INTERGESTURAL ORGANISATION AND CV-OVERLAP IN PALATALISED LIQUIDS IN RUSSIAN

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ABSTRACT

The current study investigates secondary palatalisation and its influence on vowels in liquids /lʲ/ and /rʲ/ in Russian, using Electromagnetic Articulography. First, temporal organisation between primary and secondary gestures in different word-positions and at different speech rates is analysed. Second, the overlap between secondary gesture and vowel /a/ in word-initial and -final positions is examined. Six native Russian speakers articulated real words embedded in a carrier sentence at a slow and a fast speech.

The results show that there is a greater variation in intergestural timing in /rʲ/ than in /lʲ/ subject to domain position and speech tempo. It is especially in word-initial position at slow speech rate where the lag between two gestures in /rʲ/ is the biggest. As a consequence, there is more overlap between secondary gesture and the vowel in word-initial position for /rʲ/ in comparison to /lʲ/.

Keywords: Intergestural timing, secondary palatalisation, CV-overlap, liquids.

1. INTRODUCTION

Several studies have already investigated intergestural organisation in liquids [1, 2, 6, 8, 9]. But much less work has been done on secondary articulation like palatalisation ([6]; [2] for Serbo-Croatian); and, to our knowledge, no study analyses articulatory interplay between palatalised consonants and vowels. In his studies, Kochetov [5-7] attested that different Russian palatalised consonants exhibit different patterns in intergestural timing. In [6], he analysed Russian palatalised vs plain liquids in word-final position and showed, firstly, that the timing between primary and secondary gestures is nearly simultaneous in laterals, but sequential in rhotics. Secondly, he observed less articulatory differences between palatalised vs plain rhotics than laterals (mainly manifested in shorter distances between tongue dorsum positions in former). He concluded that these two factors may lead to poorer decoding of the speech signal and to an often observed contrast neutralisation in palatalised vs plain rhotics.

In this study, we aim to investigate in more detail the relative timing between two gestures in Russian liquids as a function of syllable position and speech rate. Since trilling and palatalisation seem to be articulatorily incompatible [3, 4], we expect stronger influence of word domain and speech rate on palatalised rhotics than on laterals.

Our second aim is to analyse the intergestural coordination between palatalised consonants and the following vowel. Since /rʲ/ presents sequential timing between primary and secondary gestures, we expect more overlap between the secondary gesture and vowel in initial position for /rʲ/ than for /lʲ/.

2. METHOD

2.1. Speech material

Six native Russian speakers (5 female, 1 male; age: 25-35) pronounced real words embedded in a carrier sentence. Target words contained the consonants /r, rʲ, l, lʲ/ and the vowels /a, i, u/. We controlled for stress and number of syllables (mostly two-syllable words). In this study, only the analysis of vowel /a/ and consonants /rʲ/ and /lʲ/ will be presented. Different word domains were selected: word-initial, -medial, and -final positions. In word-initial and -medial positions, the vowel in question followed the liquid and was stressed. In word-final position, the reverse was true. The participants were asked to read the sentences at a slow and a fast speech rate alternately. The target words and translation are presented in Table 1.

Table 1: Speech material for /a/ vowel.

	word-initial	word-medial	word-final
/r/	/ˈramka/ ‘picture frame’	/zaˈrʲat/ ‘charge’	/kaˈmar/ ‘mosquito’
/rʲ/	/ˈrʲapʧik/ ‘hazel grouse’	/paˈrat/ ‘military parade’	/janˈvarʲ/ ‘January’
/l/	/ˈlampa/ ‘lamp’	/saˈlat/ ‘salad’	/slaˈmal/ ‘(he) broke’
/lʲ/	/ˈlʲamka/ ‘strap’	/paˈlʲat/ ‘(they) fire’	/eˈmalʲ/ ‘enamel’

All the subjects grew up in a Russian-speaking country and were monolingual in Russian until at least 17 years of age. They were recruited at a German university and had spent two to fifteen years in Germany at the time of recording. No speech or hearing disorders were reported. The speakers were unaware of the purpose of the study, except the first informant (first author).

