The Second Formant Dynamics in Russian and Chinese Syllables

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It is well known that the very presence of complex coarticulation processes is a universal phenomenon due to the structure of the human articulatory system. At the same time, however, the features of the coarticulation processes are specific for each language [3].

The objective of the study was to analyze the dynamics of the second formant in Russian and Chinese syllables of the CV structure with palatalized and palatal consonants. As it is known from acoustic phonetics [2], the second formant is associated with a vowel row, and since the presence of consonants with the main or additional palatal articulation before vowels inevitably shifts the vowel row in the direction of [i]- or [j]-shaped articulation (especially at the beginning of a vowel), the dynamics of the second formant in such syllables will be the main indicator of the consonant-to-vowel transition specificity in the syllables of this type. Russian syllables like " palatalized consonant + vowel" are frequent and typical, since the opposition of non-palatalized and palatalized consonants is one of the system-forming oppositions of Russian consonantism, and non-palatalized and palatalized consonants form parallel phonemic series, which include almost all consonants of the Russian language. In the theoretical descriptions of Chinese consonantism, there is no consensus on the phonological interpretation of palatalized and palatal sounds, opinions differ greatly, but the very existence of these sounds is indisputable. Articulatory descriptions of these sounds always record the process of palatalization, expressed in the presence of additional palatal articulation. It appears that if the sound is not followed by the front upper vowel [i] or [y], then the consonant is followed by the palatal glide [j] or [ɥ]. Therefore, syllables denoted in pinyin as beginning with ji-, qi-, xi-, ju, qu-, xu-, followed by a vowel, are described phonetically as beginning with [t͡sʲ], [t͡sʰʲ], [sʲ], [t͡sᶣ], [t͡sʰᶣ], [sᶣ]) [1].

In the course of the experiment, the dynamics of the second formant in Russian and Chinese syllables with a relatively similar sound were compared. The syllables contained palatalized labial and anterolingual consonants followed by back vowels [a], [o], [u], as well as a palatal approximant [j] in combination with the same vowels. Posterior consonants were not studied, since they are impossible in Chinese in this context. The speakers were 4 Russians (two men, two women, 18-20 years old), native speakers of Russian standard pronunciation, and 4 Chinese speakers (also two men, two women, 18-20 years old), native speakers of Chinese standard pronunciation. The speakers read words that included syllables with the studied sounds in similar (in Russian and Chinese) phonetic contexts. In Russian, words were selected where the studied syllables were stressed, in Chinese, words where the studied syllables were strong forms, and in both languages, the speakers were asked to read the words as clearly and legibly as possible. In total, 88 Russian and 88 Chinese words were read, in which palatalized consonants were before non-front vowels. The next stage of the work was the FII dynamics study in Russian and Chinese syllables. To do this, the duration of the [i]-shaped transition at the beginning of the second formant in each syllable was measured, its frequency difference (drop) was calculated, and then the frequency difference was calculated per 100 ms, which allowed comparing the steepness of the formant drops for each vowel in Russian and Chinese (see Fig. 1, where the rectangle is the zone [i]-shaped transition), after what the average FII drop per 100 ms was calculated for different groups of consonants.

