

Phonetic Research of the Sound Form of Modern Buryat Language

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Abstract

In this paper the phonetic research of the properties of a sound form of a modern Buryat language is reported. The research contains: 1. The study of the phoneme system of the Buryat Language. 2. Quantitative and qualitative acoustic characteristics of basic, positional and combinatorial allophones of vowel and consonant phonemes, their duration and formant structure. 3. The rules of phonemic and phonetic transcription of a Buryat text on the basis of the International phonetic alphabet (IPA), and also algorithms for automatic transcribing of a written text. 4. The statistical characteristics of distribution of allophones, phonemes and syllables. 5. The phonetic model of the Buryat text.

The research is worked out in the Laboratory of Experimental Phonetics and at the Department of Phonetics and Methods of Teaching of Foreign Languages in Saint Petersburg State University [1].

1. Introduction

Sounding speech is a cultural heritage of mankind transferred from generation to generation and is being kept during centuries due to the sound character of a language. We master a language, study and develop it thanks to the material sound form of a language. Sound units express language meanings, and by that, provide the oral and written forms of the existence of languages.

The research is devoted to a phonetic description of properties of speech units and is directed to the study of relations of language units and a degree of stability/instability of the phonological and phonetic phenomena within the system in various speech conditions.

The study of phonetic properties of sounding speech is important in respect to the description of the standard language. In the research the results of the study of the Russian language system and other existing sound systems of different languages are used [2, 3]. Also the study of phonetic processes by means of speech modeling and recognition of speech is observed especially those that connected with the standard language and its variability.

The development of speech technology has essentially changed phonetic research and, accordingly, the technique of the detailed analysis with the help of, for example, an organization of acoustic databases, digital processing of speech signals, automatic segmentation and transcription, automatic processing of a speech signal, system of recognition and synthesis of speech, modern statistical computer methods [4, 5].

The new way of analysis from the organization of the acoustic database up to the statistical database has been applied to the

present research [6]. The purpose of the present research is the complex study of the sound form of the Buryat language based on the analysis of realizations of elements of sound system in various conditions: in a syllable, a word, a text and the development of a sound database for its further application for the research and educational purposes. The goals of the research are:

1. To specify the system of phonemes in accordance with the Scherba phonological school foundations.
2. To establish variability of phonetic properties of all types of phonemes depending on various phonetic conditions.
3. To work out the system of phonemic and phonetic transcription based on IPA including the algorithms of automatic transcription.
5. To carry out the comparative statistical analysis of allophones, phonemes and syllables.
6. To carry out the acoustical analysis of the elements in different environment (isolated vowels, CV syllable context, a word and sentence context (the model text).
7. To prepare the Buryat language database with the key blocks: a sound syllable collection, a sound pronouncing dictionary, statistic database and a model text.

2. Material and Methodology

The total amount of an experimental corpus contains 5390 sound files including: 1) 72 sound files of 18 isolated vowel phonemes; 2) 864 sound files of 216 isolated syllables /CV/ of all possible combinations of phonemes; 3) 4000 sound files of 1000 lexical units; 4) Four realizations of a specially developed model text consisting of 50 sentences.

The text reflects the typical statistical distribution of phonemes, variants of phonemes, syllables and also examples of all communicative types of sentences represented both in the form of a monologue and a dialogue. The speakers of two age groups (both male and female of 20 and 50 years each) represent the standard modern language.

The recordings of the research were made and tested by expert phoneticians in the Laboratory of experimental phonetics. The material is kept in sound files in the form of a sound database, which includes: syllables, the rules of transcription, the automatic transcriber, the sound pronouncing dictionary and the text. The sound database is open for filling it with new research data, including research on dialects.

The processing of a sound material was carried out with an application of several kinds of the analysis: acoustical, spectral, auditory and statistical. During the acoustical analysis the realizations of phonemes and their variants in different phonetic conditions were analyzed, the rules and the system of the phonemic and phonetic ways of transcription of the Buryat speech are developed on the basis of the foundations of Scherba phonological school.

