronal$_{PAL2}$	MAX (dorsal)	*Cʲ	MAX (+anterior)
/pʲes-ek/				
💣 pʲesek	**			
☠ pʲeɕek	L			*W
/krok-ek/				
krokʲek	*W	L	*	
☞ krotʂek		*		

Another problem is that this affix triggers coronalization even if the initial vowel is non-front or completely deleted. As discussed in §4.2.1, such cases should be generalized as preservation of [coronal], which is guaranteed by MAX (coronal). This constraint, however, would be violated by non-palatalization candidates regardless of whether the given consonants are velar (see 89 in §4.2.1). These facts suggest that this palatalization pattern should not be attributed to the alignment of the underlying feature.

Interestingly, when this affix follows palatal(ized) non-velar consonants, it may trigger depalatalization of the preceding consonants, as seen in (145).

(145) Depalatalization

a. Russian

nógə**t**^{j}	‘nail’	nəga**t**-ók	**(**dim.)
gólu**b**^{j}-ə	‘dove (gen.sg.)’	gəlu**b**-ók	**(**dim.)
báʂ**n**^{j}-ə	‘tower’	báʂi**n**-k-ə	(dim.)
dv^{j}é**r**^{j}	‘door’	dv^{j}é**r**-k-ə	(dim.)
márko**v**^{j}-i	‘carrot (gen.sg.)’	markó**f**-k-ə	(dim.)
but			
agó**n**^{j}	‘fire’	aga**n**^{j}-ók	**(**dim.)
zv^{j}é**r**^{j}	‘beast’	zv^{j}i**r**^{j}-ók/zv^{j}i**r**-ók	**(**dim.)
s^{j}ir^{j}é**n**^{j}	‘lilac’	s^{j}ir^{j}é**n**^{j}-k-ə	(dim.)
za**r**^{j}-á	‘sunrise’	zó**r**^{j}-k-ə	(dim.)
n^{j}id^{j}é**l**^{j}-ə	‘week’	n^{j}id^{j}é**l**^{j}-k-ə	(dim.)

b. Polish

tɕf^{j}er**tɕ**	‘quater’	tɕf^{j}ar**t**-k-a	(dim.)
dʑe**ɲ**	‘day’	dʑo**n**-ek	(dim.)
kara**ɕ**	‘Crucian carp’	kara**s**-ek	(dim.)
gowẽ**b**^{j}-a	‘dove (gen.sg.)’	gowõ**b**-ek	(dim.)
but			
og^{j}e**ɲ**	‘fire’	og^{j}e**ɲ**-ek/og^{j}e**n**-ek	(dim.)
m^{j}i**ɕ**	‘(teddy) bear’	m^{j}i**ɕ**-ek	(dim.)

The targets of this depalatalization are consonant clusters consisting of a palatal(ized) consonant and the following [k] without the vowel in the diminutive affix. As noted in §4.2.1, this type of consonant is likely to be avoided before another consonant (see 97, 99). On the other hand, as discussed in §4.3.1 and §4.3.2, PU tends to be preserved in derivation; alternations are not conditioned by the vowel–zero alternation in the diminutive affix. We can thus assume that the depalatalization above serves to avoid disfavored consonant clusters while preserving PU. The coronalization triggered by the diminutive affix can also be accounted for in a similar manner, given that velar consonant clusters are rarely attested. I assume the following constraint on PU regarding palatality:

(146) PU (place):
Assign a violation mark if a form within a paradigm is different from another in specification for features under the place node on a segment.

If this constraint dominates the relevant faithfulness constraints, the coronalization and depalatalization above can be predicted. The ranking arguments are given in (147) (the markedness constraint on the disfavored consonant clusters is simplified as *COMPLEX here).

(147) Ranking arguments
i. Coronalization
/krok-ek-/ → <[krotʂek], [krotʂku],...> 'step (dim.)' (Polish)
ii. Depalatalization
/nogotʲ-ok-/ → <[nəgatok], [nəgatka],...> 'nail (dim.)' (Russian)

	PU (place)	*COMPLEX	MAX (place)
i. /krok-ek-/			
<krokʲek, krokku,...>		*12W	L
<krokʲek, krutʂku,...>	*W		*12L
☞ <krotʂek, krotʂku,...>			*14
ii. /nogotʲ-ok-/			
<nəgatʲok, nəgatʲka,...>		*10W	L
<nəgatʲok, nəgatka,...>	*W		*10L
☞ <nəgatok, nəgatka,...>			*12

This subsection has discussed velar coronalization and several palatalization patterns specific to certain morphological derivations. Unlike the palatalization discussed in §4.2.1, these processes are not phonologically motivated by assimilation to the following front vowels, but morphologically influenced by the following morphemes. In the OT framework, as we have seen, most cases can be accounted for by assuming alignment constraints on the feature [coronal] in the relevant morphemes. Coronalization triggered by a diminutive affix, in contrast, can be analyzed as another PU pattern.

4.4.2. Vowel backness alternations

In §2.2–§2.3, mainly two types of vowel backness alternations have been laid out. One is conditioned by following palatal consonants (or front vowels), which should be regarded as an assimilation (§2.2.4). The other is for Polish nasal vowels: the back one is observed in closed syllables, while the front one in open syllables (§2.3.2). These patterns are restricted to several lexical items and lack phonological productivity. Non-productive patterns should be attributed to lexically specific properties, i.e., specific underlying representations, as discussed in §3.1.2. I thus propose underspecification for backness (technically place features) in the alternating lexical items.

Let us begin with the assimilation to palatal consonants. The relevant constraint should be an AGREE-type constraint, as assumed in §4.1.2 (see 64). Consider that this constraint should be active exclusively on vowels, as given in (148), which is distinguished from the ones on consonants as assumed in §4.2.1 (see also 110 in §4.2.2).

(148) AGREE-V/_C (place):
Assign a violation mark for each vowel that does not agree with the following consonant in the place feature.

In contrast, the blocking constraint is the faithfulness constraint on place features assumed in the preceding discussions, i.e., MAX (dorsal) (105). This constraint should dominate (148) to eliminate the backness alternation unless the place features are unspecified. Note that it is

assumed that /a/ is specified for [dorsal] (or backness) in Polish unlike in Russian (see §4.2.2).[42] See (149) for the ranking argument.

(149) Vowel fronting triggered by palatal consonants (Polish)
i. /vivʲ**a**d-e/ → [vivʲ**a**dʑe] 'interview (loc.sg.)'
ii. /ɕfʲ**A**t-e/ → [ɕfʲ**e**tɕe] 'world (loc.sg.)'

	MAX (dorsal)	AGREE-V/_C (place)
i. /vivʲ**a**d-e/ [dorsal]		
☞ vivʲ**a**d-e [dorsal]		*
vivʲedʑe [dorsal][coronal]	*W	L
ii. /ɕfʲ**A**t-e/		
ɕfʲ**a**tɕe [coronal]		*W
☞ ɕfʲ**e**tɕe [coronal]		

First, as can be seen in (149i), fronting of the underlyingly back vowel is eliminated by MAX (dorsal), which outranks (148). In contrast, as demonstrated in (149ii), this faithfulness constraint is not violated when the vowel is underlyingly unspecified for the place feature (such vowels are denoted by capitalized letters). Hence, the emergence of a front vowel is selected

[42] The backness alternation is also observed in Bulgarian (§2.2.4). In §4.2.2, /a/ was assumed to be unspecified for the place features in this language, thus contradicting the assumption here. One possible resolution is to assume that [a] and [ə] are specified for [dorsal]. Considering that [dorsal] on vowels does not affect the adjacent consonants unlike [coronal], many examples in the literature regarded [a] as *back* (Rubach 2000, among others).

as the optimal output due to (148). One may wonder how the backness of the vowels unspecified for place feature is determined in the other contexts. Although this issue calls for further investigation, I assume for the present that back vowels are generally less marked than front ones.

