PHONETIC SOURCES OF PHONOLOGICAL ASYMMETRIES: RUSSIAN LATERALS AND RHOTICS*

Alexei Kochetov
Simon Fraser University

1. Introduction

It has been noted that secondary articulation contrasts in laterals and rhotics exhibit certain phonological asymmetries: If a language has palatalized (or palatal) liquids, most likely these are laterals rather than rhotics (Maddieson 1984, Walsh-Dickey 1997). Front/back contrasts in laterals are relatively stable diachronically, while similar contrasts in trills/taps exhibit a strong tendency to positional or total neutralization (Bhat 1978, Carlton 1990). Palatalized laterals tend to occur in a wider range of phonotactic contexts than palatalized rhotics do (Walsh-Dickey 1997, Hall 2000).

Depalatalization is a common process neutralizing the non-palatalized/palatalized contrast. Palatalized rhotics, however, are more susceptible to depalatalization than palatalized laterals. For example, in Irish, /r^j/ depalatalizes before (homorganic) consonants and word-initially, while the two palatalized laterals /l^j/ and /l̪^{j}/ do not (Ó Siadhail 1989:84) (1a). In Ukrainian, /r^j/ depalatalizes syllable-finally, while /l^j/ does not (Carlton 1990:283) (1b). In Russian, /r^j/ depalatalizes before homorganic consonants, while /l^j/ does not (1c).

(1)	a.	*Irish*		
		taː[r]n^{j}ə	'nail'	*taː[r^j]n^{j}ə
		[r]i	'king'	*[r^j]i
		pe[l^j]s^{j}eːr	'pilchard'	
		[l̪^{j}]ɑːm	'I melt'	
	b.	*Ukrainian*		
		lika[r]	'doctor' nom.sg.	cf. lika[r^j]a gen.sg.
		si[l^j]	'salt'	
	c.	*Russian*		
		ca[r]skij	'tsar' adj. *ca[r^j]skij	cf. ca[r^j] 'tsar' noun
		bo[l^j]noj	'ill'	cf. bo[l^j] 'pain'

In clusters, palatalized consonants often trigger secondary articulation assimilation of preceding non-palatalized consonants. This process, for example, is common in Russian. While the palatalized lateral /l^j/ assimilates preceding

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non-palatalized coronals (although variably; Avanesov 155–156) (2a), the palatalized /r^j/ never triggers assimilation (2b).

(2) *Russian*

a. pe[t^{j}l^j]i ‘loop’ pl. me[d^{j}l^j]enno ‘slowly’

b. smo[tr^j]it ‘(he) look’ bo[dr^j]et’ ‘to cheer up (oneself)’

Previous works proposed formal synchronic accounts of these markedness asymmetries (Walsh-Dickey 1997, Hall 2000). The role of phonetic factors in the evolution of these asymmetries has not been thoroughly investigated. This study examines articulatory properties of Russian liquids: the laterals /l/ and /l^j/ (e.g. mo[l] ‘pier’ vs. mo[l^j] ‘moth’), and the rhotics /r/ and /r^j/ (e.g. xo[r] ‘choire’ vs. xo[r^j] ‘polecat’). The goal of the study is to determine phonetic differences between the non-palatalized and palatalized counterparts and to establish whether these differences may shed light on the phonological asymmetries between laterals and rhotics in Russian (and possibly in cross-linguistically).

Two hypotheses are tested in this study. The first, rather general, hypothesis is that greater articulatory (and acoustic) differences between any two segments render (synchronically or diachronically) a contrast more stable phonologically, less susceptible to neutralization (Kochetov 2002; cf. Flemming 1995, Padgett 2001 for a similar approach). With respect to liquid contrasts, the prediction is that non-palatalized and palatalized laterals are more different from each other in articulation/acoustics compared to non-palatalized and palatalized (coronal) rhotics. The second hypothesis concerns gestural timing. Different patterns of timing of articulatory gestures are known to affect perceptibility of consonants (Silverman 1997). A simultaneous timing of a secondary palatal gesture and the primary tongue tip gesture for a liquid will result in a palatalized consonant cued by VC and CV transitions and the closure. A timing of the secondary palatal gesture either at the right or left edge of the tip gesture will result in a palatalized consonant cued mainly by either VC or CV transitions (as well as by the closure). Such a consonant would be more vulnerable perceptually in contexts where VC or CV transitions are not available, for example, word-initially or word-finally (or rather utterance-initially and utterance-finally). In addition, an earlier or later timing of a gesture may increase or decrease overlap of this gesture with gestures of preceding or following consonants in clusters. This may have consequences for patterns of assimilation. These two hypotheses will be tested below.