All speech material was accessible via the speech signal processing program EDS (Editing Digital Sound Signals) which had been developed at the University of Telecommunications in Saint-Petersburg on the basis of the accepted in the Laboratory of experimental phonetics methodology at Saint Petersburg state University.

The statistical analysis is made on a basis automatically transcribed texts with various samples: 9.781; 16.373; 32.978; 110.85; 152.925; 657.493 phonemes. The results of the data of twelve parameters are brought into a statistical database, on the basis of which the phonetic model text was composed and the further analysis is being made.

3. The phoneme system

In the present work the description of structure of the phonemes of modern Buryat language is studied on the basis of the foundations of the Scherba phonological school. The phonemes have been defined as a result of the phonological analysis of Buryat words and the articulatory and acoustic analysis. The Buryat language system of phonemes contains 18 vowels (15 monophthongs and 3 diphthongs): /i/ /i:/ /i̥:/ /e/ /e:/ /œ̞/ /e:/ /a/ /a:/ /ɔ/ /ɔ:/ /ə:/ /ʊ/ /ʊ:/ /ui/ /u/ /u:/ /ui/ and 27 consonants: /p/ /pʲ/ /t/ /tʲ/ /b/ /bʲ/ /d/ /dʲ/ /g/ /gʲ/ /m/ /mʲ/ /n/ /nʲ/ /ɣ/ /s/ /z/ /ʃ/ /ʒ/ /x/ /xʲ/ /ʎ/ /ʎʲ/ /r/ /rʲ/ /l/ /lʲ/.

3.1. Vowel system

All the vowels are opposed to each other according to five basic features: 1. Length: short and long vowels. 2. Stability of articulation: monophthongs and diphthongs. 3. Labialization: rounded and unrounded vowels. 4. Horizontal movement of the tongue: front: front, front-retracted; back: back advanced, back. Vertical movement of the tongue: close: narrow, broad; close-mid: narrow, broad; open: narrow, broad.

According to the law of vowel harmony the vowels are divided into three groups: hard, soft and neutral. Vowels of the hard and soft groups cannot meet within one word. Vowels from the neutral group can form words together with vowels from hard or soft groups. For each phoneme the transcription symbol from the International Phonetic Alphabet was defined. Figures 1, 2 present the systems of monophthongs and diphthongs. The long and short vowels are very close to each other according to their acoustic parameters therefore they are marked on one line. The hard, soft and neutral groups of vowels are marked with the dash line. The outer 'circle' (hard group), the inner 'circle' (soft group) and the common (neutral group) circle.

3.2. Consonant system

All the consonants are classified according to five basic features: 1. Manner of the production: plosives, nasals, fricatives and thrills; 2. Place of obstruction: bilabial, alveolar, palatal, velar and guttural; 3. Voice: voiced and voiceless; 4. Noise: noise and sonants; 5. Soft palate: hard and soft. For each consonant phoneme the transcription symbol from the International Phonetic Alphabet was defined.

Figure 3 presents the classification of consonants. A. Occlusives, B. Fricatives, C. Thrill. a- noise, b - sonants.

1 – Labial, 2 – Lingual, 3 – Guttural.

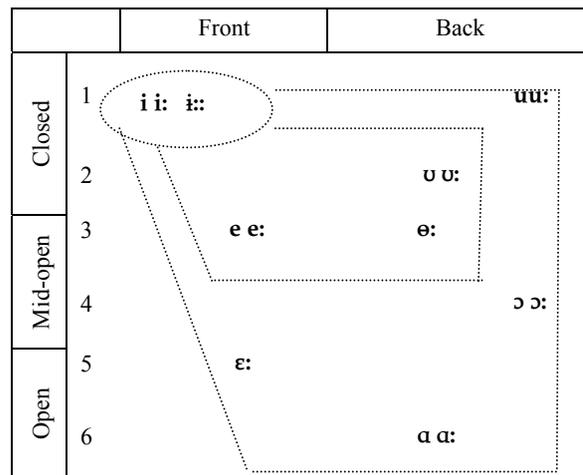


Figure 1: The classification of Buryat vowel (monophthongs)