The alternation of nasal vowels can be accounted for in a similar manner. The relevant markedness constraint is *ẽ/_C)$_{\sigma}$ assumed in (77b) (see §4.1.2), which should be dominated by the faithfulness constraint MAX (coronal) (65).

(150) Backness alternation of nasal vowels (Polish)
i. /mʲ**ẽ**s/ → [mʲ**ẽ**s] 'meat (gen.pl.)'
ii. /r**Ṽ**k/ → [r**õ**k] 'hand (gen.pl.)'

	MAX (coronal)	*ẽ/_C)$_{\sigma}$
i. /mʲ**ẽ**s/		
☞ mʲ**ẽ**s		*
mʲ**õ**s	*W	L
ii. /r**Ṽ**k/		
r**ẽ**k		*W
☞ r**õ**k		

This subsection has considered vowel backness alternations in Polish. From the fact that these patterns are observed exclusively in few morphemes, as discussed so far, they should be accounted for by assuming a certain lexically-specific underlying representation. I thus proposed underspecification for the place feature in the alternating vowels concerned. Next subsection deals with one more case of this sort, vowel length alternations in Czech.

4.4.3. Vowel length alternations in Czech

As outlined in §2.3.3, vowel length alternations in Czech are lexical rather than phonological: only a few nouns undergo alternation in inflection (see 26), while productive lengthening is triggered by the diminutive affix (see 27). In this sense, these alternations can be regarded as the combined effect of the two types of processes that have been discussed so far in this section. Let us begin with the nominal inflection.

First, as noted in §2.3.3, this length alternation is observed exclusively in few nouns (see Table 17). In addition to its infrequency, this process does not extend to loanwords. This suggests that this pattern is lexically specific to several nouns. One way to formalize such specificity is underspecification, as adopted in the last subsection. In this framework, the vowel length alternation can be accounted for as follows. Since vowel length is specified in most nouns, it is preserved due to a certain faithfulness constraint (see 79 in §4.1.2). However, if length is underlyingly underspecified, the alternation is motivated by constraints dominated by the faithfulness constraint.

Next, let us consider exactly what triggers the alternation. As noted earlier, this process is almost always lexically or morphologically determined. To generalize the length alternations, Scheer (2003) proposed moraic templates for the relevant morphological categories. Adopting this idea, I assume the following OT constraints on nouns.

(151) Length template constraints
   a. MASC≥2μ:
      Assign a violation mark for each masculine noun with vowels weighed less than 2 morae.
   b. NONMASC=3μ:
      Assign a violation mark for each non-masculine noun with vowels not weighed 3 morae.

These constraints prefer the patterns in which long vowels emerge in masculine nouns with the zero case/number suffix and in non-masculine nouns with a suffix including vowel. In contrast, the emergence of short vowels should be explained by another constraint; masculine nouns must have at least two morae unless the zero suffix follows, and non-masculine nouns cannot have three morae when the zero suffix follows. One possible assumption is that long vowels are generally more marked than short ones. This is supported by the facts that some long vowels are unattested in Czech (as will be discussed later), and contrasting length is absent in many languages. The following markedness constraint can thus be assumed:

(152) *$V_{\mu\mu}$:
      Assign a violation mark for each vowel with two morae (i.e., long or diphthong vowel).

This constraint should be dominated by the constraints in (151) to predict long vowels for the alternating nouns.

Now, let us consider the constraint ranking. The three constraints assumed above should be dominated by (79). In other words, these constraints are satisfied only when vowel length is underlyingly unspecified. (153) demonstrates the ranking arguments (capitalized letters stand for moraless vowels). Note that final devoicing is not shown here.

(153) Vowel length alternation in nominal declensions: ranking arguments

i. /br**a**t-ø/ → [br**a**t] 'brother (nom.sg.)'
ii. /kl**a:**d-ø/ → [kl**a:**d] 'log (gen.pl.)'
iii. /mr**A**z-ø/ → [mr**a:**z] 'frost (nom.sg.)'
iv. /mr**A**z-u/ → [mr**a**zu] 'frost (gen.sg.)'
v. /b**A**b-a/ → [b**a:**ba] 'gramma (nom.sg.)'
vi. /b**A**b-ø/ → [b**a**b] 'gramma (gen.pl.)'

	FAITH-V-μ	MASC≥2μ	NONMASC = 3μ	*$V_{\mu\mu}$
i. /br**a**t-ø/				
☞ br**a**t		*		
br**a:**t	*W	L		*
ii. /kl**a:**d-ø/				
☞ kl**a:**d			*	*
kl**a**d	*W		*	L
iii. /mr**A**z-ø/				
mr**a**z		*W		L
☞ mr**a:**z				*
iv. /mr**A**z-u/				
☞ mr**a**zu				
mr**a:**zu				*W
v. /b**A**b-a/				
☞ b**a:**ba				*
b**a**ba			*W	L
vi. /b**A**b-ø/				
b**a:**b			*	*W
☞ b**a**b			*	

First, as can be seen in (153i–ii), change in length is eliminated by FAITH-V-μ when length is specified in the inputs. Next, (153iii–vi) accounts for the cases in which vowels in nominal roots are underlyingly unspecified for length. When masculine nouns have the zero suffix, as shown in (153iii), short vowels are eliminated by MASC≥2μ. Since this constraint cannot be violated unless the zero suffix follows, short vowels are preferred over long ones in the other forms due to *$V_{\mu\mu}$, as seen in (153iv). In contrast, as demonstrated in (153v), long vowels

emerge in non-masculine nouns unless the zero suffix follows because NONMASC=3μ dominates *$V_{μμ}$. Since the former constraint cannot be satisfied when the zero suffix follows, as (153vi) indicates, long vowels are ruled out by *$V_{μμ}$.

In contrast, as mentioned in §2.3.3, vowel lengthening triggered by a diminutive affix /-ek/ is much more frequent and occurs even when the length alternation is unattested in the declension. This suggests that a certain property, e.g., a floating mora, specific to this morpheme triggers this process, which can be accounted for in the same manner as the coronalization discussed in §4.4.1. I assume the following constraint:

(154) ALIGN ($μ_{DIM}$, R, Root, R) (ALIGN-$μ_{DIM}$):
"For every mora on morphemes indexed as DIM, its right edge must coincide with the right edge of the exponent of a root."

This constraint must be ranked higher than FAITH-V-μ to predict the lengthening of underlyingly short vowels. The ranking argument is demonstrated in (155). Note that vowels unspecified for length emerge as short: linking of the mora on the affix to root vowels results in the emergence of short vowels. As can be seen in (155ii), long vowels are eliminated by *$V_{μμ}$.