2. Previous investigations of the articulation of Russian liquids

I will begin with a review of relevant articulatory descriptions of the Russian liquids, focusing on the accounts given in Matusevich 1976 (based on x-ray data), Skalozub 1963 (x-ray data and palatography), Bolla 1981 (x-ray data, palatography, and acoustics), and Jones & Ward 1969 (based on informal, yet astute auditory observations).

2.1 Laterals /l/ and /l^j/

According to Matusevich (1976:152–56), the non-palatalized /l/ is articulated with the tongue tip at the teeth; the front and mid part of the tongue are substantially lowered, while the tongue dorsum is slightly raised to the velum and moved back; the tongue sides are lowered. The consonant is thus a velarized apical dental lateral. For /l^j/, the tongue tip is in the same position as for /l/, its blade and the tongue front are raised to the hard palate, as for the vowel [i]. The tongue dorsum and the tongue root are moved forward and lowered. The consonant is thus a palatalized apical/laminal dental/alveolar lateral.

Other researchers provide similar descriptions of /l/: a velarized apical dental or fronted alveolar (Skalozub 1963:57), a velarized apical dental/alveolar (Jones & Ward 1969:167), or a pharyngealized apical alveolar (Bolla 1981:143–148). /l^j/ is described as a palatalized laminal post-alveolar (Skalozub 1963:57), a palatalized apical/laminal alveolar (Jones & Ward 1969:165–166), or a palatalized apical alveolo-prepalatal (Bolla 1981:143–148). Skalozub (1963:63) notes that the "articulatory focus" of /l^j/ is moved back compared to the non-palatalized /l/, even further than for the palatalized alveolar stops and nasals /t^j d^j n^j/. She also notes that the tongue tip during /l^j/ is lowered to the lower teeth. Ladefoged & Maddieson (1996:187), based on cine x-rays from Koneczna & Zawadowski (1956), confirm that the main distinction between the two Russian laterals is in the retracted tongue dorsum vs. raised/fronted tongue front, as well as in narrowing vs. widening of the pharynx. They also note that that /l/ and /l^j/ differ in their primary articulation, which is realized as apical alveolar vs. laminal alveolar, or for some speakers, laminal dental (187).

2.2 Rhotics /r/ and /r^j/

Matusevich (1976:152–56) describes /r/ as 'retroflexed', having the tongue tip raised to the teeth or alveolar ridge. The tongue blade and the tongue front are lowered, while the tongue dorsum is moved back and slightly raised to the velum. The consonant, however, is not velarized. For /r^j/, the tongue front is raised to the hard palate as for /i/; the tongue tip is straightened and directed to upper teeth, somewhat lower than for /r/; the tongue dorsum and the tongue root are moved forward.

Other researchers describe /r/ is an apical/retroflex post-alveolar (Skalozub 1963:57), an apical alveolar (Jones & Ward 1969:176), or a weakly pharyngealized apical/retroflexed alveolar (Bolla 1981:143–148). /r^j/ is described as a palatalized apical/laminal alveolar (Skalozub 1963:57), a palatalized apical fronted alveolar (Jones & Ward 1969:184–185), and a palatalized apical alveolar (Bolla 1981:143–148). Based on palatograms from Skalozub (1963), Ladefoged & Maddieson (1996:221, 223) conclude that the Russian /r/ is post-alveolar, while /r^j/ is dental; both are also differentiated by the tongue shape.

All researchers describe /r/ as a trill having 1 to 4 taps, depending on environment. According to Matusevich (1976:152–56), /r/ has 1-2 taps word-initially before vowels, before, and after consonants, 3-4 partly devoiced taps word-finally, and only one tap intervocalically. /r^j/ is noted to have the same number of taps as /r/, being strongly devoiced utterance-finally. Jones & Ward (1969:184–185) come to a similar conclusion, while noting that "it is more difficult to prolong r^j than to prolong r" (185). Kavitskaya (1997:751) also notes the difficulty of trilling /r^j/. She observes that the sound tends to have only one tap even in word-initial position in hyper-articulated speech. (See also Skalozub 1963 and Bondarko 1977:66 on the trill/tap differences between the two rhotics).

2. Method

Data for this study came from a corpus of Russian EMMA data (Kochetov & Goldstein 2002; EMMA = Haskins Electromagnetic Midsagittal Articulometer, Perkell et al. 1992). The subjects were three female native speakers of Russian speakers, further referred to as S1, S2, and S3. The data included nonsense utterances with word-final liquids /l/, /l^j/, /r/, and /r^j/: ta[ɫ] apɨ, ta[l^j] apɨ, ta[r] apɨ, ta[r^j] apɨ. Each utterance was produced 5 times in a random order.

