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In this paper I investigate factors responsible for neutralization of plain-palatalized contrasts, focusing on coronal and labial stops in Standard Russian. I argue that the full range of distributional facts characterizing these segments can be adequately characterized only if one derives neutralization from phonetic perceptual and articulatory factors (*Licensing by Cue*: Steriade 1997; also Flemming 1995, Hamilton 1996, Silverman 1997, among others). As it will be shown, some environments support the 'plain-palatalized' contrast better than others, while other contexts tend to neutralize it. Places of articulation differ in their neutralization patterns. I will demonstrate that whether the contrast licensed or neutralized, depends crucially on the availability of perceptual cues encoded in a certain environment. I will determine the relative importance of these cues and propose a fixed markedness hierarchy of context-sensitive constraints on plain-palatalized contrasts.

1 Distribution of Palatality Contrasts in Russian

1.1 Inventory and Palatalized Contrasts

The Russian consonant inventory is given in Table 1.[1] As we see, the language can be considered as fully representative of the typology of palatalization. The plain-palatalized phonemic distinction involves all places of articulation: labials, coronals and velars. Plain consonants may be velarized to some extent (Skalozub 1963, etc.).

In this paper I limit the discussion to the distribution of coronal and labial stops (highlighted in Table 1), disregarding their laryngeal distinction. I show these segments again in Table 2.

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[1]My assumptions concerning phonotactics and articulatory and acoustic phonetics of Russian are based on the following sources: Avanesov 1972, Bolla 1981, Bondarko 1977, Derkach 1975, Halle 1959, Jones & Ward 1969, Kuznetsova 1969, Lazova 1974, Matusevich 1976, and Skalozub 1963.

Labials		Coronals					Velars	
p	**p^j**	**t**	**t^j**				k^j	k
b	b^j	d	d^j				[g^j]	g
		ts			$tʃ^j$			
f	f^j	s	s^j	ʃ	$ʃ^j$:		[x^j]	x
v	v^j	z	z^j	ʒ				
m	m^j	n	n^j					
		l	l^j					
		r	r^j					
						j		

Table 1. Russian consonant inventory.

	Labial	Coronal
'Plain'	p	t
Palatalized	p^j	t^j

Table 2. Plain and palatalized labial and coronal stops.

1.2 Distribution of Plain and Palatalized Stops

The distribution of plain and palatalized stops is summarized in Table 3.[2]

I consider single stops and these segments in two- and three-consonant clusters. Note that while the unmarked, plain segments occur in all of the contexts under consideration, their palatalized counterparts exhibit rather asymmetrical distributional patterns. What we see in Table 3, is that in some environments both palatalized labials and coronals are unrestricted (abcd), that is, fully contrastive. In other contexts they are restricted to a certain number of clusters. There is only one attested cluster with a final palatalized labial (e). Coronals have a limited number of clusters in other positions (fg). In still other positions the segments in question are completely neutralized in favour of the unmarked plain stops ((h) and (fg) for labials only). Interestingly, palatalized coronals enjoy a fuller contrastive potential than palatalized labials.

It is also worth emphasizing that some of these environments are subjects to additional constraints imposed by the nature of the following consonant. In the preconsonantal positions (fgh) coronals may be tolerated only if

[2]See Kochetov (to appear) for details.

the following segment is of a different place of articulation (Table 4). There are also some restrictions before front vowels (Kochetov 1998 (to appear)).

	Environment	Contrast C • C^j Labial	Coronal
a.	V__V	yes	yes
b.	#__V	yes	yes
c.	C__V	yes	yes
d.	V__#	yes	yes
e.	C__#	yes/no (1)	yes/no (5)
f.	V__C[3]	no	yes/no (3)
g.	#__C	no	yes/no (1)
h.	C__C	no	no

Table 3. The distribution of plain and palatalized stops (Note: yes = unrestricted; yes/no = restricted, no = prohibited; (1) = the number of attested contrastive clusters).