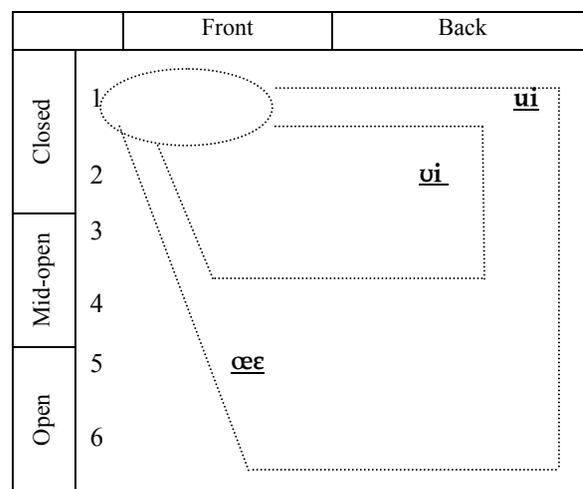


Figure 2: The classification of Buryat vowels (diphthongs)

		1		2			3	
A	Aa	p	b	t	d		g	
		pʲ	bʲ	tʲ	dʲ		gʲ	
	Ab		m		n			ŋ
			mʲ		nʲ			
B	Ba			s	z		x	ʃ
							xʲ	
				f	ʒ			
	Bb				l	j		
					lʲ			
C	Cb				r			
					rʲ			

Figure 3: The classification of Buryat consonants

4. Research

4.1. Quantitative acoustic data

4.1.1. Vowel duration (basic and combinatory allophones)

The research of quantitative aspect of basic and combinatory allophones showed:

1. All allophones are characterized by their own quantitative data.
2. Long vowels and diphthongs exceed the duration of short vowels in 1,5 - 2 times.
3. Open vowels are longer than the closed ones.
4. Paired long and short vowels have various ratio on duration. Closed vowels have the greatest scope of variation. Open vowels have twice less a scope of variation. Thus, the range between the open long and short vowels is reduced, and between the closed vowels the range of duration increases.
5. Relative duration of the basic allophones correlates with the duration of the combinatory allophones in the syllable context.
6. Vowel duration in a syllable context decreases in comparison with the duration of the vowels pronounced in isolation.
7. The variation of vowel duration depends on a context in syllable structure /CV/. The greatest relative vowel duration is marked in the forelingual consonant context. The second place of vowel duration is marked in the backlingual consonant context. The least vowel duration is marked in the guttural consonant context.
8. The variation of vowel duration depends on a manner of production of the previous consonant context. The greatest duration is observed among short and long vowels in the syllable structure /CV/ in the fricative consonant context. The duration of the short vowels is more reduced in the thrill consonant context. On the contrary, the duration of the diphthongs in the thrill consonant context increases.
9. The duration of all vowels in the soft consonant context exceeds in comparison with the firm consonant context.
10. The vowel duration of the hard harmony group exceeds the vowel duration of the soft and neutral harmony groups in the condition of the isolated pronunciation.
11. The vowel duration of the hard and soft harmony groups aspires to balance their duration in a syllable context.

4.1.2. Vowel duration (positional allophones)

1. The duration of short, long vowels and diphthongs in the first syllable of a word exceeds the duration of all vowels in any syllable, except for the last one.
2. The duration of short, long vowels and diphthongs of a final syllable of a word is more than the vowel duration of all syllables in a word, if it is an open syllable.
3. The duration of short vowels of the final closed syllable is reduced in comparison with the vowel duration in an open syllable of the final syllable in a word.
4. The duration of short vowels in the middle of a word is always less than the short vowel duration in the first and final syllable position.
5. The duration of long vowels and diphthongs always is larger than the short vowel duration in any position of a separately pronounced word.

6. With an increase of the duration of a word and the quantity of syllables in a word, the relative duration of all vowels decreases alongside with the duration proportions specified in the rules from 1 to 5.

7. With an increase of duration of a word and the quantity of syllables in a word, the vowel duration in the first syllable of a word increases concerning other vowels in a word.

8. The relative duration of all long vowels and diphthongs does not vary depending on a position in a word.

9. The duration of all long vowels and diphthongs in the middle of a word is less than the duration in a final syllable position of a given word.