During data collection, articulometer receivers were placed on the following the following articulator points: upper lip (UL), lower lip (LL), maxilla (M; at the lower teeth), and four points on the tongue: from the tongue tip (or rather a few mm beyond it) to a point close to the tongue dorsum. Figure 1 (sagittal displays) depicts these points during the articulation of the four consonants as produced by one of the speakers. The analysis below is based on the movement trajectories of two receivers most relevant to the production of the non-palatalized/palatalized liquids: the tongue tip (TT) and the tongue body (TB) – the first and third receivers placed on the tongue, from left to right.

The trajectories of the TT and TB receivers are shown in Figure 1 below the corresponding sagittal displays. Onsets and offsets of movements of articulators were automatically labeled (see Kochetov, to appear), approximating the beginning of an articulatory gesture (See *A* in the display of the TB trajectory of /l^j/), its target achievement (*B*), its constriction release (*C*), and its offset (*D*). Note that while all four liquids have clearly defined tongue tip gestures (TT raising in Figure 1), only the palatalized liquids have the tongue body gesture (TB raising). The placement of the tongue dorsum receiver was not sufficiently posterior to capture the velarization (tongue body backing) of the non-palatalized /l/; therefore, data from this receiver were not analyzed.

Measurements involved the vertical and horizontal position of the tongue tip and the tongue body measured at the vertical maximum (TT and TB, in mm), the duration of the two gestures (the closing movement and the constriction, in ms), and the relative timing of the TT and TB constrictions for palatalized consonants (in ms). The timing was based on the measures of achievement lag (the TB target achievement minus the TT target achievement) and release lag (the TB constriction release minus the TT constriction release). Analyses of variance (ANOVA) with the factor consonant (4 levels: /l/, /l^j/, /r/, and /r^j/) were used to determine significant effects. The results are presented below in the following order: the TT position, the TB position, duration and timing of the TT and TB gestures.