		Labial	Coronal
a.	#__C_{htr}V	no	yes/no (1)
b.	V__C_{htr}(#)	no	yes/no (3)
c.	V__C_{hm}(#)	no	no

Table 4. Constraints on occurrence before hetero-organic (C_{htr}) and homorganic (C_{hm}) consonants.

In sum, not a single environment in Table 3 is free from some kind of constraint on palatalized stops. Several questions arise with regard to these data. Why are certain environments better for realization of the contrast than others? Why is the contrast tied up to the quality of the following consonant or vowel? How can we explain the distributional discrepancies between labials and coronals?

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[3]For simplicity I exclude the clusters with a palatalized C2. The summary of distribution of stops before palatalized consonants is given in Kochetov 1998 (to appear).

2 Licensing by Cue: Phonetic Cues to Palatalized Consonants

In order to account for these complex distribution patterns, I turn to the hypothesis of *Licensing by Cue*, developed in the works of Steriade 1997, 1998, as well as Flemming 1995, Hamilton 1996, and Silverman 1997. According to this approach, phonological contrasts are neutralized in environments poor in terms of phonetic cues and are preserved or licensed in positions that are high on a scale of perceptibility. This scale is based on relative number of cues, their relative duration and perceptual salience.

2.1 Cues to Palatalized Stops

I will begin with identifying cues to palatalized stops. I frame my analysis in the gestural representations developed in the framework of Articulatory Phonology (Browman & Goldstein 1989 and Zsiga 1997) and the auditory representations worked out in Flemming 1995.

A palatalized consonant is characterized as having a primary gesture (Lips or Tongue Tip) with a secondary palatal articulation superimposed onto it. Consider the gestural score of sequences *ap^{j}a-at^{j}a* (1a). The secondary gesture (Tongue Body-palatal), which is acoustically characterized by high F2, overlaps with the gestures of the preceding and following vowels, resulting in formant transitions. The overlap is usually more apparent at the release than at the formation of the primary constriction (Ladefoged & Maddieson 1996: 364; Flemming 1995: 35).

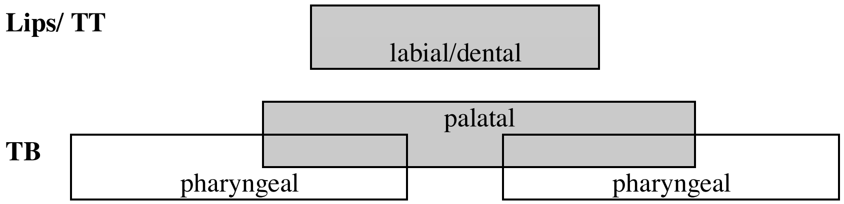
This alignment of gestures provides the sequence of acoustic events in (1b): approach, closure, burst, and release. Of these four, approach (V-C formant transitions), release (C-V transitions), and burst of fricative noise are known to contain important information about the place of articulation of the stop (Flemming 1995: 33-37). It is crucial for our analysis to know what the relative importance, or perceptual salience of each of these cues is. Here I consider acoustic details of release, approach and burst. For simplicity I refer to them as cues. I do not discuss the properties of closure, since this component, having no acoustic energy, cannot differentiate stops.

A release after a palatalized consonant in Russian (Table 5) is characterized by a fairly long period (up to 35-40 per cent of the vowel[4]) with F2

[4]Here the release includes the period of the vowel with F2 typical for front vowels [i] and [ɛ]; the duration of release may vary in different positions (Kuznetsova 1969: 73).

(1) Intervocalic: [ap^{j}a] or [at^{j}a]:

a. Articulation:



b. Acoustic sequence of events:

[a] [i] silence noise [i] [a]

|----------------------|---|----------------------------|----|--------|--------------|

↑ approach ↑ closure ↑ burst ↑ release

Time ——→

(Note: TB = Tongue Body; TT = Tongue Tip; Constriction degree and gestures of Glottis and Velum are omitted).

gradually lowering. For example, the release of initial palatalized t^j in t^jat^ja 'daddy' is 35 per cent of the vowel time (Kuznetsova 1969: 73). The duration of release is approximately the same for labials and coronals (Bondarko 1977: 95-100).