10. The duration of all vowels depends on the quality of the preceding consonant.

11. The vowel duration in the first syllable position correlates with the vowel duration in the condition of an isolated pronunciation and in a syllable context.

Thus, the analysis of vowel duration of basic, combinatory and positional allophones in a word demonstrated the specific character of the distribution of vowel duration in a word depending on the vowel position in a word and on the vowels own qualitative characteristics.

The results obviously show, that a word consisting of three and more syllables is divided into three parts: the first syllable, not first (the middle of a word) and the final syllable. If it is a two-syllable word, it is divided into the first and not the first syllables. In a word there are two centers with the longest vowels: the first and the last. If a root morpheme is enlarged and the number of syllables in a word is increased, so it causes a redistribution of vowel duration of a word. The final syllable of a root morpheme turns out to be in the middle of a word and, accordingly, its duration is reduced.

The vowel position in the first and the final syllables can be related to the strong position, in middle of a word - to the weak position, and a syllable may be called, allocated or not allocated. The analysis of the vowel duration data show that the distribution of long vowels and diphthongs duration aspires to keep the vowels' own duration in any word position, therefore the system of vowel duration distribution of the allocated or not allocated syllables becomes more complicated [7].

4.1.3. Vowel duration and stressed syllables

The nature of stress and its function vary in different languages. In some languages stressed syllables unite syllables in a single unit. For a number of languages the phenomena of harmony and tonality play the uniting role alongside with the stress [8]. For the Buryat language system the nature of stress is the subject for discussion.

In the present research the experiment was to find whether the Russian informants would mark syllables with long vowels and diphthongs as stressed ones in Buryat words. The material included words of various syllable duration from two up to seven syllables. These words contained the following models of syllables: 1) consonant + short vowel (CV), 2) consonant + long vowel (CV:), 3) consonant + diphthong (CD), 4) consonant + short vowel + consonant (CVC). The combination of models of syllables of 58 types of words, for example were chosen: CVCV,V:CV:, CDCV:, CDCVCV, CV: CDCV, CVCVCCV CDCV, CVCVCV:CVCCV:CD, etc. The group of Russian phoneticians participated in the experiment. As it is known, in the Russian language the

stressed syllable is always longer, than the unstressed one. In the experiment 870 answers were received.

The results were analyzed depending on: 1) the presence of stress, 2) quantity of stressed syllables in a word, 3) quantity of stressed syllables depending on a number of syllable within the a word, 4) the place of stress in a word. The informants noted the presence of stress in all 58 words. The analysis showed, that 30 % of all 870 answers have one stress in the words, presented in the experiment, 68, 2 % of the answers have two stresses and 1.72 % of the answers - three stresses. Thus, the majority of the informants marked two stresses in all the words.

The analysis of the words consisting of three syllables showed that 69.2 % of all the answers had two stresses, and 30.7 % of the answers - one stress. In four syllable words 72.8 % of the answers involved two stresses, and 27.1 % - one stress. In five syllable words 83.5 % of the answers had two stresses, and 16.6 % mark one stress. The analysis of the words consisting of six syllables showed, that 20 % of the answers had one stress, 55.5 % had two stresses and 24.4 % three stresses. In the words consisting of seven syllables 70.3 % of the answers had two stresses, and 30.5 % - three stresses. The results show that with an increase of quantity of syllables in a word the percentage of answers with two and more accents in a word increases. The quantity of stressed syllables in a six syllable word increased up to three.

The data of the experiment were analyzed from the point of view of a place of a stress in a word. The analysis of 3-4-5 syllable words showed that the majority (91.1 %) of answers had two stresses - on the first and the last syllables of words. In the words consisting of six or seven syllables two and three stresses were observed.

The analysis result in the idea that a word of any syllable duration has two stresses on the first and the last syllables of a word. In a two syllable word there are also two stresses on the first and on the second (the last) syllable. The structure of a syllables consisting of short, long vowels or diphthongs does not influence the place of stress in a word [9].