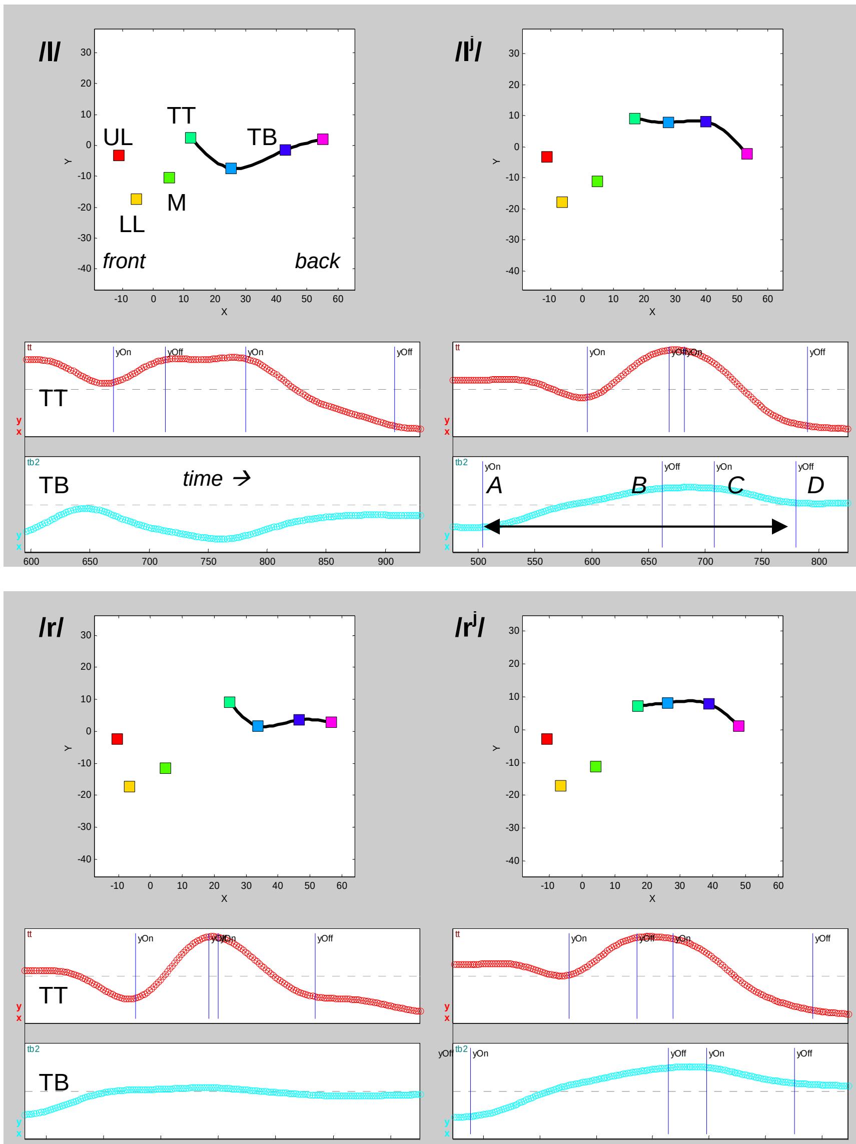

Figure 1. Sample sagittal displays and vertical trajectories of the tongue tip (TT) and tongue body (TB) of /l/, $/l^j/$, /r/, and $/r^j/$ produced by Speaker 2 in the context [ta__ apɨ] (the second repetition). The sagittal displays show positions of EMMA receivers at the offset of the tongue tip constriction.

3. Results

3.1 The tongue tip position

The ANOVA results for the tongue tip (TT) position indicated that there was a main effect of consonant for all three speakers, both for TT raising ($F(3,19)=78.606$, $p<.001$; $F(3,19)=30.574$, $p<.001$; $F(3,20)=23.968$, $p<.001$) and for TT fronting: ($F(3,19)=87.364$, $p<.001$; $F(3,19)=141.035$, $p<.001$; $F(3,20)=60.935$, $p<.001$). Figure 2 presents the spatial TT position values for actual tokens for the four consonants produced by three speakers (S1, S2, and S3). In the figure, more front values are shown on the left, and more back values are shown on the right.

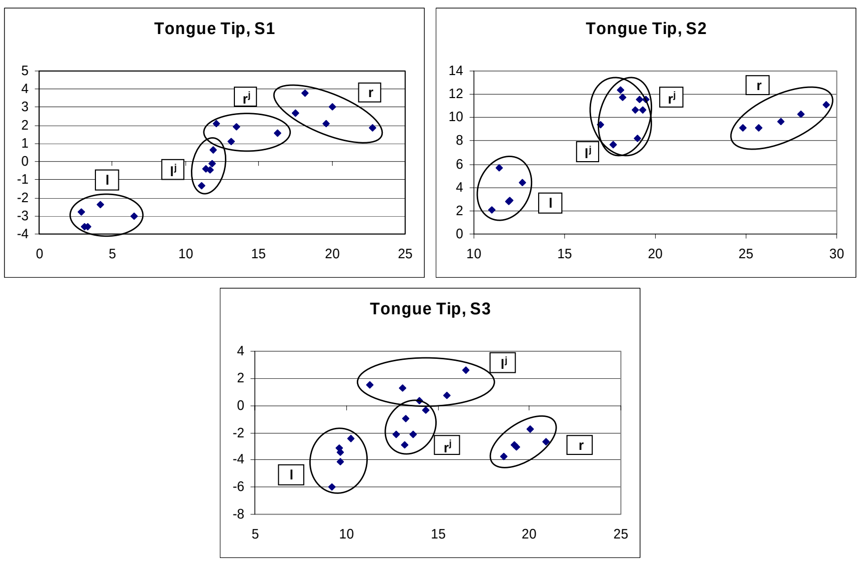

Figure 2. Position (xy) values of the maximum tongue tip constriction for /l/, /l^j/, /r/, and /r^j/ (in mm), actual tokens for three subjects.

For all speakers, the TT of /l^j/ is higher and more back than the TT of /l/ ($p<.001$ for all three speakers). On average, the vertical difference is about 5 mm; the horizontal difference is about 6 mm. The TT for /r^j/ is of about the same height as the TT for /r/ (n.s.); the former, however, is considerably more front than the latter ($p<.001$). This difference is on average 8 mm. For the non-palatalized liquids, the TT for /l/ is lower than the TT for /r/ for some speakers (S1 and S2; $p<.001$). The former is more front than the latter for all three speakers ($p<.001$). This difference is on average 16 mm. For the palatalized liquids, there were no consistent differences in the TT front/back or high/low position. Thus, for one speaker, the TT for /l^j/ was lower than the TT for /r^j/ (S1: $p<.001$); the reverse was observed for another speaker (S3: $p<.001$). There were no other significant differences.

In sum, the palatalized/non-palatalized differences in the TT position are asymmetrical for laterals and rhotics. While the constriction for /l^j/ is more back and higher than for /l/, the constriction for /r^j/ is more front than for /r/.

3.2 The tongue body position

The ANOVA results for the tongue body (TB) position indicated that there was a main effect of consonant for all three speakers, both for TB raising ($F(3,19)=47.813$, $p<.001$, $F(3,19)=199.602$, $p<.001$, $F(3,20)=850.646$, $p<.001$) and for TB fronting ($F(3,19)=170.692$, $p<.001$, $F(3,19)=18.102$, $p<.001$, $F(3,20)=143.948$, $p<.001$). Figure 3 presents the spatial TB position values for actual tokens for the four consonants produced by three speakers.