2.2. Recordings

The participants were recorded with EMA (Carstens AG501) at a data rate of 1250 Hz. EMA coils were attached to the upper and lower lips, the jaw, and the tongue: tip (TT), mid (TM), and back (TB). Additional coils for head movement correction were located above the upper incisors, on the bridge of the nose, and behind each ear. Acoustic data were sampled at 25600 Hz. The speech material was presented to the speakers for reading ten to twenty times in randomised order. The sentences were displayed on a monitor in Cyrillic script.

2.3. Measurements

2.3.1. Relative timing between the primary and secondary gestures

In order to compare the relative timing between the primary and secondary gestures, we measured the distance (*lag*) between temporal midpoints of the plateaus:

(1) Lag = TM-plateau midpoint – TT-plateau midpoint

2.3.2. Overlap between secondary gesture and vowel

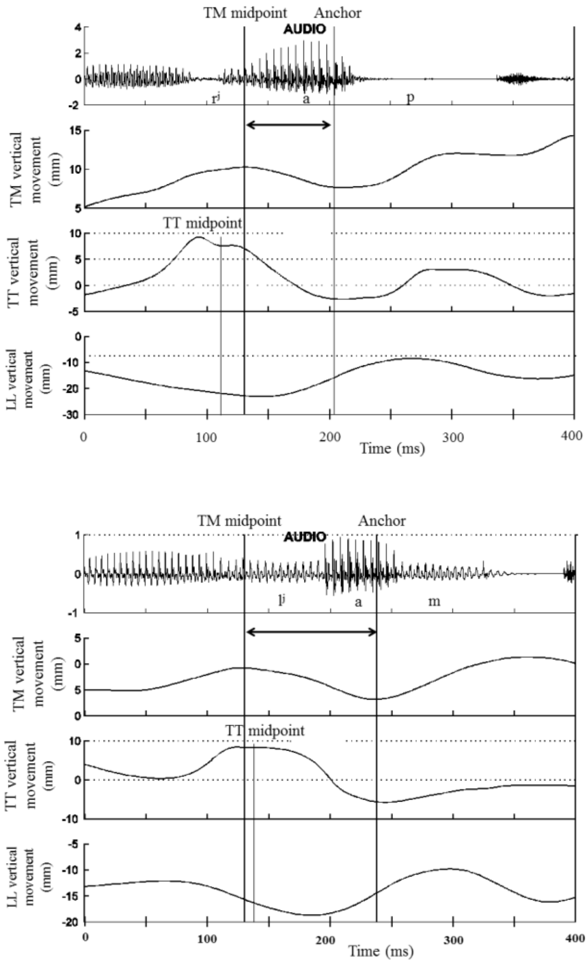
The interval between temporal TM-plateau midpoint and an anchor was measured. Lower lip maximum velocity of the following (or preceding, for the word-final position) labial consonant was selected as the anchor point. The lower lip maximum velocity onset was taken for word-initial position, and the offset for word-final position. Word-medial position was not considered here because the following consonant was an alveolar.

Figure 1 shows the interval measurements between the temporal TM-plateau midpoint and lower lip maximum velocity onset.

Acoustic vowel duration was also measured.

A statistical analysis with a linear mixed model (MM) in R with the speaker as a random factor and with consonant, speech rate, and word position as fixed factors was performed. If necessary, the post hoc Tukey test was used.

Figure 1: Example articulatory measurements for palatalised rhotic (top) and lateral (bottom) in word-initial position at a slow speech rate (female speaker 2).