4.2. Qualitative acoustic data

4.2.1. Vowel formant structure (basic allophones)

In the research the formant parameters of the basic vowel allophones were studied. Each allophone has a definite area of F1-F2 distribution. The F1-F2 parameters of the basic allophones in the realization of four speakers were tested. The received characteristics have become an initial material for the comparison of vowels realized in other conditions (a syllable, a word and a text). Figure 4 shows the formant structure of basic allophones (monophthongs) in the realization of 4 speakers.

4.2.2. Vowel formant distribution (combinatory allophones)

The changes in vowel formant distribution of the combinatory allophones occur under the influence of the preceding consonants, on the transition from a consonant to a stationary part of a vowel. The F1 and F2 parameters of vowels were measured in syllables /CV/. The results of the analysis of a trajectory formant changes are shown in Figure 5.

In the research the data on the acoustic characteristics of combinatory allophones in the contexts of labial, forelingual, backlingual and guttural consonants on the border of the transition from a consonant to a vowel were measured.

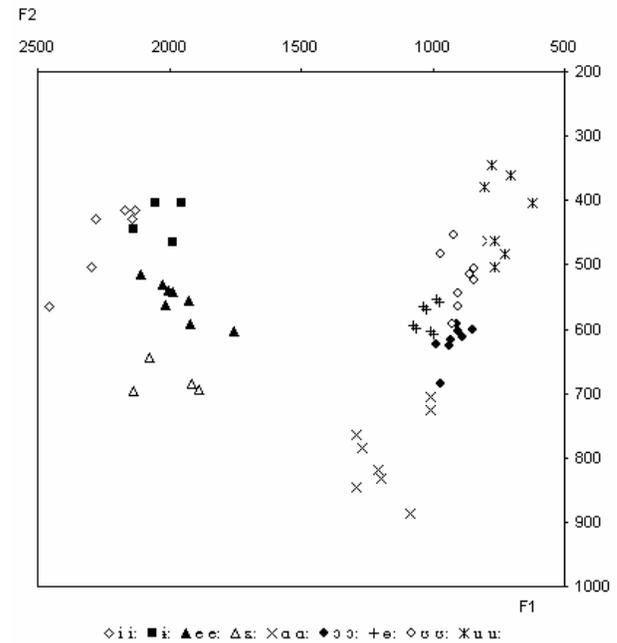


Figure 4: Formant structure of basic allophones (monophthongs)

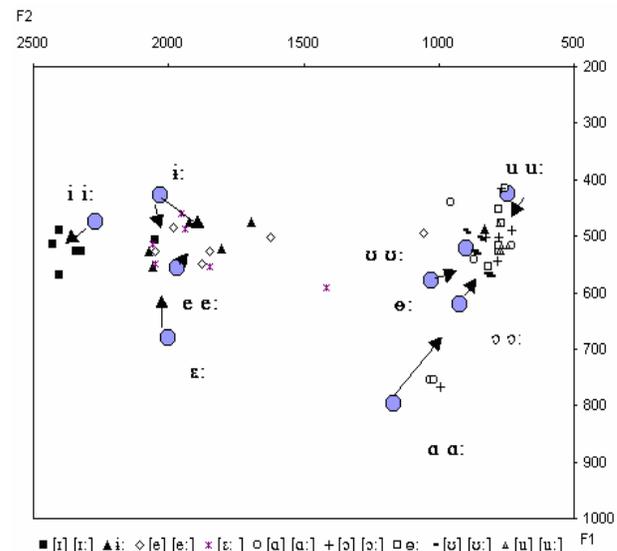


Figure 5: Formant distribution of the basic and combinatory allophones (monophthongs)

1. The character of acoustic parameters of vowels in a syllable structure depends on the quality of the preceding consonant.
2. The vowel quality depends on the preceding hard and soft consonants.
3. The vowel quality of combinatory allophones changes more in the following sequence order: labial, backlingual,

forelingual. Vowels in the mediallyngual and guttural consonant context are modified in the minimal degree.

4. The formant updating of vowels occurs on the border of a transition from a consonant to a vowel.
5. The size and the degree of formant changes of allophones depend on the quality of the preceding consonant. The greatest changes are caused by a labial consonant context.
6. The front vowel allophones change more, as a whole, in comparison with the allophones of back vowels.