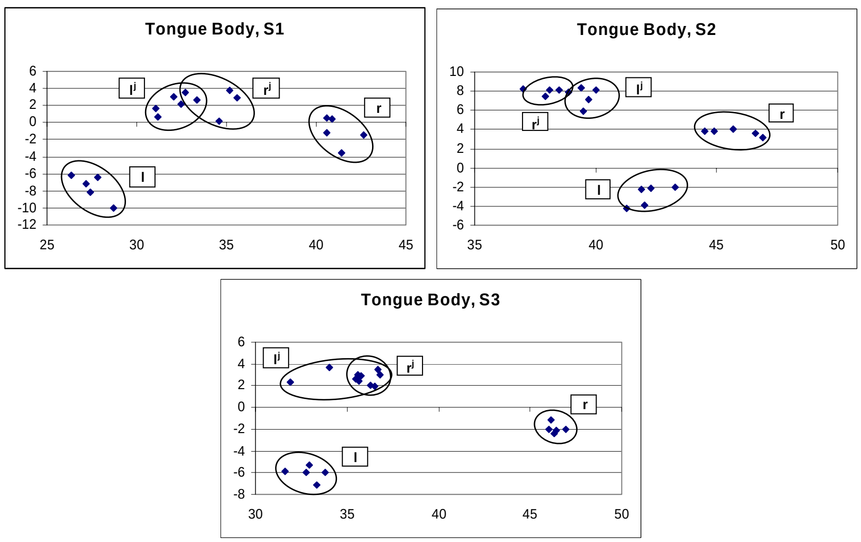

Figure 3. Position (xy) values of the tongue body measured at the release of tongue tip constriction for /l/, /l^j/, /r/, and /r^j/ (in mm), actual tokens for three subjects.

It can be seen from the figure that palatalized consonants /l^j/ and /r^j/ have higher TB values than non-palatalized consonants /l/ and /r/ ($p<.001$ for all three speakers). Interestingly, however, the differences in the TB height (the main articulatory correlate of palatalization; Kochetov, to appear) are larger for the laterals than for the rhotics. Averaged across speakers, /l^j/ is different from /l/ in terms of the tongue body raising position by about 10 mm, while /r^j/ is different from /r/ by about 4 mm. Further, the TB for the non-palatalized /l/ is substantially lower than for the non-palatalized /r/, on average by 6 mm ($p<.001$). The difference between the palatalized consonants is not significant for any of the speakers. In terms of the TB fronting, speakers show some variation in laterals: the TB of /l/ is more front than that of /l^j/ for some speakers (S1: $p<.001$; S3: $p<.05$), while the reverse is found for others (S2: $p<.001$). For all speakers, /r^j/ is considerably more front than /r/ ($p<.001$). On average, this difference is about 8 mm. Further, the TB for /l/ is substantially more front than the TB for /r/ ($p<.001$). The values for /l^j/ tend to be somewhat more front than for /r^j/; this difference is significant for two out of three speakers (S1: $p<.001$; S2: $p<.05$).

In sum, the tongue body for palatalized liquids is higher (and more front for /r^j/) than for their non-palatalized counterparts. The difference in the tongue body raising, the main correlate of palatalization, is greater for the laterals than the rhotics. The tongue body is more front for the laterals than for the rhotics, particularly for the non-palatalized liquids.

3.3 Duration and timing

The results for the TT constriction duration of the four liquids indicated that there was a main effect of consonant for all three speakers ($F(3,19)=12.876$, $p<.001$, $F(3,19)=36.380$, $p<.001$, $F(3,20)=14.385$, $p<.001$). The TT constriction for /l^j/ was shorter than for /l/ for two speakers (S2: $p<.001$; S3 $p<.01$). For the other speaker, the difference was in the same direction, but did not reach the significance level (S1; $p=.065$). On average, the constriction for /l^j/ had the duration of 22 ms, while the constriction for /l/ had the duration of 54 ms. The TT constriction duration did not significantly differentiate the rhotics /r/ and /r^j/ for two speakers (S1 and S2). For the other speaker, /r^j/ had a shorter constriction than /r/ (S3; $p<.01$). On average, the constriction for /r^j/ had the duration of 12 ms, while the constriction for /r/ had the duration of 25 ms. For all three speakers, the constriction of /l/ was longer than the constriction of /r/ ($p<.001$). The duration differences between /l^j/ and /r^j/ were not significant for two speakers (S2 and S3); for the other speaker, /l^j/ had a longer constriction than /r^j/ (S1; $p<.05$).