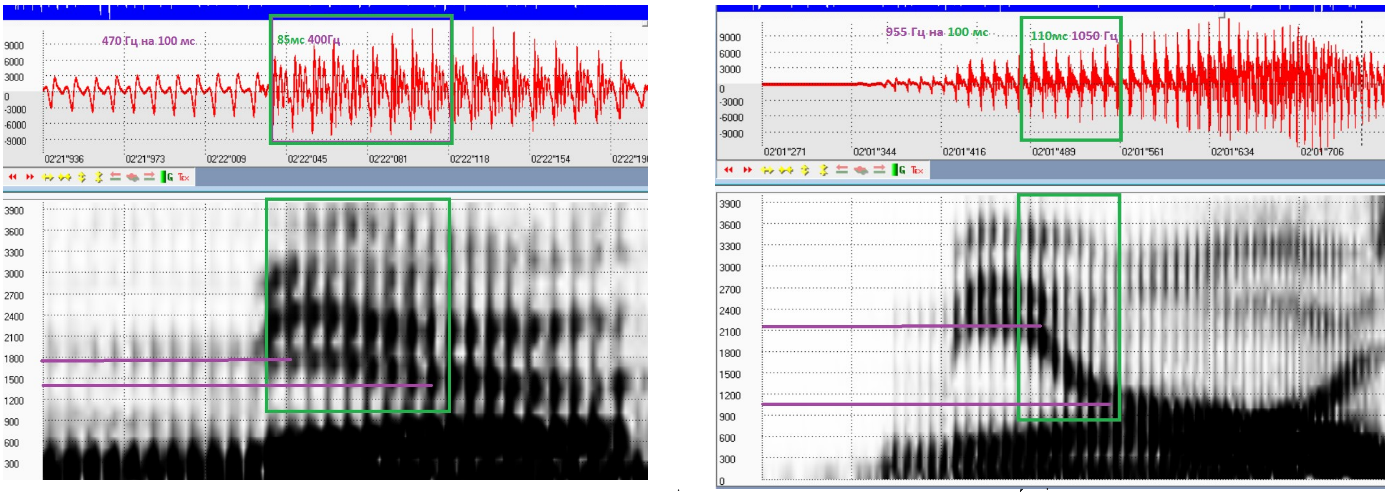

Fig. 1. The oscillogram and the spectrogram of the syllable [*mʲa*] in the Russian word *мясо* [ˈmʲasa] (on the left) and the Chine word *miao xiao* (on the right).

According to the results of statistical analysis, the following data were obtained.

In both languages, the value of the FII difference (see Fig. 2) for the sound [j] exceeds all other values, and at the same time is almost the same in both languages. This is easily explained: it is during the articulation of the palatal approximant [j] that the middle of the tongue rises as high as possible, which leads to a strong difference between the second formant of [j] (about 2500 Hz) and the second formant of non-front vowels. However, a more detailed analysis shows that the drop after [j] is different for different vowels in both languages (see Fig. 3): for [a] and [o], it is less in Russian than in Chinese, and for [u], on the contrary, in Russian the value is greater. The excess of Russian drop for [u] is such that it equalizes the drop average values for both languages. For labial consonants (see Fig. 2) the difference is greater in Chinese than in Russian, and this trend persists for different vowels (see Fig. 3). For the anterolingual in general (see Fig. 2) in Russian the difference is greater than in Chinese, but this excess is achieved due to (see Fig. 3) FII dynamics of labialized vowels [o] and [u]. For [a] the result is opposite, Russian has a larger FII difference, i.e. in Russian the FII value is lower than in Chinese, in other words, Russian [a] is pronounced as a more retracted vowel compared to Chinese in these consonant contexts.

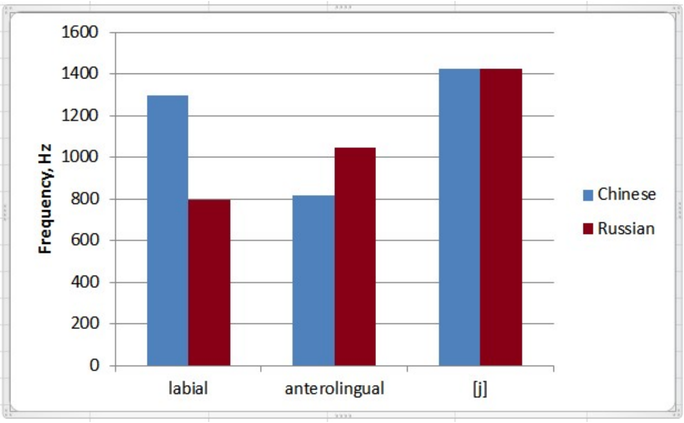

Fig. 2. FII dynamics after different types of consonants, the data is averaged over all vowels