	F2	Duration
C^{j}a	high → low	35-40%

Table 5. Release: C-V transitions.

Release is considered to be the main acoustic cue to palatalized consonants in general (e.g. Ladefoged & Maddieson 1996: 364, Derkach 1975). However, this is the case only if the following vowel has a lower F2, that is, there is a perceptible difference between the release and the nucleus of the vowel. For example, the difference in F2 between the beginning of the release (F2 = 1700 Hz) and F2 of the vowel [a] (F2 = 1200 Hz) is significant (500 Hz), while this difference may be minimal with the following front vowel (Bondarko 1977).

Unlike release, an approach to a palatalized stop is a much shorter period of 6-9% characterized by a lower F2 (Table 6). For example, the approach to the intervocalic palatalized t^j in t^jat^ja 'daddy' is 6% of the overall duration of the vowel. Approach tends to be slightly shorter for labials, accompanied by a still lower F2 (Bondarko 1977: 95-100; Kuznetsova 1969: 73, 78).

	F2	Duration
aC^j	low → high	6-9%

Table 6. Approach: V-C transitions.

The values of burst in terms of fricative noise are given in Table 7 (based on Bolla 1981: 117-121; cf. Kuznetsova 1969 for t^j)[5]. We can notice a significant acoustic difference between the labial and coronal stops. While the palatalized labial has a rather short period of fricative noise (12% of the overall duration of the consonant), the coronal stop with a secondary palatal articulation exhibits a very long (51%) high frequency strong, strident noise. This factor makes palatalized coronal stops similar to affricates.

	Burst quality		Duration
p^j	[φ^jç]	low frequency	12%
t^j	[s^jç]	high frequency high intensity	51%

Table 7. Palatalized burst.

Notice that release and approach are measured in terms of how much of the vowel time they occupy. Thus, these components are present *only* if there is a following or preceding vowel correspondingly. Burst is also context-sensitive: it may occur before some consonants and may be inhibited before others. These factors relate the cues crucially to linear environments.

After considering the components of approach, burst, and release of a palatalized stop, we can propose an implicational hierarchy of salience, as in (2). The relative salience of the cues is based on their durational characteristics, as well as on acoustic salience of different phonetic properties (e.g. high intensity strident fricative noise) (Flemming 1995: 31). The implication in

[5]The values for burst are average. Burst tends to be longer before unstressed vowels, as well we in final and preconsonantal positions (Kochetov 1999; cf. Kuznetsova 1969: 105).

(2a) holds that release, constitutes the most important cue to a palatalized stop, followed by burst, while approach is the least important in cueing the segment. (2b) states an important place of articulation difference: the coronal burst is more salient than the labial burst.

(2) a. Release » Burst » Approach
    b. Coronal Burst » Labial Burst

Having established the cues to palatalized stops and their relative salience, we will take a closer look at three different sets of cues present in certain environments and we will see whether these sets correlate with preserving or neutralization of the contrast between plain and palatalized stops.

2.1.1 All Cues: Intervocalic

The presence of all cues to palatality (release, burst, and approach) makes the intervocalic environment ideal for realization of the contrast (3).

(3)

Environment:	V__V	
Cues:	release, burst, approach	
Input:	ap^{j}a	at^{j}a
Output:	ap^{j}a	at^{j}a

As we would expect, Russian palatalized labials and coronals are fully contrastive in this environment, as we see in (4).

We may reasonably expect that with the removal of any of the three significant cues to a palatalized stop the perception of the segment will deteriorate, and thus, it will be more likely to be neutralized in a given environment.