The results for the TB constriction duration of palatalized liquids indicated that there were no significant differences between /l^j/ and /r^j/ for two out of three speakers (S1: $F(1,8)=1.022$, $p=.346$; S3: $F(1,9)=.017$, $p=.899$). For the other speaker, the effect of consonant was significant (S2: $F(1,9)=14.981$, $p<.01$): /l^j/ had a somewhat longer constriction than /r^j/. On average, the TB constriction for /l^j/ had the duration of 33 ms, while the constriction for /r^j/ had the duration of 23 ms.

The results for the timing of the TT and TB constrictions, showed that there was a main effect of consonant for all three speakers for both achievement lag ($F(1,9)=40.181$, $p<.001$; $F(1,10)=123.371$, $p<.001$; $F(1,10)=13.315$, $p<.01$) and release lag ($F(1,9)=147.912$, $p<.001$, $F(1,10)=7.778$, $p<.05$, $F(1,10)=61.141$, $p<.001$). Figure 4 presents the timing of the TT and TB gestures for both palatalized liquids for three speakers. The duration of each gesture includes the closing movement (the movement towards the constriction) and the constriction. Dotted lines indicate the lag between the achievement and release of the TT and TB constrictions. The gestures are aligned by the achievement of the TT constriction.

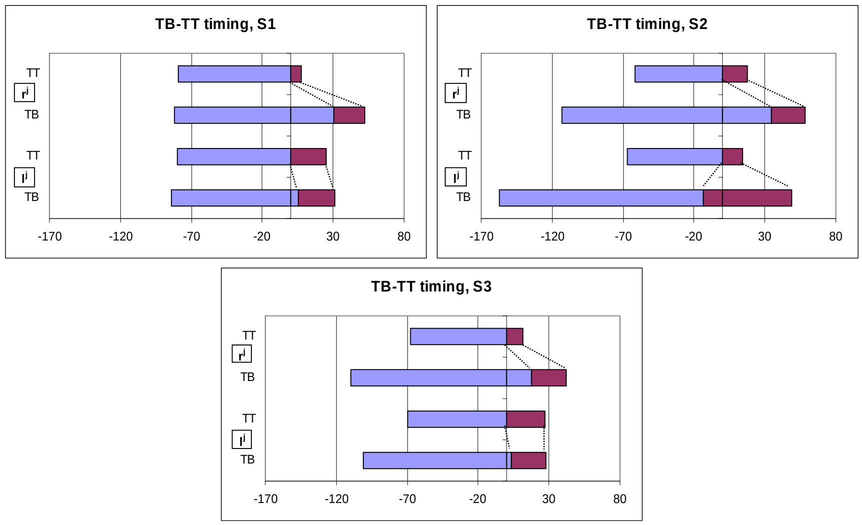

Figure 4. Timing of the tongue body and tongue tip of the palatalized /l^j/ and /r^j/, mean values (in ms) for three subjects.

The important difference between the two palatalized liquids is the timing of the two constrictions. For /l^j/, the TB achieves its target and is released almost simultaneously with TT. On average, the achievement lag for /l^j/ is about -5 ms and the release lag is about 9 ms. For /r^j/, the achievement and the release of TB are considerably delayed with respect to TT. On average, the closing lag is about 28 ms and the opening lag is about 38 ms. (Note that the greater length of the TB closing movements for Speaker S2 can be in part attributed to the tongue body lowering during the production of the preceding [t]; see Figure 1).

In sum, the duration of TT and TB constrictions does not differentiate the consonants consistently, however, there is a tendency for the laterals to be longer than the rhotics, and for the non-palatalized liquids to be longer than their palatalized counterparts. While the TT and TB constrictions are near-simultaneous for /l^j/, the TB is delayed with respect to the TT for /r^j/.

4. Discussion

The results show that the non-palatalized/palatalized liquids differ in terms of the location of their primary and secondary constrictions; they also show some differences in the duration and in the relative timing of constrictions.

In terms of the tongue tip position (the primary constriction) of the laterals, /l^j/ is articulated higher and more back than /l/. This corresponds to the alveolar vs. dental distinction (Jones & Ward 1969, Skalozub 1963). The more back TT position for the palatalized lateral can be a by-product of the raising of the TB, the gesture described as the “articulatory focus” of /l^j/ (Skalozub 1963). The non-palatalized /l/ tends to have a longer TT constriction than the palatalized /l^j/. The palatalized /l^j/ is characterized by a TB position considerably higher than the TB position of /l/. These differences reflect two distinct tongue configurations: while the tongue blade/front is raised to the hard palate for /l^j/, it is lowered for /l/, likely due to the tongue dorsum backing and raising (velarization: Jones & Ward 1969; Matusevich 1976). Note that the TB raising movement (the secondary articulation) for /l^j/ has a substantial extent in time; it is longer than the TT fronting movement (the primary articulation). The constrictions of the two gestures tend to be timed simultaneously. In terms of the more back TT position and the timing of TT and TB gestures, /l^j/ is rather similar to the palatalized stop /t^j/ (Kochetov 2002).