(155) Vowel lengthening in diminutive derivations: ranking arguments

i. /d**a**r-ek$_{DIM}$/ → [d**a:**rek] 'gift (dim.)'

ii. /b**A**b-ek$_{DIM}$-a/ → [b**a**bka] 'gramma (dim.)'

	ALIGN-μ$_{DIM}$	FAITH-V-μ	$^{*}V_{\mu\mu}$
i. /d**a**r-ek$_{DIM}$/			
d**a**rek	*W	L	L
☞ d**a:**rek		*	*
ii. /b**A**b-ek$_{DIM}$-a/			
☞ b**a**bka			
b**a:**bka			*W

Unlike coronalization, as laid out in §2.3.3, this process shows variation. While many native nouns, especially feminine ones, fail to undergo lengthening, this pattern extends to several loanwords. This situation is similar to the alternations discussed in §4.3 and is attested among lexical items in a certain stratum. To account for this variation, therefore, the faithfulness constraint on vowel length should be lexically indexed. I leave the detailed analysis open to discussion.

One more thing to be considered about length alternation is qualitative change: some vowels avoid surfacing as long (see also §2.1.3 and §2.3.3). Needless to say, this situation can be formalized by assuming the markedness constraints on certain long vowels dominating the relevant faithfulness constraint, such as MAX (high)/MAX (low) (see 70 in §4.1.2). Since long [o] and [u] and long [e] following palatal consonants are avoided, the following constraints should be ranked higher than the faithfulness constraints.

(156) Markedness constraints on long vowels
a. *o: :
Assign a violation mark for each [o] with two morae.
b. *u: :
Assign a violation mark for each [u] with two morae.
c. *e:/[coronal, −anterior]_ (*Je:):
Assign a violation mark for each [e] with two morae following palatal consonants.

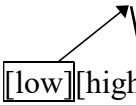
A complication is that [u:] does emerge from /o/, rather than from /u/: /u/ emerges as [ou] instead. This situation is regarded a kind of chain shift, which cannot be accounted for by output-based phonology such as standard OT. As discussed in §3.2.2, one resolution is to assume Turbid Representations, in which underlying properties can be considered even if deleted and can be distinguished from those inserted in the process of derivations. In this framework, I assume that the derivation of a diphthong [ou] from /o/ is prevented by the constraint on incomplete spreading of underlying features on the vowel concerned (i.e., [high, low, dorsal]), whereas this vowel can be derived from /u/ because the underlying features ([high, dorsal]) are spread within a syllable with [low] inserted in the first mora. The following constraint is tentatively assumed:

(157) *DIPH(THONG):
Assign a violation mark for each syllable that consists of vowels specified for multiple features that are not squared.

One more assumption to correctly predict the lengthening patterns is that place features are preserved, preventing the emergence of [a:] from any back or front vowels. This is similar to Bulgarian vowel reduction, which can be accounted for by MAX (dorsal) and MAX (coronal).

Note that MAX (dorsal) is required to dominate *u: so that [a:] would be defeated by [u:] in the derivation of /o/. The ranking arguments are demonstrated in (158).

(158) Qualitative change in vowel lengthening
i. /Co/ → [Cu:]
ii. /Cu/ → [Cou]
iii. /Je/ → [Ji:]

	*o:	*Je:	*DIPH	MAX (dorsal)	*u:	MAX (height)	MAX (coronal)
i. /Co/  [low][high]							
Co:	*W				L		
☞ Cu:					*	*	
Cou  [low][high]			*W		L		
Ca:				*W	L	*	
ii. /Cu/ [high]							
Cu:					*W		
Ca:				*W		*	
☞ Cou  [low][high]			✓				
iii. /Je/							
Je:		*W				L	
☞ Ji:						*	
Ja:						*	*W

Note that vowel quality remains unchanged in loanwords. This can be formalized by assuming a certain *loanword-specific* faithfulness constraint such as MAX_{LS1} (low), likewise in other loanword phonology patterns as discussed in §4.3.3.

This subsection has analyzed vowel length alternations in Czech. First, alternations in the declension of few nouns can be accounted for by underspecification for length. While length alternation is blocked by the relevant faithfulness constraint, the length of vowels underlyingly unspecified for length is determined by several lower-ranked constraints. In contrast, lengthening triggered by the diminutive affix should be explained by a morpheme-specific alignment constraint due to its productivity.

4.5. Summary

This chapter shows the analysis conducted for the sound alternations in the Slavic languages outlined in Chapter 2. The discussion so far is summarized as follows.

First, the phonological patterns addressed in this chapter can be formalized by a featural representation of sounds (see §4.1.1) and language-specific rankings of phonological (OT) constraints (see §4.1.2). Based on these assumptions, Section 4.2 accounted for phonologically predictable or unexceptional alternations such as palatalization (§4.2.1) and vowel reduction (§4.2.2). Next, I classified phonological exceptionality into two types according to their productivity (see §4.1.3). Section 4.3 formalized phonologically productive patterns by assuming lexical stratification and faithfulness constraints specific to each stratum. This theory was applied not only to native phonology such as vowel raising (§4.3.1) and vowel–zero alternation (§4.3.2), but also to loanword-specific patterns such as palatalization avoidance in

Russian (§4.3.3). Section 4.4, on the other hand, addressed sound alternations limited to several specific morphemes. To account for these patterns, morpheme-specific alignment constraints and underspecifications were proposed. The former approach accounted for velar coronalization or palatalization triggered by specific morphemes (§4.4.1) and vowel lengthening in the diminutive derivation (§4.4.3), while the latter accounted for vowel backness alternation (§4.4.2) and vowel length alternation (§4.4.3).

The current analysis has provided further support for the core principles of OT. First, the sound patterns concerned could be predicted by one-step or parallel derivations based on the ranked constraints. Second, some phonological processes could be generalized as the effect of an identical type of constraint(s). For instance, palatalization and vowel fronting were explained by a constraint demanding featural agreement between adjacent consonants and vowels (i.e., AGREE). In addition, faithfulness constraints turned out to be active in various alternation patterns. Finally, inter-language variations could be accounted as different rankings of the same set of constraints. For example, the AGREE-type constraints were ranked higher than the relevant faithfulness constraints in the languages where palatalization was observed, while this ranking was reversed in others.

5. CONCLUSION

This work has discussed the sound alternations in Slavic languages, with particular focus on interactions between adjacent consonants and vowels and vowel alternations triggered by various factors.

In Chapter 2, we have seen the similarity and diversity of sound patterns in Slavic languages. While similar patterns are observed among many languages, the factors underlying or conditioning the given alternations may vary from language to language. While palatalization (§2.2.1–§2.2.3), vowel reduction (§2.3.1), and vowel–zero alternation (§2.3.4) are widely observed among Slavic languages, the type of consonants or vowels that undergo the alternations and of alternation processes is not uniform. Variations are also observed within a specific language: a process may not necessarily occur under a certain phonological condition. In addition to the above mentioned vowel–zero alternation, vowel alternations in backness (Polish and Bulgarian: §2.2.4, §2.3.2), height (Polish: §2.3.2), or length (Czech: §2.3.3) are of this sort. This suggests that factors that cannot be phonologically generalized should also be considered when seeking to predict the sound alternations in question.

