

Phonetic Correspondences Between Formant and Articulatory Features of Standard and Accented (Karachay-Balkar) Russian Speech

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Abstract: This paper presents a quantitative and comparative description of the standard and accented Russian speech of speakers of the Karachay-Balkar and Russian languages. The importance of creating phonetic correspondences between orthoepic and interfering speech stems from the need to develop and improve universal automated speech systems. Experimental phonetic studies of bilingualism, focused on the quantitative assessment of actual speech errors, also provide the key to identifying indicators of developmental disabilities, neurological disorders, and changes in emotional state for use in the development of intelligent systems for recognizing emotionally charged speech and diagnosing atypical speech development. This paper presents estimates of the average formant values of deviant Russian vowels in Balkar-Russian bilinguals and identifies systematic articulation errors occurring in the speech of bilingual speakers of the studied language pair.


1 INTRODUCTION


The development of language contacts, driven by cultural ties, globalization, migration processes, and other factors, is contributing to the spread of multilingualism and, in particular, bilingualism. Although numerous sources claim that more than half of the world's population is bilingual, there are no precise estimates of the prevalence of bilingualism (Grosjean, 2021). According to rough estimates, in North America, 35% of the population of Canada and approximately 18-20% of the population of the United States are bilingual. In Europe, 59% of residents can maintain a conversation in two languages (Europeans and their languages, 2024). In Russia, according to the Levada Center, the proportion of people who speak at least one foreign language is 15% (Novitsky, 2016). However, these figures do not include the proficiency in the languages of the peoples of Russia. According to the

2020 census, the proportion of people fluent in the languages of the peoples of Russia is 20% of the total number of those reporting proficiency in two or more languages (All-Russian Population Census 2020). Unfortunately, these facts say nothing about the degree of proficiency, regularity, or areas of language use, but they do provide an idea of the broad scope of the phenomenon of bilingualism.

Despite active research into bilingualism, a generally accepted formal definition of this phenomenon has not yet been formulated. N. N. Rogoznaya, for example, compared 30 definitions of the concepts "bilingualism" and "biglottism" currently used by linguists (Rogoznaya, 2014). Bilingualism is simply understood as "knowledge" of two languages, since its key characteristic is the use of the native (L1) and acquired (L2) languages in speech practice. Difficulty arises when trying to define what "knowledge" of languages is. Bilingualism ranges from ambilingual to dominant in terms of the relative degree of language proficiency

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(De Houwer, 2015). Conceptualizing "knowledge" of languages as a binary category – as in "knows/doesn't know" – is insufficient when studying a highly heterogeneous sample. Perhaps lumping the extreme diversity of bilinguals into a single category is one reason for the inconsistency in the results of experimental studies aimed at elucidating the presence or absence of cognitive processing advantages in bilinguals compared to monolinguals (Vishnevskaya, 2018).

A methodological challenge in studying bilingualism is the need to consider a range of external and internal factors that shape the very different products of bilingualism, which is usually illustrated by numerous classifications of bilinguals. When studying bilingualism, an integrative approach must consider the conditions of its emergence, the degree and nature of its prevalence, the number of bilingual individuals in the contexts being studied, the level of proficiency in the components of bilingualism, the quality of the connection with thought, the time, method, and causes of second language acquisition, the form of functioning, the duration of linguistic exposure, etc. Research on this phenomenon is complicated by its examination within the framework of different scientific fields. Depending on the academic perspective, bilingualism can be defined as a system of linguistic abilities through which a person acquires two languages; as a socio-psychological phenomenon inherent to members of a society where two languages are used; and as a societal phenomenon reflecting the nuances of the institutional and non-institutional use of languages in a multiethnic society.

To overcome the methodological challenges of studying bilingualism, we believe the most promising approach to describing the linguistic status of bilinguals is the characteristic grid proposed by François Grosjean (2021). To describe bilinguals in terms of regularity of use and level of language proficiency, Grosjean proposes defining the frequency of language use on the vertical axis, ranging from "never used" to "use daily," and the level of proficiency on the horizontal axis, ranging from low to fluent. These are undoubtedly among the most important criteria for defining bilingualism, but they only serve as the basis for a very general description. Such grids can be constructed and used to represent status in terms of language skills (speaking, listening, reading, writing), language modality (oral, written, sign), the domains in which languages are used, etc. Establishing linguistic configurations over different periods of time will help trace language history: periods of language

acquisition, their restructuring, or even loss. Identifying the connection between the linguistic configuration of bilingual individuals and neuroplasticity induced by second language acquisition, the neuromorphological features of the bilingual brain, and the ways in which linguistic information is stored and processed may help introduce a number of formal concepts related to this phenomenon. A generalized assessment of this term is relevant not only for constructing general theoretical understandings of bilingualism but also for guiding the work of clinicians and neuropsychologists faced with challenging testing situations due to the diversity and ambiguity of symptoms, as well as for educators determining teaching strategies based on language learning experience and proficiency.