(4) a.

ko[p]at’[6]	‘dig’	o[p^j]at’	‘again’
sa[p]og	'high boot'	sa[p^j]ër	'combat engineer'
lo[p]ux	‘burdock‘	ku[p^j]ura	‘banknote’

[6]Here and below I use the transliteration adopted in North American literature on Russian, while using the IPA symbols for transcription. ë = fronted [o] (C^j__) , y = [ɨ], C’ = [C^j].

b.	va[t]a	'cotton'	ba[t^j]a	'dad'
	po[t]ok	'stream'	po[t^j]ok	'began to flow'
	pe[t]ux	'rooster'	u[t^j]ug	'iron'

2.1.2 No Release: Preconsonantal (__C_{htr})

Let's consider the result of removing one of the cues, a release of a palatalized stop, while retaining burst and approach. We will look at the medial preconsonantal environment. Taking into account the fact that in Russian stops retain their burst when followed by another hetero-organic consonants, especially, by stops and nasals (Jones and Ward 1969: 89, 105; cf. Zsiga 1998), we will consider only hetero-organic clusters. In sequences *ap^{j}ka-at^{j}ka* (5) the most important cue, release, is missing. The two other components, burst and approach, are still present.

(5)	*Environment:*	V__C_{htr}	
	Cues:	burst, approach	
	Input:	ap^{j}ka	at^{j}ka
	Output:	apka	at^{j}ka

How does the loss of the most important cue affect the distribution of the contrast? As we see from (6a), palatalized labials are completely disallowed in this environment. As for coronals (6b), we find here a few sequences, all of which are hetero-morphemic clusters. Palatalized coronals are prohibited in clusters within morphemes.

Similar patterns are also manifested in alternations in (7). While adding a hetero-organic suffix depalatalizes labials, it does not necessarily affect coronals.

(6)	a.	šlë[pn]ut'	'to slap'	*-[p^jn]-	
		le[pt]a	'mite'	*-[p^jt]-	
		to[pk]a	'furnace'	*-[p^jk]-	
	b.	po[dm]oga	'help'	ve[d^jm]a	'witch'
		o[tp]ast'	'to fall off'	su[d^jb]a	'fate'
		re[tk]o	'rarely'	re[t^jk]a	'radish'

(7)	a.	golu[p^j]	'pigeon'	golu[pk]a	'female pigeon'
		ce[p^j]	'chain'	ce[pn]oj	'chain', adj.
	b.	ba[t^j]a	'dad'	ba[t^jk]a	'dad', familiar
		xo[d^j]it'	'to walk'	xo[d^jb]a	'walking'

Table 8 summarizes the distribution of labials and coronals in the absence of release providing the number of attested clusters with plain and palatalized stops, as well as the number of contrastive clusters (in parenthesis).

V__C_{htr}V	Labial	Coronal
Clusters with C	9	4
Clusters with C^j	0	3
Contrasts C • C^j	no	yes/no (3)

Table 8. Labial and coronal stops before hetero-organic consonants.

2.1.3 No Release, No Burst: Preconsonantal (__C_{hm})

Let's consider environments that lack both release and burst, which possess the two most salient cue sets. Here we look at positions before homorganic consonants or a lateral, since stops in Russian do not have their independent burst when followed by these segments (Jones and Ward 1969: 89, 105). The sequences *ap^{j}ma-at^{j}na* (8) are different from those in (5) only in the quality of following segment: it is a consonant of the same primary place of articulation as the palatalized stop (either labial or coronal). The only cues available here are those of the approach, the least important cueing component.

The result of this poorly cued combination of gestures is a complete neutralization of both palatalized labials (9a) and coronals (9b).

(8)	*Environment:*	V__C_{hm}	
	Cues:	approach	
	Input:	ap^{j}ma	at^{j}na
	Output:	apma	atna

(9)	a.	o[bm]an	‘deception’	*-[b^{j}m]-
		ca[pf]a	‘pin’	*-[p^{j}f]-
	b.	e[tn]os	‘ethnos’	*-[t^{j}n]-
		o[tl]ožit’	‘to put off’	*-[t^{j}l]-
		o[tt]orgnut’	‘to tear away’	*-[t^{j}t]-
		o[ts]adit’	‘to displant’	*-[t^{j}s]-
		o[tʃ]el’nik	‘hermit’	*-[t^{j}ʃ]-
		o[tts]epit’	‘to unhook’	*-[t^{j}ts]-

This is also evident in the synchronic depalatalization in (10). For example, the nasal plosion in *pu*[tn]*yj* or lateral plosion in *ko*[tl]*y*, or the following fricative in *my*[ts]*a* do not allow for an independent burst, and lead to neutralization of the underlying palatalized coronal.