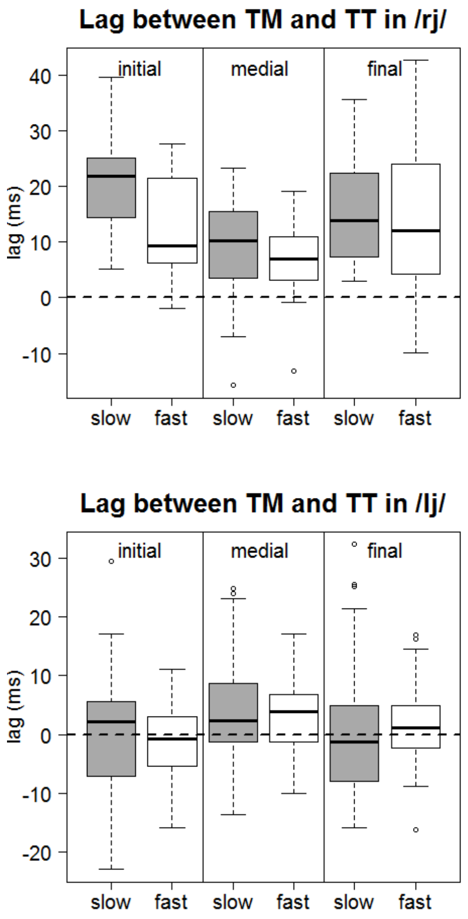
3. RESULTS

3.1. Intergestural timing

The results in lag differences between /l^j/ and /r^j/ are shown in Figure 2. Lag equal to zero means that the two gestures are simultaneous. Positive lag means that the secondary gesture occurred later than the primary one.

It can be observed that the lag between primary and secondary gestures is sequential in /r^j/ and almost simultaneous in /l^j/ (as already demonstrated in [6]). Moreover, note a greater influence of speech tempo and word position in /r^j/ than in /l^j/. Post hoc Tukey analysis indicated that there is a significant difference between word-initial and -medial positions at a slow speech rate for /r^j/ (z value = 5.2, $p < 0.001$). The difference between slow and fast speech rate in initial position was also significant (z value = 3.6, $p < 0.05$). In word-initial and –final positions, the lag was significantly greater in /r^j/ than in /l^j/, at both speech rates (Initial slow: z value = 7.1; Initial fast: z value = 4.8; Final slow: z value = 5.1; Final fast: z value = 4.8. $p < 0.001$). Interestingly, no significant difference in lag between /r^j/ and /l^j/ in medial position was observed, neither at a slow, nor at a fast speech rate (z value = 2, p = 0.6; z value = 1.4, p = 0.9, respectively).

Figure 2: Lag (in ms) between TM-plateau and TT-plateau midpoints in /r^j/ (top) and /l^j/ (bottom) for different word positions (initial, medial, final) and speech rates (slow, fast).



No influence of speech tempo or word domain on the timing between primary and secondary gesture was found in /l^j/.