4.2.3. Vowel formant distribution (positional allophones)

The changes in vowel formant distribution of the positional allophones depend on the syllable position in which vowels occur (the first syllable and not the first syllable).

The analysis of positional allophones of not the first syllables showed their essential variability in comparison with the positional allophones of the first syllables. The variability of the allophones of not the first syllables is caused by the qualitative and quantitative reduction. The received data were compared with the formant parameters of the basic allophones and allophones which occur in the first syllables. The F1-F2 distribution of the basic allophones coincides with the formant data of positional allophones from the first syllable. Positional allophones of the first syllable have similar formant structure parameters of the basic allophones.

The results of the analysis of the comparison of some basic and positional allophones of the first and not the first syllables are shown in Figure 6. As it is seen from the Figure 6 the formant structure of the positional allophones of the first syllable is very close to the formant structure of the basic allophones, while the formant structure of the positional allophones of not the first syllables varies essentially.

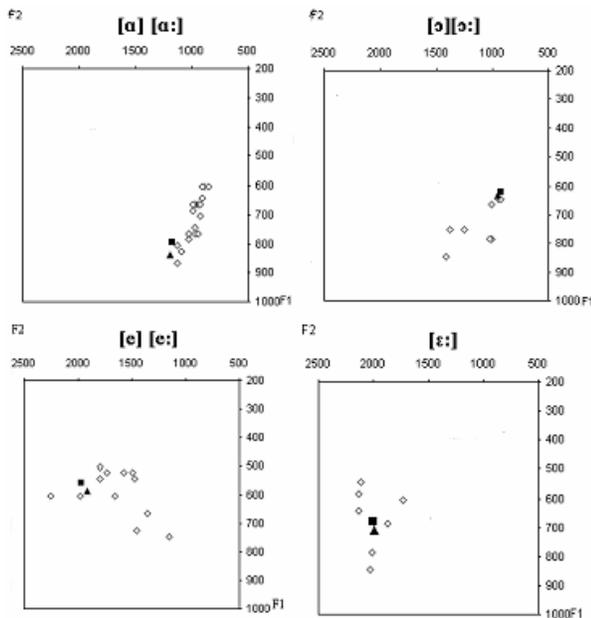


Figure 6: Formant distribution of the positional allophones
 ▲ - positional allophones of the first syllable; ■ – basic allophones; ◇ - positional allophones from not the first syllables.

4.3. IPA for the Buryat language transcription

One of the problems of the phonetic aspect of the Buryat language is connected with transcription. Researchers adhere to different ways of transcription depending on the phonological principles. As a result there are various ways of transcription. During the research the rules of phonemic and phonetic (allophonic) transcription of a Buryat text were developed on the basis of the Scherba phonological school. In the research the symbols of the International Phonetic Alphabet with an application of algorithms the automatic transcription are used. The standard Buryat pronunciation served as a model for both types of transcription [10]. In the present research both oral and written Buryat texts were used as a material for transcription. It is necessary to note, that the written form of the Buryat language has undergone changes of three alphabets beginning from the Old Mongolian language (XII century) up to the letters based on the Latin alphabet (the thirties of the XXth century) and, at last, Cyrillic letters that are in use now. The Buryat alphabet consists of 36 letters (Table 1). Letters like: <ф>, <ц>, <ч>, <ш> occur only in the borrowed Russian words. The graphic system of the language is also represented by the combinations of letters like: аа, ее, ии, оо, өө, уу, үү, ээ, ай, ой, уй, үй which indicate definite phonemes (Table 2). The combinations of letters like: ео, ёо, юу, яа, яя transmit the preceding palatalized consonants.