(10)	pu[t^j]	‘way’	pu[tn]yj	‘worthwhile'
	my[t^j]	‘to wash’	my[ts]a	‘to wash oneself'
	ko[t^j]ël	‘boiler’, sg.	ko[tl]y	‘boiler’, pl.
	o[t^j]ec	‘father’	o[ts:]a	‘father’, gen.sg.

I summarize the outcome caused by the absence of two most salient cue sets in Table 9: palatalized stops are never found here.

V__C_{hm}	Labial	Coronal
Clusters with C	2	7
Clusters with C^j	0	0
Contrast C • C^j	no	no

Table 9. Labial and coronal stops before homorganic consonants.

As we can see in (11) only the sequences that allow for a burst constitute a set of well-formed clusters: *t^{j}p, t^{j}k, t^{j}m,* and *t^{j}f* (11a). Those that are not characterized by burst result in ungrammatical sequences (11b).

(11)	a.	t^{j}p, t^{j}k, t^{j}m, t^{j}f	Burst: yes
	b.	*t^{j}t, *t^{j}s, *t^{j}ʃ, *t^{j}n, *t^{j}l, *t^{j}ts	Burst: no

Summing up the facts reviewed here, the presence of all cues to palatality results in the most contrastive context. An absence of release leads to neutralization of palatalized labials. And the absence of burst is the factor that triggers neutralization of palatalized coronals. Having no approach does not affect palatalized stops to the same degree as having no release or burst.

2.2 Word Edges

It should be noted that segments at word edges may benefit from more acoustic cues in connected speech than segments in word-internal clusters (Hamilton 1996: 235). Thus a word-initial consonant following a vowel-final word receives additional approach cues (12a), and a word-final consonant preceding a vowel-initial word is supplied with release cues (12b) correspondingly. On the other hand, segments in internal clusters are not affected and thus are at a disadvantage. Thus, we are to expect systematic distributional asymmetries between these contexts.

(12) a. vo t'mu -[ʌt^{j}m]- ‘in the dark'
additional approach

b. golub' uletel -[up^{j}u]- ‘a pigeon flew away'
additional release

2.3 Summary

Let’s now summarize how the available phonetic cues determine whether palatality in Russian is preserved or neutralized. In Table 10 I show sets of cues (a through k) that differ in perceptual salience and can be found in the corresponding linear environments.

Comparing the sets of cues and environments with the corresponding neutralization patterns reveals the fact that licensing of a plain-palatalized contrast depends crucially on the cues. Having at least two high salient cues, those of release and burst, results in a fully licensed plain-palatalized contrast (abc). Burst and approach with an optional release are sufficient to support the distinction (d). However, removing approach from this set causes minor restrictions, more apparent with labials: there is only one contrastive

	Cues			Environment	Contrast C • C^j	
	release »	burst »	approach		Labial	Coronal
a.	√	√	√	V__V	yes	yes
b.	√	√	(√)	#__V	yes	yes
c.	√	√		C__V	yes	yes
d.	(√)	√	√	V__#	yes	yes
e.	(√)	√		C__#	yes/no (1)	yes/no (5)
f.		√	√	V__C_{htr}	no	yes/no (3)
g.		√	(√)	#__C_{htr}	no	yes/no (1)
h.		√		C__C_{htr}	no	no
i.			√	V__C_{hm}	no	no
j.			(√)	#__C_{hm}	no	no
k.				C__C_{hm}	no	no

Table 10. Cues provided by environments and distribution of plain and palatalized stops (Note: (√) = the cue is optionally provided in connected speech; (1) = one contrastive cluster is attested).

cluster (e). Having no release is 'deadly' for labials; coronals still survive, provided two other components are present (fg). Only burst (h) or only approach (i, j) do not constitute a sufficient cueing environment. Even more so, no contextual cues (k) will inevitably lead to non-recoverability of the contrast by a listener. The discrepancies between the places of articulation follow from the hierarchy of salience (2), repeated in (13).