Theoretical frameworks assumed in previous studies were reviewed in Chapter 3. One issue involves the way in which linguistic sounds should be represented by abstract phonological units, such as *distinctive features*. The current discussion has argued for three points. First, consonants and vowels should be represented by the same set of features. This

assertion is supported by the fact that adjacent consonants and vowels may interact with one another, triggering various phonological processes (e.g., palatalization). Second, features should be *privative*, not binary. In other words, I have suggested that phonological features should be active when specified. Although some features have + and – counterparts (e.g., [+/–anterior]), this does not denote positive and negative values, but each counterpart plays its own phonological roles. In particular, the present work focused on vowel height features, i.e., [high] and [low]. Mid vowels were thus represented as [high] and [low], which accounts for the fact that they share some properties with high vowels and others with low vowels. On the one hand, for instance, front mid vowels along with high vowels trigger palatalization; on the other hand, both mid and low vowels may undergo vowel reduction. Finally, while arbitrary featural representations that are unattested at the surface should be dismissed, certain features (or other units) that must be present at the surface may be unspecified in underlying forms. In this case, specification for the *underspecified* feature is determined by phonological contexts, resulting in some alternation.

Another important issue is the question of how phonological processes should be accounted for. This work adopts OT (§3.2), in which surface sound patterns are regarded as the optimal candidates according to the ranking of *universal* phonological constraints in a given language. Various processes can be uniformly explained by means of these constraints. In addition, the inter-language variations can be accounted for by considering the differences in

constraint rankings. The current discussion has argued for *parallelism* over *serialism*. Although some researchers have claimed that parallelism cannot account for *opaque* sound patterns, I have shown that such patterns can be accounted for by parallel Containment Theory with Turbid Representations. Serial OT should be turned down owing to the assumption of arbitrary derivational levels (§3.2.2). Besides, as noted earlier, some sound alternations are variable in that they are not fully predictable by a certain constraint ranking alone. Two principle approaches to phonological exceptionality have been proposed. One is to assume specific representation (e.g., *underspecification*) in cases where the alternation in question occurs (§3.1.2–§3.1.3). The other is to assume *lexical strata* among which phonological patterns may vary (§3.3.3). The above discussion has asserted that each framework should be adopted for a specific phenomenon. As outlined in Chapter 2, the variations in sound patterns are classified into two types: some alternations can extend their range within the lexicon (especially in loanword phonology), whereas others are restricted to few lexical items, lacking phonological *productivity*. The main claim was that the former should be attributed to lexical stratification and the latter to lexically specific representations. In other words, the difference in phonological productivity can be accounted for by adopting different approaches to phonological exceptionality (§4.1.3).

Finally, Chapter 4 analyzed the sound patterns in question. Analysis of various alternations in §4.2–4.4 have mainly proved the following two points. First, phonological similarity among

Slavic languages is grounded in the same set of active constraints, whereas synchronic variation results from differences in the constraint rankings. In particular, I have demonstrated the unity in the diversity of phonological palatalization (§4.2.1; see also Appndix 3), vowel reduction (§4.2.2), and vowel–zero alternation (§4.3.2; see also Appndix 4). The constraints were shown to be a part of the universal constraints, which have been argued for in the literature (§4.1.2). The other point is that some alternation patterns are not purely phonological, which may be explained by other factors. Some processes are specific to certain lexical strata (§4.3) and others to several morphemes (§4.4). In other words, the current analysis has shown that some OT constraints should also refer to these lexical or morphological properties. I have argued that phonologically productive and nonproductive patterns should be explained by assuming the lexical stratification and by assuming certain morpheme-specific properties, respectively (§4.1.3). As a productive case, this work dealt with Polish vowel raising (§4.3.1) and vowel–zero alternation (§4.3.2). Furthermore, I demonstrated that loanword-specific patterns are also formalized in this manner (§4.3.3). By contrast, morphologically motivated palatalization (§4.4.1; cf. §4.2.1), Polish vowel backness alternations (§4.4.2), and Czech vowel length alternations (§4.4.3) should be attributed to morpheme-specific properties.

In conclusion, the analysis of the Slavic sound patterns undertaken here provides further support for the current phonological theory: these patterns can be accounted for in terms of cross-linguistic universality along with language-specific properties. To examine phonological

mechanisms in more detail, future research should seek access to greater amounts of data from surveys on new words or nonce-word experiments as well as typological investigation of languages other than Slavic.

APPENDIX

1. Transcriptions

1.1. Russian

Orthography	IPA	Example
а	[a]	т**а**к [t**a**k] ‘so’
и	[i] [(C)ʲi] (< /i/)	**и**кра [**i**kra] ‘caviar’ р**и**с [rʲ**i**s] ‘rice’
ы	[i] (< /ɨ/)	м**ы** [m**i**] ‘we’
у	[u]	т**у**т [t**u**t] ‘here’
э	[e]	мэр [m**e**r] ‘mayer’
о	[o]	р**о**т [r**o**t] ‘mouth’
я	[ja] [(C)ʲa]	**я**сный [**ja**snɨ] ‘clear’ взя**я**ть [vzʲ**a**tʲ] ‘to take’
ю	[ju] [(C)ʲu]	и**ю**ль [i**ju**lʲ] ‘July’ с**ю**да [sʲ**u**da] ‘here’
е	[je] [(C)ʲe]	**е**м [**je**m] ‘I eat’ п**е**ть [pʲ**e**tʲ] ‘to sing’
ё	[jo] [(C)ʲo]	забыть**ё** [zabɨtʲ**jo**] ‘unconsciousness’ н**ё**с [nʲ**o**s] ‘he carried’
й	[j]/[i̯]	кра**й** [kra**i̯**] ‘edge’
п	[p]	**п**еть [**p**ʲetʲ] ‘to sing’
б	[b]	**б**ок [**b**ok] ‘side’
ф	[f]	**ф**акт [**f**akt] ‘fact’
в	[v]	**в**ы [**v**i] ‘you (pl.)’
м	[m]	**м**ы [**m**i] ‘we’
т	[t]	**т**ы [**t**i] ‘you (sg.)’
д	[d]	**д**ом [**d**om] ‘house’
с	[s]	**с**он [**s**on] ‘sleep’
з	[z]	**з**онт [**z**ont] ‘umbrella’
ц	[ʦ]	**ц**арь [**ʦ**arʲ] ‘tsar’
ч	[ʧ]	**ч**ас [**ʧ**as] ‘hour’
ш	[ʂ]	**ш**ар [**ʂ**ar] ‘sphere’
ж	[ʐ]	**ж**ар [**ʐ**ar] ‘heat’
щ	[ɕ:]	бор**щ** [bor**ɕ:**] ‘borshch’
н	[n]	**н**ос [**n**os] ‘nose’
р	[r]	**р**от [**r**ot] ‘mouth’
л	[l]	**л**ук [**l**uk] ‘onion’
к	[k]	**к**от [**k**ot] ‘cat’
г	[g]	**г**усь [**g**usʲ] ‘goose’
х	[x]	**х**ор [**x**or] ‘chorus’
ь	[(C)ʲ]	цар**ь** [ʦarʲ] ‘tsar’