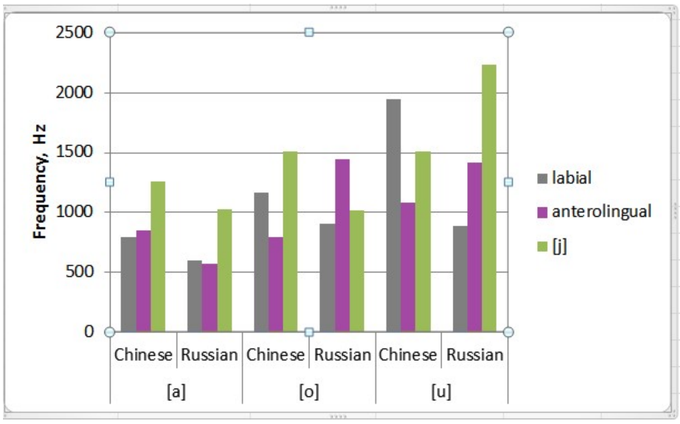

Fig. 3. FII dynamics after different types of consonants before different vowels.

The dependence of the drop on the vowel is obvious (see Fig. 4): the difference is the greater the more a vowel is retracted: in both languages it is least for [a], more for [o] and maximum for [u], which is explained by the articulatory and, consequently, acoustic characteristics of the corresponding sounds: among the three studied vowels, the vowel [u] has the minimal second formant, and for [a] it is maximal. At the same time, for all vowels, the drop in Chinese slightly exceeds the drop in Russian, and this excess is maximum for [a] and minimum for [u].

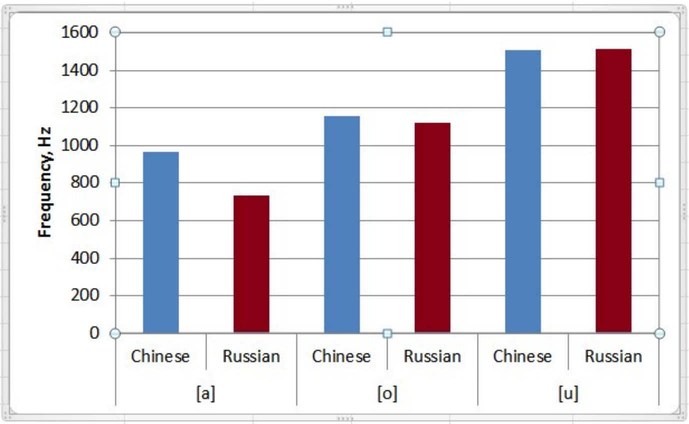

Fig. 4. FII dynamics for different vowels, the data is averaged over all consonants

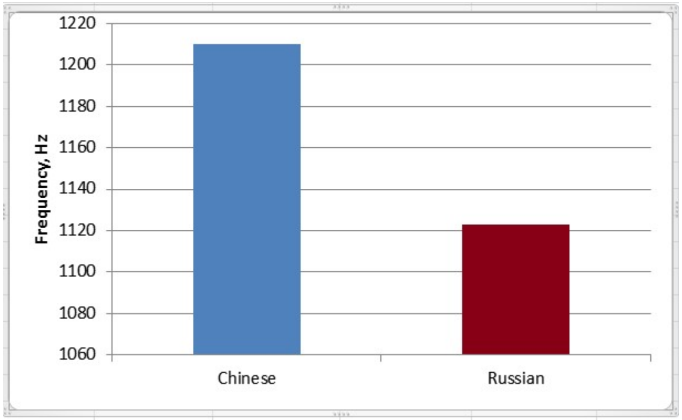

Fig. 5. FII dynamics in Chinese and Russian, averaged data.

The average values of the FII difference (see Fig. 5), i.e. the values averaged over all groups of consonants and over all vowels are somewhat larger in Chinese than in Russian.

These data allow us to conclude that the syllabic structure of the Chinese language and the integrity of the syllable as a meaningful unit does not necessarily imply a greater articulatory and, consequently, acoustic interdependence of sounds compared to the Russian language.

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