(13) a. Release » Burst » Approach
b. Coronal Burst » Labial Burst

In short, all the characteristic constraints on distribution of palatalized stops are derivable from phonetic information manifested in acoustic cues.[7]

We can formalize these results in the following way. We recast the hierarchy of cued environments given in (13) into a perceptibility scale, or fixed ranking of constraints (cf. Steriade 1997, Boersma 1997). These constraints, illustrated in (14), require neutralization of palatality in different environments. The constraints on gesture combinations that result in fewer cues are ranked higher, and those with more cues are lower.

[7] See Kochetov 1998 (to appear) on the neutralization before front vowels.

(14) *PAL/V__V: Neutralize palatality contrast between vowels.
*PAL/#__V: Neutralize palatality contrast word-initially (in the absence of the preceding vowel).
*PAL/V__#: Neutralize palatality contrast word-finally (in the absence of the following vowel), etc.

The faithfulness constraint to palatalized consonants, PRESPAL (15), can be ranked against the fixed hierarchy, determining a language-specific pattern of neutralization, or a threshold of perceptibility of the contrast. Preserving the contrast in a less cued environment implies maintaining it in a more informative context. (16) illustrates the distributional patterns attested in Russian. Some other possible cross-linguistic patterns based on different rankings of PRESPAL against the same hierarchy are shown in Appendix.

(15) PRESPAL: Preserve a plain-palatalized contrast.

(16)

	Constraint hierarchy: *Labials*	Constraint hierarchy: *Coronals*	Cues
neutralize	*PAL/C__C		*fewer cues*
	*PAL/#__C		
	*PAL/V__C	*PAL/C__C	
PRESPAL	---------------	---------------	⇓
	*PAL/C__#	*PAL/#__C	
	*PAL/V__#	*PAL/V__C	
	*PAL/C__V	*PAL/C__#	
preserve	*PAL/#__V	*PAL/V__#	
	*PAL/V__V	*PAL/C__V	
		*PAL/#__V	
		*PAL/V__V	*more cues*

This hierarchy can be further refined if we consider factors that affect perception of palatalized consonants: the quality of the following or preceding consonant (hetero-organic vs. homorganic; sonorant vs. obstruent) and vowel (back vs. front), stress, etc. These factors form sub-hierarchies within the constraints in (16). They differ in their relative importance and may interact with each other allowing for certain trade-offs.

It is important that this hierarchy of constraints is not a devised stipulation, but a result of the presence or absence of phonetic cues provided by the environments.

3 Conclusion

The presented analysis of neutralization of plain-palatalized contrasts in stops is based on the phonetic and phonotactic facts of Russian. The account provides evidence for the hypothesis of *Licensing by Cue*, demonstrating that palatalized stops can be licensed or neutralized depending on availability of phonetic auditory information, and, particularly, the contextual cues of release, burst, and approach, and their relative salience. Further, differences between places of articulation are based on acoustic properties of burst and approach. The distribution of these cues in linear environments results in a perceptibility scale that can be modeled as a fixed hierarchy of contextual constraints on the palatality contrast. Finally, the account provides additional support for the view that phonotactics make reference to phonetic information available in contextual cues and that phonetics plays an important role in determining environments for the neutralization of phonological contrasts.

Appendix

Type	Language	V__V	#__V	V__#	V__C	C__C
A	???	yes	yes	yes	yes	yes
B	Russian Mordva Scots Gaelic	yes	yes	yes	yes	no
C	Irish Manx	yes	yes	yes	no	no
D	Bulgarian Lithuanian Nenets	yes	yes	no	no	no
E	Karelian Saami	yes	no	no	no	no

Table 1. A typology of palatalized contrast: coronal stops (from Kochetov 1998 (to appear).

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