1.2. Polish

Orthography	IPA	Example
a	[a]	m**a** [m**a**] ‘exists’
i	[i]/[(C)ʲi] (< /i/)	m**i** [mʲ**i**] ‘me’
y	[ɨ] (< /ɨ/)	m**y** [m**ɨ**] ‘we’
u	[u]	t**u** [t**u**] ‘here’
e	[e]	s**e**n [s**e**n] ‘sleep’
o	[o]	p**o**t [p**o**t] ‘sweat’
ę	[ɛ̃]	si**ę** [ɕ**ɛ̃**] ‘oneself’
ą	[õ]	r**ą**k [r**õ**k] ‘hand (gen.pl.)’
ó	[u]	g**ó**rka [g**u**rka] ‘mountain (dim.)’
j	[j]/[i̯]	**j**eść [**j**ɛɕtɕ] ‘to eat’
p	[p]	**p**ot [**p**ot] ‘sweat’
b	[b]	**b**ok [**b**ok] ‘side’
f	[f]	**f**akt [**f**akt] ‘fact’
w	[v]	**w**y [**v**ɨ] ‘you (pl.)’
m	[m]	**m**y [**m**ɨ] ‘we’
t	[t]	**t**y [**t**ɨ] ‘you (sg.)’
d	[d]	**d**om [**d**om] ‘house’
s	[s]	**s**en [**s**en] ‘sleep’
z	[z]	**z**ont [**z**ont] ‘umbrella’
c	[ʦ]	**c**el [**ʦ**el] ‘goal’
dz	[ʣ]	**dz**won [**ʣ**von] ‘bell’
cz	[ʧ]	**cz**as [**ʧ**as] ‘time’
sz	[ʂ]	**sz**ary [**ʂ**arɨ] ‘gray’
ż	[ʐ]	**ż**ar [**ʐ**ar] ‘heat’
ć/ci	[ʨ]	mie**ć** [mʲje**ʨ**] ‘to have’ **ci**eń [**ʨ**eɲ] ‘shadow’
dź/dzi	[ʥ]	mie**dź** [mʲje**ʥ**] ‘copper’ **dzi**eń [**ʥ**eɲ] ‘day’
ś/si	[ɕ]	wie**ś** [vʲje**ɕ**] ‘village’ **si**ę [**ɕ**ɛ̃] ‘oneself’
ź/zi	[ʑ]	**ź**le [**ʑ**le] ‘badly’ **zi**emia [**ʑ**emʲja] ‘earth’
n	[n]	**n**os [**n**os] ‘nose’
ń/ni	[ɲ]	dzie**ń** [ʥe**ɲ**] ‘day’ **ni**e [**ɲ**e] ‘not’
r	[r]	**r**ok [**r**ok] ‘year’
rz	[ʐ]	**rz**eka [**ʐ**eka] ‘river’
ł	[w]	**ł**uk [**w**uk] ‘bow’
l	[l]	**l**as [**l**as] ‘forest’
k	[k]	**k**ot [**k**ot] ‘cat’
g	[g]	**g**ora [**g**ora] ‘mountain’
ch	[x]	**ch**ory [**x**orɨ] ‘sick’
(C)i	[(C)ʲ]	ziem**i**a [ʑemʲja] ‘earth’

1.3. Czech

Orthography	IPA	Example
a	[a]	hr**a**d [ɦr**a**d] ‘castle’
á	[a:]	m**á** [m**a:**] ‘my (fem.)’
i, y	[i]	m**i** [m**i**] ‘me (dat.)’; m**y** [m**i**] ‘we’
í, ý	[i:]	p**í**t [p**i:**t] ‘to drink’; mlad**ý** [mlad**i:**] ‘young’
u	[u]	t**u** [t**u**] ‘here’
ú, ů	[u:]	**ú**kol [**u:**kol] ‘task’; d**ů**m [d**u:**m] ‘house’
e	[e]	s**e**n [s**e**n] ‘dream’
ě	[(C)je]	b**ě**h [b**je**x] ‘run’
é	[e:]	nov**é** [nov**e:**] ‘new (neut.)’
o	[o]	r**o**k [r**o**k] ‘year’
ó	[o:]	telef**ó**nek [telef**o:**nek] ‘telefone (dim.)’
ou	[ou]	k**ou**pit [k**ou**pit] ‘to buy’
ej	[ei]	časop**ej**sek [ʧasop**ei**sek] ‘magazine (dim.)’
j	[j]/[i̯]	**j**et [**j**et] ‘to travel’
p	[p]	**p**ot [**p**ot] ‘sweat’
b	[b]	**b**ok [**b**ok] ‘side’
f	[f]	**f**akt [**f**akt] ‘fact’
v	[v]	**v**y [**v**i] ‘you (pl.)’
m	[m]	**m**y [**m**i] ‘we’
t	[t]	**t**y [**t**i] ‘you (sg.)’
d	[d]	**d**ům [**d**u:m] ‘house’
s	[s]	**s**en [**s**en] ‘dream’
z	[z]	**z**ima [**z**ima] ‘winter’
c	[ʦ]	**c**el [**ʦ**el] ‘goal’
č	[ʧ]	**č**eský [**ʧ**eski:] ‘Czech’
š	[ʃ]	**š**est [**ʃ**est] ‘six’
ž	[ʒ]	**ž**ár [**ʒ**a:r] ‘heat’
ť/ti/tě	[c] [ci] [ce]	chu**ť** [xu**c**] ‘taste’ **ti**chý [**ci**xi:] ‘quiet’ **tě**lo [**ce**lo] ‘body’
ď/di/dě	[ɟ] [ɟi] [ɟe]	poj**ď**me [poi̯**ɟ**me] ‘let’s go’ mla**dí** [mla**ɟi:**] ‘young (masc.pl.)’ **dě**vče [**ɟe**fʧe] ‘girl’
n	[n]	**n**os [**n**os] ‘nose’
ň/ni/ně	[ɲ] [ɲi] [ɲe]	kůň [ku:**ɲ**] ‘horse’ **ni**c [**ɲi**ʦ] ‘nothing’ **ně**ha [**ɲe**ɦa] ‘tenderness’
r	[r]	**r**ok [**r**ok] ‘year’
ř	[r̝]	**ř**eč [**r̝e**ʧ] ‘speech’
l	[l]	**l**es [**l**es] ‘forest’
k	[k]	**k**ůň [**k**u:ɲ] ‘horse’
h	[ɦ]	no**h**a [no**ɦ**a] ‘leg’
ch	[x]	**ch**odit [**x**oɟit] ‘to walk’