Turning to the rhotics, the tongue tip for the palatalized /r^j/ is in a more front position compared to the non-palatalized /r/ (unlike for the laterals). This corresponds to the alveolar vs. post-alveolar distinction (Skalozub 1963). The TT fronting for /r^j/ can be caused by the incompatibility of the apical post-alveolar articulation with the TB raising: the curling of the TT back to the hard palate and the fronting/raising of the TB in the same direction are inherently conflicting gestures (Ladefoged & Maddieson 1996:188; Hamann 2003, Kochetov 2002). The TB position for /r^j/ is almost as high and front as for /l^j/. The TB for /r/ is intermediately raised and substantially backed, a likely side effect of the tongue tip raising towards the post-alveolar region for this consonant (discussed further). Given these articulatory differences, the main correlate of the non-palatalized/palatalized contrast in coronals – the high vs. low position of the fronted tongue body gesture – is smaller for rhotics than for laterals. The constriction duration of both rhotics is relatively short, reflecting their tap-like rather than trill-like articulation in the intervocalic position (Matusevich 1976).

As with /l^j/, the TB raising movement for /r^j/ is longer than the TT fronting movement; however, the timing of the two constrictions is different: the TB follows the TT showing a considerable lag. The timing pattern exhibited by /r^j/ can be explained by several factors. First, the asynchrony of the two gestures can be caused by the conflicting demands imposed on the tongue by apical and palatal articulations mentioned above: it may not be possible to achieve the two targets simultaneously, at least without jeopardizing the rhotic percept. Second, perhaps related to the previous point, the asymmetry may be caused by purely aerodynamic factors: "the raising of the blade and front of the tongue that is required for the palatalization may make it more difficult to maintain the aerodynamic conditions for trilling" (Ladefoged & Maddieson 1996:221; see also Kavitskaya 1997 for detailed discussion). Retiming of the two gestures may thus make it possible for trilling to occur (at least in certain contexts; Matusevich 1976; Jones & Ward 1969; Skalozub 1963). Third, timing differences between the palatalized laterals and rhotics may be affected by their perceptual properties: Laterals tend to have a clear acoustic formant pattern during their closure periods, so a simultaneous timing of the TT and TB gestures insures stable formant transitions during the closure: a relatively high F2 for /l^j/ (around 1900 Hz: Bolla 1981). In the production of the non-palatalized /l/, a simultaneous timing of the TD backing and the TT raising would produce a stable formant pattern of a relatively low F2 (around 800 Hz; Bolla 1981). The formant differences between /l^j/ and /l/, extended over about 100 ms, result in a robust contrast. Apical trills (and taps) are less clearly characterized by their formant patterns which are interrupted by short periods of silence (Ladefoged & Maddieson 1996:219). Thus, a simultaneous timing of the TB and TT gestures for the palatalized rhotic would not have the same consequences as for the palatalized lateral. A delay of the TB, however, could be perceptually beneficial to /r^j/, since it contributes to the period of high frequency noise after the closure. This frication, typical of the Russian palatalized trill (Bondarko 1977:60), can be seen as an enhancement of the contrast between /r^j/ and /r/. At the same time, the delay of TB makes the non-palatalized/palatalized acoustic contrast more robust during the CV transition and less robust at the VC transition. This is unlike the acoustic contrast in laterals, which is relatively evenly distributed throughout the VCV sequence.

5. Conclusion

The study has identified substantial articulatory asymmetries between the Russian lateral and rhotic contrasts. Overall, the laterals /l/ and /l^j/ are more different from each other than the rhotics /r/ and /r^j/. The differences between the two non-palatalized/palatalized pairs are particularly apparent in the tongue body raising position. Further, the near-synchronous timing of the two gestures in /l^j/ makes the consonant relatively well-cued acoustically regardless of the position. Its contrast with /l/ is enhanced by the secondary velar articulation of the latter. The sequential timing of the two gestures in /r^j/ makes the consonant better cued in the prevocalic position rather than word-finally (utterance-finally) or before a consonant.