This study examined the speech of speakers of the bilingual Karachay-Balkar/Russian language pair.

2 MATERIALS AND METHODS

The study's material consisted of phonograms of accented Russian speech by native Karachay-Balkar speakers, comprising more than 4,610 audio files. The accented Russian speech of 10 bilingual speakers of Karachay-Balkar (L1) and Russian (L2) was recorded, and the spectral characteristics of the allophones of six vowels [a], [o], [u], [e], [i], and [y] were measured. For phonation reading, words were selected representing variants of each of these phonemes in stressed positions (isolated pronunciation, stressed position at the beginning of a word, any stressed position) surrounded by unpalatalized and palatalized stops, sonorants, fricatives, and some vowels (Gurtueva, 2024). The results of acoustic measurements of the sound segments corresponding to the studied allophones were compared with the acoustic characteristics of the same vowels in standard Russian speech (Kozlachkov, 2016; Sorokin, 2004). The values of the first two formants (Ladefoged, 2014) were analyzed, using the Praat speech analysis program (Praat, 2025). More precisely, the average F1 and F2 values in the selected segments were calculated.

The bilingualism type of the informants participating in this experimental study can be defined as natural based on the conditions of its onset, and as early based on the age of acquisition. Since children hear their native language (Karachay-Balkar) from birth until early school age within the family circle, and Russian on television, in playgrounds, stores, and clinics, the transition

between languages is easy. During the early stages of speech development, Karachay-Balkar and Russian are used constantly, but the national language predominates in terms of exposure. From early preschool age, the scope of Russian language use begins to expand (kindergartens, educational institutions, social and professional relationships, etc.), leading to children using both their native and Russian languages depending on communicative needs: their native language for everyday communication, and Russian for social interactions. Their Russian language skills develop, and in most cases, their native language is supplanted. Clarifying the type of bilingualism among the population of the Kabardino-Balkarian Republic based on the type of speech activity and skills – reproductive or productive – and the degree of proficiency – subordinative or coordinative – requires a more thorough analysis and is beyond the scope of this study. All participants in the experiment use Russian professionally. Two of the subjects also use their native language in their professional lives. Informants independently assessed their native language proficiency during the questionnaire. However, this assessment is largely dependent on self-reflection, which is distorted by factors such as a person's attitude toward their native language or the interviewer, etc. It should be noted that only those who were speaking their native language for the first time were invited to participate in the experiment. This decision was based on the fact that the first language significantly influences the development of neural structures in the brain, causing long-term distortion of auditory perception (Kuhl, 2021). Although recent research suggests that the native language is acquired with sufficient stability by age 12 – signs of language attrition are reversible after this age – the phonological system is the most resistant to loss. Bilinguals who acquired their native language at an early age and lost it in adulthood retain the ability to distinguish and pronounce its sounds, which is likely due to early development.

3 RESULTS AND DISCUSSION

A paired quantitative-comparative study of the acoustic characteristics of vowels in the Karachay-Balkar and Russian languages revealed objective, identifying features of accent in the Russian speech of Balkar speakers. As demonstrated by the phonetic correspondence assessment, the interfering vowels of speakers of the studied language pair can be divided into three groups: those deviating significantly, moderately, and slightly from the reference standards.

For the Karachay-Balkar accent, the first group includes the vowels [a], [i], and [e] – their identification probability is over 90%. The distances between the interfering and reference vowels [y], [u], and [o] do not exceed one standard deviation. Thus, the accented vowels of Russian speech by speakers of Karachay-Balkar can be reliably identified (Gurtueva, 2024). For convenience, the results of the acoustic contrastive analysis are briefly summarized in Tables 1 and 2.