1.4. Serbo–Croatian

Orthography		IPA	Example (Latin/Cyrillic/Phonetic)
Latin	Cyrillic		
a	а	[a]	t**a**ko / т**а**ко / [t**a**ko] ‘so’
i	и	[i]	knj**i**ga / књ**и**га / [kɲ**i**ga] ‘book’
u	у	[u]	t**u** / т**у** / [t**u**] ‘here’
e	е	[e]	j**e** / j**е** / [j**e**] ‘is’
o	о	[o]	g**o**dina / г**о**дина / [g**o**dina] ‘year’
j	ј	[j]/[i̯]	**j**a / **ј**a / [**j**a] ‘I’
p	п	[p]	**p**iti / **п**ити / [**p**iti] ‘to drink’
b	б	[b]	**b**ok / **б**ок / [**b**ok] ‘side’
f	ф	[f]	**f**akt / **ф**акт / [**f**akt] ‘fact’
v	в	[v]	**v**i / **в**и / [**v**i] ‘you (pl.)’
m	м	[m]	**m**i / **м**и / [**m**i] ‘we’
t	т	[t]	**t**i / **т**и / [**t**i] ‘you (sg.)’
d	д	[d]	**d**om / **д**ом / [**d**om] ‘house’
s	с	[s]	**s**ok / **с**ок / [**s**ok] ‘juice’
z	з	[z]	**z**ima / **з**има / [**z**ima] ‘winter’
c	ц	[ʦ]	**c**ena / **ц**ена / [**ʦ**ena] ‘price’
ć	ћ	[ʨ]	i**ć**i /и**ћ**и / [i**ʨ**i] ‘to go’
č	ч	[ʧ]	**č**as / **ч**ас / [**ʧ**as] ‘hour’
š	ш	[ʂ]	**š**est / **ш**есть / [**ʂ**est] ‘six’
ž	ж	[ʐ]	**ž**ena / **ж**ена / [**ʐ**ena] ‘woman’
đ	ђ	[ʥ]	ro**đ**enje / ро**ђ**ење / [ro**ʥ**eɲe] ‘birth’
dž	џ	[dʐ]	**dž**em / **џ**ем / [**dʐ**em] ‘jam’
n	н	[n]	**n**os / **н**ос / [**n**os] ‘nose’
nj	њ	[ɲ]	k**nj**iga / кн**њ**ига / [k**ɲ**iga] ‘book’
r	р	[r]	**r**aditi / **р**адити / [**r**aditi] ‘to do’
l	л	[l]	**l**ed / **л**ед / [**l**ed] ‘ice’
lj	љ	[ʎ]	**lj**ubav / **љ**убав / [**ʎ**ubav] ‘love’
k	к	[k]	**k**ako / **к**ако / [**k**ako] ‘how’
g	г	[g]	**g**rad / **г**рад / [**g**rad] ‘city’
h	х	[x]	**h**vala / **х**вала / [**x**vala] ‘thanks’

1.5. Bulgarian

Orthography	IPA	Example
а	[a]	к**а**к [k**a**k] ‘how’
и	[i]	с**и**ла [s**i**la] ‘force’
у	[u]	д**у**х [d**u**x] ‘spirit’
е	[e]	с**е**дя [s**e**dʲa] ‘sit (1sg)’
о	[o]	д**о**бър [d**o**bər] ‘good’
я	[ja] [(C)ʲa]	**я**м [**ja**m] ‘eat (1sg)’ ход**я** [xodʲ**a**] ‘walk (1sg)’
ю	[ju] [(C)ʲu]	**ю**ноша [**ju**noʃa] ‘youth’ с**ю**жет [sʲ**u**ʒet] ‘subject’
ъ	[ə]	с**ъ**м [s**ə**m] ‘(I) am’
й	[j]/[i̯]	кра**й** [kra**i̯**] ‘end’
п	[p]	**п**итане [**p**itane] ‘question’
б	[b]	**б**ой [**b**oi̯] ‘battle’
ф	[f]	**ф**акт [**f**akt] ‘fact’
в	[v]	**в**и [**v**i] ‘you (pl.)’
м	[m]	**м**и [**m**i] ‘we’
т	[t]	**т**и [**t**i] ‘you (sg.)’
д	[d]	**д**ом [**d**om] ‘house’
с	[s]	**с**ън [**s**ən] ‘sleep’
з	[z]	**з**има [**z**ima] ‘winter’
ц	[ʦ]	**ц**ел [**ʦ**el] ‘goal’
ч	[ʧ]	**ч**ар [**ʧ**ar] ‘charm’
ш	[ʃ]	**ш**ирок [**ʃ**irok] ‘wide’
ж	[ʒ]	**ж**иво [**ʒ**ivo] ‘vigorously’
щ	[ʃʧ]	**щ**е [**ʃʧ**e] ‘will’
н	[n]	**н**ос [**n**os] ‘nose’
р	[r]	**р**ъка [**r**əka] ‘hand’
л	[l]	**л**ист [**l**ist] ‘leaf’
к	[k]	**к**ос [**k**os] ‘oblique’
г	[g]	**г**оре [**g**ore] ‘above’
х	[x]	ду**х** [du**x**] ‘spirit’

2. List of constraints

2.1. Markedness constraints on features, segments, or segment sequences

[high, low]/σ̆** (UNSTRMID**) (68), (107a):
Assign a violation mark for each unstressed vowel with both [high] and [low] (i.e., mid vowel).

[low]/σ̆** (UNSTRNONHIGH**) (69a):
Assign a violation mark for each vowel with [low] (i.e., non-high vowel) in unstressed syllables.

[low]/σ** (NONMORAICNONHIGH**) (107b):
Assign a violation mark for each vowel with [low] (i.e., non-high vowel) that bears no morae.

***[high]/σ̆** (69b):
Assign a violation mark for each vowel with [high] (i.e., non-low vowel) in unstressed syllables.

***V/…V** (72):
Assign a violation mark for each vowel preceding a vowel.

[high, low, dorsal]/_C)$_\sigma$** (o/_C)$_\sigma$**) (77a):
"Assign a violation mark for each [o] in closed syllables."

[coronal, nasal]/_C)$_\sigma$** (ẽ/_C)$_\sigma$**) (77b):
"Assign a violation mark for each [ẽ] in closed syllables."

***V$_{\mu\mu}$** (152):
Assign a violation mark for each vowel with two morae (i.e., long or diphthong vowel).

***o:** (156a):
Assign a violation mark for each [o] with two morae (i.e., [o:]).

***u:** (156b):
Assign a violation mark for each [u] with two morae (i.e., [u:]).

e:/[coronal, −anterior]_** (Je:**) (156c):
Assign a violation mark for each [e] with two morae (i.e., [e:]) following palatal consonants.

***DIPH(THONG)** (157):
Assign a violation mark for each syllable that consists of vowels specified for multiple features that are not squared.

***o/_<[+voice]>)$_\sigma$** (116):
Assign a violation mark for each [o] preceding <[+voice]> in closed syllables.
i.e., "No [o] preceding [+voice] specified in the input in closed syllables regardless of whether the [+voice] is phonetically realized in the output."

*Cʲ (90):
Assign a violation mark for each consonant specified for [coronal, −anterior] under V-place node.
“Assign a violation mark for each secondarily palatalized consonant.”

*CʲC (95a):
“Assign a violation mark for each secondarily palatalized consonant preceding another consonant.”

*Cʲ# (95b):
“Assign a violation mark for each secondarily palatalized consonant in word-final positions.”

*COMPLEX (125):
“Assign a violation mark for each complex consonant cluster.”

2.2. Agreement constraints

AGREE-LABIAL/_V (coronal, −anterior) (**AGREE-P**) (80a):
Assign a violation mark for each labial consonant that does not agree with the following vowel in [coronal, −anterior].

AGREE-CORONAL/_V (coronal, −anterior) (**AGREE-T**) (80b):
Assign a violation mark for each coronal consonant that does not agree with the following vowel in [coronal, −anterior].

AGREE-DORSAL/_V (coronal, −anterior) (**AGREE-K**) (80c):
Assign a violation mark for each dorsal consonant that does not agree with the following vowel in [coronal, −anterior].