The findings confirm the two hypotheses. Greater articulatory differences (and resulting acoustic differences) between the two Russian laterals may render the contrast more phonologically stable. Smaller differences between the two rhotics, as well as the sequential timing of the palatalized gesture in /r^j/ possibly play a role in inducing the depalatalization of /r^j/ before consonants, the context where the perceptually valuable CV transitions are absent. In addition, the delay in timing of the palatalized gesture of /r^j/ leads to a smaller overlap of the gesture with the gestures of preceding consonants in clusters. It therefore may also explain the phonological status of /r^j/ as a non-trigger of palatal assimilation (2b).

To conclude, the asymmetries between laterals and rhotics in terms of secondary articulation contrasts are rooted in the physical properties of the consonants, and thus are, to a large degree, language-independent. Lateral articulations, in general, allow for more flexibility in realizations of secondary articulation contrasts than (alveolar) rhotic articulations do. The observed low-level asymmetries, mediated by learner's misperceptions (Ohala 1981; cf. Kochetov 2002, Blevins 2004), can be seen as the main driving force behind the evolution of the phonological asymmetries between palatalized laterals and rhotics.

References

Avanesov, R.I. 1972. *Russkoe literaturnoe proiznoshenie*. Moscow: Prosveshchenie.

Bhat, D.N.S. 1978. A general study of palatalization. In *Universals of language*, Vol. 2: Phonology, ed. J. H. Greenberg. Stanford University Press, 47–91.

Blevins, Juliette. 2004. *Evolutionary phonology*. Cambridge University Press.

Bolla, K. 1981. *A conspectus of Russian speech sounds*. Cologne: Bölau.

Bondarko, L.V. 1977. *Zvukovoi stroi sovremennogo russkogo iazyka*. Moscow: Prosveshchenie.

Carlton, Terrence R. 1990. *Introduction to the phonological history of the Slavic languages*. Slavica.

Flemming, E.S. 1995. Auditory representations in phonology. Doctoral dissertation. University of California, Los Angeles.

Hall, T. A. 2000. Typological generalizations concerning secondary palatalization. *Lingua* 111:1–25.

Hamann, Silke. 2003. *The phonetics and phonology of retroflexes*. Utrecht: LOT Press.

Kavitskaya, Darya. 1997. Aerodynamic constraints on the production of palatalized trills: The case of the Slavic trilled [r]. In *Proceedings from the 5th European Conference on Speech Communication and Technology*. Vol. 2, 751–754.

Kochetov, Alexei. 2002. *Production, perception, and emergent phonotactic patterns: A case of contrastive palatalization*. New York, London: Routledge.

Kochetov, Alexei. (to appear). Syllable position effects and gestural organization: Articulatory evidence from Russian. In: *Papers in Laboratory Phonology VIII*, eds. Louis Goldstein, Douglas Whalen, and Catherine Best. Berlin, New York: Mouton de Gruyter.

Kochetov, Alexei and Louis Goldstein. 2002. A corpus of Russian magnetic articulometer data. Haskins Laboratories. New Haven, CT.

Koneczna H. and W. Zawadowski. 1956. *Obrazy rentgenograficzne głosek rosyjskich.* Warszawa: Państwowe wydawnictwo naukowe.

Ladefoged, Peter and Ian Maddieson. 1996. *The sounds of the world's languages*. New York: Blackwell.

Maddieson, Ian. 1984. *Patterns of sounds*. Cambridge: Cambridge University Press.

Matusevich, M. I. 1976. *Sovremennyi russkii iazyk: fonetika*. Moscow: Prosveshchenie.

Ó Siadhail, Michael. 1989. *Modern Irish*. Cambridge: Cambridge University Press.

Ohala, John. 1981. The listener as a source of sound change. In *Papers from Chicago Linguistic Society parasession on language and behavior*, eds. C.S. Masek, R.A. Hendrick, and M.F. Miller. Chicago Linguistic Society, 178–203.

Padgett, Jaye. 2001. Contrast dispersion and Russian palatalization. In *The role of speech perception in phonology*, eds. Elizabeth Hume and Keith Johnson. San Diego, CA: Academic Press, 187–218.

Perkell, J.S., M. Cohen, M. Svirsky, M. Matthies, I. Garabieta, and M. Jackson. 1992. Electro-magnetic midsagittal articulometer (EMMA) systems for transducing speech articulatory movements. *Journal of the Acoustical Society of America* 92:3078–3096.

Silverman, D. 1997. *Phasing and recoverability*. New York, NY: Garland Publishing.

Skalozub, L.G. 1963. *Palatogrammy i rentgenogrammy soglasnykh fonem russkogo literaturnogo iazyka*. Kiev: Izdatel'stvo Kievskogo universiteta.

Walsh-Dickey, Laura. 1997. The phonology of liquids. Doctoral dissertation, University of Massachusetts.