Table 1: Comparison of average formant frequencies of normative and accented stressed vowels for male voices, Hz.

phoneme	F1		F2		F2-F1	
	std	accent	std	accent	std	accent
A	500	584	1180	1258	680	674
E	350	426	1690	1743	1340	1317
O	380	462	1090	1287	710	825
U	340	387	980	1506	640	1119
Y	300	342	1810	1742	1510	1400
I	290	317	1850	2090	1560	1773

Table 2: Comparison of average formant frequencies of normative and accented stressed vowels for female voices, Hz.

phoneme	F1		F2		F2-F1	
	std	accent	std	accent	std	accent
A	540	781	1140	1436	600	655
E	400	545	1980	2033	1580	1488
O	430	520	1200	1060	770	540
U	410	433	1120	1291	710	858
Y	390	415	2010	1968	1620	1553
I	380	375	1960	2461	1580	2086

By solving the so-called inverse problem, articulatory errors corresponding to spectral distortions were identified. As is known, formant frequency values are inversely related to the articulatory features of vowels. The frequency of the first formant reliably correlates with the vowel's height: the higher the F1 value, the lower the height. The frequency of the second formant is related to the degree of labialization and the backness of the vowel. To eliminate the effect of labialization, the difference between formants is traditionally considered. The closer the formants F1 and F2 are, the more back the vowel sound is.

As a comparison of the average formant values of accented and reference vowels presented in Tables 1 and 2 shows, in women's speech, the accented [a] is lower in terms of labialization and shifted forward in terms of backness compared to the pronunciation norm of the Russian language. In men's speech, the Russian [a] is also slightly lower, but not significantly

so. Based on the row feature, this vowel is articulated by men in almost exact accordance with the pronunciation norms of the Russian language. The accented vowels [e] and [y] are pronounced by informants of both sexes as vowels of lower rise and more back compared to the vowels of the Russian language. A specific feature of the accented [u] is a relatively slight shift in rise downwards and forwards along the row in the speech of men and women. In the speech of women, the interfered [i] exactly matches the orthoepic norm in rise, but is significantly fronted. In the speech of L2 male speakers, Russian [i] is also realized as a more front vowel, but lower in rise. The accented [o] is pronounced by both men and women as a vowel of lower rise. However, based on the row feature, the production of this vowel differs in the speech of men and women. Women articulate this vowel as more back, while men articulate it as more front. These articulatory distortions are more clearly illustrated in Figure 1.

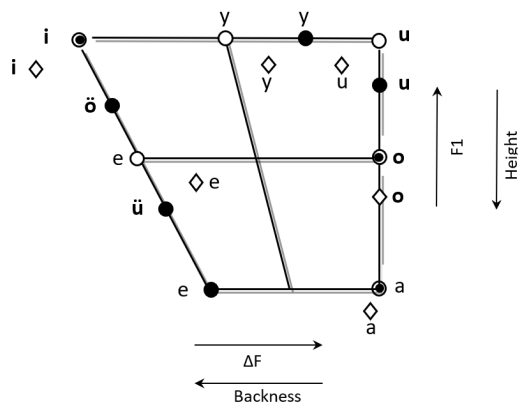


Figure 1: Trapezoid of the Karachay-Balkar (•), Russian (○), and accented (◇) vowel phoneme systems.

4 CONCLUSIONS

To create more effective automated systems for recognizing and diagnosing deviant speech, a deeper understanding of the mental processes that determine the interference effects of languages interacting in the minds of bilinguals is necessary (Dyrmovsky et al., 2015). Identifying the relationship between the linguistic configuration of bilingual individuals and the neuroplasticity associated with second language acquisition, the neuromorphology of the bilingual brain, and the methods for storing and processing linguistic information may help introduce a number of formal concepts related to this phenomenon. Research on bilingualism, interference, and accent is

conducted within the framework of contrastive analysis theory, which is currently considered a limited but useful tool, the results of which should be supplemented by corpus studies and big data analysis. The contrastive analysis using acoustic information presented in this study revealed that a number of pronunciation errors that Karachay-Balkar and Russian speakers are likely to make in speech production are due to the interfering influence of their native language. Balkar-Russian bilinguals tend to lower the Russian vowels [u], [o], [e], [y] a compared to their reference rise in native Russian pronunciation, which can also be explained by the influence of the first linguistic competence, as the corresponding Karachay-Balkar vowels are categorized as "lower" compared to the corresponding Russian ones.

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