AGREE-C/_i (coronal, −anterior, high) (**AGREE-C/_i**) (83a):
Assign a violation mark for each consonant that does not agree with the following [i] in [coronal, −anterior, high].

AGREE-C/_e (coronal, −anterior, high) (**AGREE-C/_e**) (83b):
Assign a violation mark for each consonant that does not agree with the following [e] in [coronal, −anterior, high].

AGREE-ă/C_ (coronal, −anterior, +distributed) (110a):
Assign a violation mark for each unstressed [a] that does not agree with the preceding consonant with [coronal, −anterior, +distributed].

AGREE-ə̆/C_ (coronal, −anterior, +distributed) (110b):
Assign a violation mark for each unstressed [ə] that does not agree with the preceding consonant with [coronal, −anterior, +distributed].

AGREE-ŭ/C_ (coronal, −anterior, +distributed) (110c):
Assign a violation mark for each unstressed [u] that does not agree with the preceding consonant with [coronal, −anterior, +distributed].

AGREE-V/_C (place) (148):
Assign a violation mark for each vowel that does not agree with the following consonant in the feature(s) under the place node.

2.3. Faithfulness constraints

MAX (coronal) (65):
Assign a violation mark for each feature [coronal] that is present in the input and absent in the output.

DEP (coronal) (82a):
Assign a violation mark for each feature [coronal] that is absent in the input and present in the output.

DEP-SEG (coronal) (66):
Assign a violation mark for each feature [coronal] on segments that is absent in the input and present in the output.

DEP-C/_# (coronal) (100):
Assign a violation mark for each feature [coronal] on word-final consonants that is absent in the input and present in the output.

MAX (dorsal) (91a), (105):
Assign a violation mark for each feature [dorsal] that is present in the input and absent in the output.

MAX (+anterior) (91b):
Assign a violation mark for each feature [+anterior] that is present in the input and absent in the output.

MAX (labial) (91c):
Assign a violation mark for each feature [labial] that is present in the input and absent in the output.

MAX (high) (70a):
Assign a violation mark for each feature [high] that is present in the input and absent in the output.

DEP (high) (82b):
Assign a violation mark for each feature [high] that is absent in the input and present in the output.

MAX (low) (70b):
Assign a violation mark for each feature [low] that is present in the input and absent in the output.

MAX-V (73):
Assign a violation mark for each vowel that is present in the input and absent in the output.

MAX-V/NONFINAL (74):
Assign a violation mark for each non-morpheme-final vowel that is present in the input and absent in the output.

MAX-V-μ (79a):
Assign a violation mark for each mora on vowels that is present in the input and absent in the output.

DEP-V-μ (79b):
Assign a violation mark for each mora on vowels that is absent in the input and present in the output.

2.4. Constraints on Paradigm Uniformity

PU (low) (121):
Assign a violation mark if a form within a paradigm is different from another in specification for [low] on a segment.

PU-V (127):
Assign a violation mark if a form within a paradigm is different from another in the presence of a vowel.

PU-V/non-final (129):
Assign a violation mark if a form within a paradigm is different from another in the presence of a non-final vowel.

PU-V/stem (131):
Assign a violation mark if a form within a paradigm is different from another in the presence of a vowel that is an exponent of stems.

PU (place) (146):
Assign a violation mark if a form within a paradigm is different from another in specification for features under the place node on a segment.

2.5. Generalized Alignment and other morpho-phonological constraints

ALIGN ([coronal]$_{PAL}$, L, σ, L) (**ALIGN-coronal**) (137), (see also 141):
"For every feature [coronal] on morphemes indexed as PAL, its left edge must coincide with the left edge of a syllable."

ALIGN (μ_{DIM}, R, Root, R) (**ALIGN-μ_{DIM}**) (154):
"For every mora on morphemes indexed as DIM, its right edge must coincide with the right edge of the exponent of a root."

MASC≥2μ (151a):
Assign a violation mark for each masculine noun with vowels weighed less than 2 morae.

NONMASC=3μ (151b):
Assign a violation mark for each non-masculine noun with vowels not weighed 3 morae.

3. OT analysis of the variation in palatalization

3.1. Russian

i. /ti/ → [tʲi] e.g., /atvʲetʲ-i-tʲ/ → [atvʲetʲitʲ] ‘to answer’
ii. /tɨ/ → [ti] e.g., /atvʲetʲ-ɨ/ → [atvʲeti] ‘answer (nom.pl.)’
iii. /te/ → [tʲe] e.g., /krasatʲ-e/ → [krasatʲe] ‘beauty (loc.sg.)’
iv. /ki/ → [kʲi]/[ʧi] e.g., /rukʲ-i-tʲ/ → [ruʧitʲ] ‘to hand’
v. /kɨ/ → [kʲi] e.g., /rukʲ-ɨ/ → [rukʲi] ‘hand (nom.pl.)’
vi. /ke/ → [kʲe]/[ʧe] e.g., /rukʲ-e/ → [rukʲe] ‘hand (loc.sg.)’

	Agree-K/_i	Dep (coronal)	Agree-C/_i	Agree-C/_e	Dep-C (coronal)
i. /ti/					
a. ti			*W		L
b. tʲi					*
ii. /tɨ/					
a. ☞ ti			*		L
b. tʲi		*W	L		*
iii. /te/					
a. te				*W	L
b. ☞ tʲe					*
iv. /ki/					
a. ki	*W				L
b. ☞ kʲi					*
c. ☞ ʧi					*
v. /kɨ/					
a. ki	*W	L			
b. ☞ kʲi		*			*
c. ʧi		*			*
vi. /ke/					
a. ke				*W	L
b. ☞ kʲe					*
c. ☞ ʧe					*

3.2. Polish

i. /ti/ → [tɕi] e.g., /pot-i-tɕ/ → [potɕitɕ] ‘to sweat’
ii. /tɨ/ → [ti] e.g., /kot-ɨ/ → [koti] ‘cat (nom.pl.)’
iii. /te/ → [tɕe] e.g., /kot-e/ → [kotɕe] ‘cat (loc.sg.)’
iv. /tɛ/ → [te] e.g., /kot-ɛm/ → [kotem] ‘cat (inst.sg.)’
v. /ki/ → [kʲi]/[ʈʂi] e.g., /krok-i-tɕ/ → [krotʂitɕ] ‘to step’
vi. /kɨ/ → [kʲi] e.g., /krok-ɨ/ → [krokʲi] ‘step (nom.pl.)’
vii. /ke/ → [kʲe]/[ʈʂe] e.g., /pʲek-e/ → [pʲeʈʂe] ‘bake (3sg)’
viii./kɛ/ → [kʲe] e.g., /krok-ɛm/ → [krokʲem] ‘step (inst.sg.)’