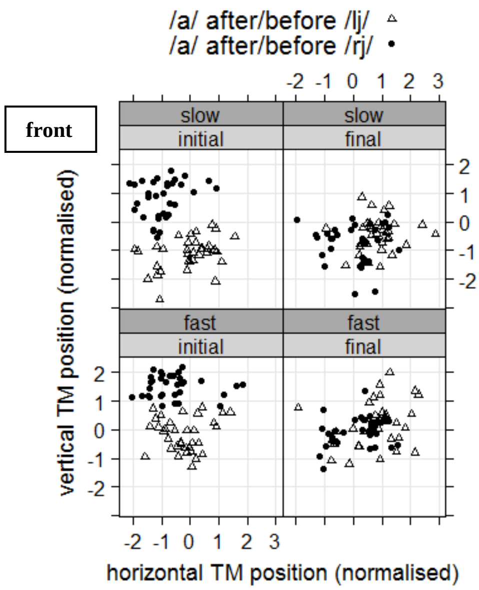
3.1. CV-overlap

Since the timing between the two gestures is sequential in /r^j/, the aim also was to analyse whether the secondary gesture in /r^j/ is more overlapped with the following vowel than in the case of /l^j/, word-initially. For this reason, the interval between TM-plateau midpoint and the anchor was measured. For initial position in sequences /r^ja/- and /l^ja/- a statistically significant difference was found (Initial slow: z value = 7.1; Initial fast: z value = 4.8. $p < 0.001$): The distance between TM-plateau midpoint and anchor was smaller for rhotics than for laterals (μ = 33 ms). In contrary, this distance was greater for rhotics in word-final position (μ = 19 ms. Final slow: z value = 3.1, $p < 0.05$; Final fast: z value = 3.8, $p < 0.01$).

If we compare the acoustic vowel duration after or before palatalised liquids, we find that there is a difference in vowel duration between /r^ja/- and /l^ja/- only in word-initial position at fast speech rate: vowel duration is greater after a palatalised rhotic (z value = 2.933, p = 0.045). There is no other statistical difference in acoustic vowel duration, irrespectively of whether /a/ occurred after or before a palatalised rhotic or lateral.

Finally, the TM positions in the temporal midpoint of /a/ vowel are presented in Figure 3. It can be seen that the vowel is more fronted and raised when a palatalised rhotic precedes the vowel. No differences can be observed when the /a/ vowel precedes the palatalised liquid (in word-final position).

Figure 3: TM position in the temporal midpoint of /a/ vowel following (word-initially) or preceding (word-finally) /l^j/ and /r^j/ at slow and fast speech. Normalised data over all speakers.



4. DISCUSSION

In this study, we analysed the intergestural timing in palatalised rhotics and laterals and the temporal organisation between secondary gesture and vowel /a/.

First, the results indicate that the intergestural timing is less stable in palatalised rhotics than in laterals, since rhotics are significantly influenced by word domain and speech tempo. Contrary to the predictions for liquids [9, 1, 2], it was shown that the lag between two gestures in /r^j/ is the greatest in initial position at a slow speech rate. Surprisingly, the timing between the two gestures in /r^j/ is nearly simultaneous in word-medial position and there was no statistical difference in lag between laterals and rhotics in this position. This asymmetry in rhotics may be explained in terms of perceptual recoverability (as already suggested in [6, 7]): word-initially, secondary palatalisation can be perceived almost only on C-to-V transitions. In word-medial position intervocalically, the hearer can perceive a palatalised rhotic on both V-to-C and C-to-V transitions.

However, the nearly simultaneous timing in rhotics word-medially raises the question of whether trilling and palatalisation are, after all, compatible (see [3, 4] for a phonetic explanation of conflicting production requirements between them). One possible explanation, which should still be investigated in our data, could be a gesture undershoot in word-medial position in comparison to the -initial position (resulting in a less stiff tongue tip contact or less tongue dorsum raising), which enables primary and secondary gestures to achieve their targets simultaneously.

Second, unlike other studies on laterals [9, 2] which showed differences in timing depending on word position, our results don't show any influence of word position or speech rate on intergestural coordination in palatalised laterals. As suggested in [2] for Serbo-Croatian, the two gestures seem to be coupled more tightly when a language presents a phonological opposition between palatalised and plain laterals (like in Russian). Unfortunately, it was impossible to put the coils further back on the tongue in order to analyse also the secondary articulation in plain (velarised) laterals.

Finally, since the interval between the TM-plateau midpoint and anchor is smaller for /r^j/ + /a/ than for /l^j/ + /a/ word-initially (although the acoustic vowel duration is the same), we conclude that there is more overlap between secondary gesture and vowel in rhotics than in laterals in this word position. The plotted TM position of /a/ followed or preceded by /l^j/ or /r^j/ (Fig. 3) clearly shows that the vowel is affected by the type of liquid in initial position: /a/ is more fronted when preceded by a palatalised rhotic than a palatalised lateral.

5. REFERENCES

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