	AGREE-K/_i	AGREE-K/_e	DEP (high)	DEP (coronal)	AGREE-C/_i	AGREE-C/_e	DEP-C (coronal)
i. /ti/							
a. ti					*W		L
b. tɕi							*
ii. /tɨ/							
a. ☞ ti					*		
b. tɕi				*W	L		*
iii. /te/							
a. te						*W	L
b. ☞ tɕe							*
iv. /tɛ/							
a. ☞ te						*	
b. tɕe			*W			L	*
v. /ki/							
a. ki	*W						L
b. ☞ kʲi							*
c. ☞ ʈʂi							*
vi. /kɨ/							
a. ki	*W			L	*		
b. ☞ kʲi				*			*
c. ʈʂi				*			*
vii. /ke/							
a. ke						*W	L
b. ☞ kʲe							*
c. ☞ ʈʂe							*
vii. /kɛ/							
a. ke		*W	L			*	
b. ☞ kʲe			*				*
c. ʈʂe			*				*

3.3. Bulgarian

i. /ti/ → [ti] e.g., /vrat-i/ → [vrati] ‘door (pl.)’
ii. /te/ → [te] e.g., /zlat-en/ → [zlaten] ‘gold (masc.sg.)’
iii. /ki/ → [kʲi]/[ʧi] e.g., /rek-i/ → [rekʲi] ‘river (pl.)’
iv. /ke/ → [kʲe]/[ʧe] e.g., /tek-e/ → [teʧe] ‘flow (3sg)’

	AGREE-K/_i	AGREE-K/_e	DEP-C (coronal)	AGREE-C/_i	AGREE-C/_e
i. /ti/					
a. ☞ ti				*	
b. tʲi			*W	L	
ii. /te/					
a. ☞ te					*
b. tʲe			*W		L
iii. /ki/					
a. ki	*W		L		
b. ☞ kʲi			*		
c. ☞ ʧi			*		
iv. /ke/					
a. ke		*W	L		*
b. ☞ kʲe			*		
c. ☞ ʧe			*		

3.4. Serbo–Croatian (also for Czech)

i. /ti/ → [ti] e.g., /zlat-ima/ → [zlatima] ‘gold (dat.pl.)’
ii. /te/ → [te] e.g., /brat-e/ → [brate] ‘brother (voc. sg.)’
iii. /ki/ → [ki] e.g., /srb-sk-i/ → [srpski] ‘Serbian’
iv. /ke/ → [ke] e.g., /ruk-e/ → [ruke] ‘hand (nom.pl.)’

	DEP-C (coronal)	AGREE-K/_i	AGREE-K/_e	AGREE-C/_i	AGREE-C/_e
i. /ti/					
a. ☞ ti				*	
b. tʲi	*W			L	
ii. /te/					
a. ☞ te					*
b. tʲe	*W				L
iii. /ki/					
a. ☞ ki		*			
b. kʲi	*W	L			
c. ʧi	*W	L			
iv. /ke/					
a. ☞ ke			*		
b. kʲe	*W		L		
c. ʧe	*W		L		

4. OT analysis of the variation in vowel–zero alternation

4.1. Russian

i. /l^{j}od$_{LS2}$-a/ → [l^{j}da] ‘ice (gen.sg.)’
ii. /d^{j}en^{j}$_{LS2}$-i/ → [dn^{j}i] ‘day (nom.pl.)’
iii. /urov^{j}en^{j}$_{LS2}$-a/ → [urovn^{j}a] ‘level (gen.sg.)’
iv. /rod$_{LS1}$-a/ → [roda] ‘kin (gen.sg.)’
v. /t^{j}en^{j}$_{LS1}$-i/ → [t^{j}en^{j}i] ‘shadow (gen.sg.)’
vi. /sad-a/ → [sada] ‘garden (gen.sg.)’

	MAX-V/ NONFINAL	MAX-a	MAX$_{LS1}$-o	MAX$_{LS1}$-e	*V/…V	MAX$_{LS2}$-o	MAX$_{LS2}$-e
i. /l^{j}od$_{LS2}$-a/							
l^{j}oda					*W	L	
☞ l^{j}da						*	
ii. /d^{j}en^{j}$_{LS2}$-i/							
d^{j}en^{j}i					*W		L
☞ dn^{j}i							*
iii. /urov^{j}en^{j}$_{LS2}$-a/							
urov^{j}en^{j}a					***W		L
☞ urovn^{j}a					**		*
urv^{j}en^{j}a	*W				**	*	
urvn^{j}a	*W				*L	*	*
iv. /rod$_{LS1}$-a/							
☞ roda					*		
rda			*W		L		
v. /t^{j}en^{j}$_{LS1}$-i/							
☞ t^{j}en^{j}i					*		
tn^{j}i				*W	L		
vi. /sad-a/							
☞ sada					*		
zda		*W			L		

4.2. Polish (also for Czech)

i. /dex$_{LS2}$-u/ → [txu] ‘breath (gen.sg.)’
ii. /mebel$_{LS2}$-a/ → [mebla] ‘furniture (gen.sg.)’
iii. /ser$_{LS1}$-a/ → [sera] ‘cheese (gen.sg.)’
iv. /lod-u/ → [lodu] ‘ice (gen.sg.)’

	MAX-V/ NONFINA	MAX-o	MAX$_{LS1}$-e	*V/…V	MAX$_{LS2}$-e
i. /dɛx$_{LS2}$-u/					
dexu				*W	L
☞ txu					*
ii. /mebel$_{LS2}$-a/					
mebela				**W	L
☞ mebla				*	*
mbela	*W			*	*
mbla	*W			L	**
iii. /sɛr$_{LS1}$-a/					
☞ sera				*	
sra			*W	L	
iv. /lod-u/					
☞ lodu				*	
ldu		*W		L	

4.3. Serbo–Croatian

i. /pas$_{LS2}$-a/ → [psa] ‘dog (gen.sg.)’
ii. /papar$_{LS2}$-a/ → [papra] ‘pepper (gen.sg.)’
iii. /dan$_{LS1}$-a/ → [dana] ‘day (gen.sg.)’
iv. /led-a/ → [leda] ‘ice (gen.sg.)’

	MAX-V/ NONFINA	MAX-e	MAX$_{LS1}$-a	*V/…V	MAX$_{LS2}$-a
i. /pas$_{LS2}$-a/					
pasa				*W	L
☞ psa					*
ii. /papar$_{LS2}$-a/					
papara				**W	L
☞ papra				*	*
ppara	*W			*	
iii. /dan$_{LS1}$-a/					
☞ dana				*	
dna			*W	L	
iv. /led-a/					
☞ leda				*	
lda		*W		L	

4.4. Bulgarian

i. /kompʲutərLS2-i/ → [kompʲutri] ‘computer (pl.)’
ii. /denLS2-i/ → [dni] ‘day (pl.)’
iii. /venetsLS2-i/ → [ventsi] ‘wreath (pl.)’
iv. /brauzərLS1-i/ → [brauzəri] ‘browser (pl.)’
v. /utʃitelLS1-i/ → [utʃiteli] ‘teacher (pl.)’
vi. /udar-i/ → [udari] ‘hit (pl.)’

	MAX-V/ NONFINAL	MAX-a	MAXLS1-ə	MAXLS1-e	*V/… V	MAXLS2-ə	MAXLS2-e
i. /kompʲutərLS2-i/							
kompʲutəri					*W	L	
☞ kompʲutri						*	
ii. /denLS2-i/							
deni					*W		L
☞ dni							*
iii. /venetsLS2-i/							
venetsi					*W		L
☞ ventsi							*
vnetsi	*W						*
iv. /brauzərLS1-i/							
☞ brauzəri					*		
brauzri			*W		L		
v. /utʃitelLS1-i/							
☞ utʃiteli					*		
utʃitli				*W	L		
vi. /udar-i/							
☞ udari					*		
udri		*W			L		

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