Table 1: Buryat Language Alphabet and IPA

Buryat	IPA	Buryat	IPA	Buryat	IPA
А а	ɑ	Л л	l	Х х	x
Б б	b	М м	m	Һ һ	h
В в	v	Н н	n	Ц ц	ts
Г г	g	О о	ɔ	Ч ч	tʃ
Д д	d	Ө ө	ø	Ш ш	ʃ
Е е	je	П п	p	Щ щ	ʃʃ
Ё ё	jɔ	Р р	r	Ы ы	i
Ж ж	ʒ	С с	s	Э э	e
З з	z	Т т	t	Ю ю	ju
И и	i	У у	u	Я я	ja
Й й	ji	Ү ү	u		
К к	k	Ф ф	f		

Table 2: Buryat Language Letter Combinations and IPA

аа	ɑ:	оо	ɔ:	уй	ui	ээ	e:
ай	ɛ:	ой	œɛ	үү	u:	эй	e:
ии	i:	уу	u:	үй	ui		

The developed systems of phonemic and phonetic transcription reflect all the phonetic processes which characterize the modern Buryat language. The simultaneous transformation of written texts to the IPA symbols is carried out through the algorithms of automatic transcription designed by A. Kondratovskaya. The example of the transcription of the Buryat text in the phonemic and allophonic transcription is presented below.

The Buryat text in the phonemic and phonetic (allophonic) transcription

Buryat Text in Cyrillic:

Доргон гээшэ нүхэн соо байрладаг амитан. Үдхэн бургаахан соо ба бэшэнье газарта дайралдажа болохо. Намар орой эшээндэ ородог.

Хабар болоходо, эшээнхээ гараад ябадаг. Зундаа олон гүлгэ гаргаад, тэдэнээ тэжээдэг. Доргог хурса хабартай, тиймэхээ диилэхэ амитандаа довтолдог. Мяханда ехэ дуратай. Мяханай оллоогүй хаа, элдэб юумээр хооллодог.

Phonemic transcription of the text:

/dɔrgɔŋ ge:je nuxɛŋ so: bɛ:rlɔdɔk ɔmʲitɔŋ utxɛŋ burɡa:fiɔŋ so : ba beʃɛʃje ɡazarta dɛ:raldɔzɔ bɔlɔxɔ namar ɔcɛɛ eʃɛ:nde ɔr ɔdɔk xabar bɔlɔxɔdɔ eʃɛ:ŋfiɛ: ɡara:t ʃabadak zunda: ɔɔŋ ɡul ge ɡarɡa:t tedene: teze:dɛk dɔrgɔŋ xursa fiabarte: ʃi:mɛfiɛ: dʲ i:lɛxe ɔmʲitanda: dɔptɔldɔk mʲaxanda jexe durate: mʲaxane: ɔ lɔdɔ:ɡui ʃia: eldep ju:mɛ:r xɔ:l:ɔdɔk /

Phonetic (allophonic) transcription of the text:

[dʷɔrgɔŋ ge:ʃɛ nʷuxɛŋ so: bɛ:rlɔdɔkʰ ɔmʲitɔŋ utxɛŋ burɡa:fiɔŋ ŋ sʷɔ: ba beʃɛʃjɛ ɡazɔɮʲtɔ dɛ:rlɔdɔzɔ bɔlʷɛxʷɛ nɔmɔɮr ɔrʷɛɛ eʃ ɛ:ndʷɛɔ ɔrʷɛdʷɛkʰ xɔβɔɮr bɔlʷɛxʷɛdʷɛ eʃɛ:ŋfiɛ: ɡara:t ʃaβɔdɔkʰ zʷʲndɔ: ɔlʷɛŋ ɡʷulɣɔ ɡarɡa:t tedɛnɛ: teze:dɔkʰ dʷɔrɣʷɛŋ xʷur sɔ ʃiaβɔɮrte: ʃi:mɛfiɛ: dʲi:lɛxɔ ɔmʲitɔnda: dʷɔptʷɔldʷɛkʰ mʲɔxɔɮ ndɔɮ jexɔ dʷʲrɔtɛ: mʲɔxɔnɛ: ɔldʷɔ:ɡʷui ʃia: eldɔp jʷu:mɛ:ɮ xʷɔ:lʷɛdʷɛkʰ]

4.4. Statistic data and Phonetic Model of Text

4.4.1. Statistic database

In the research on the basis of the transcribed texts of different styles the statistic information was received and included into the database. The received statistic data on the properties of sound units contain the information about the way the language system functions. The statistic database includes the information about twelve parameters: 1. Vowel and consonant phoneme distribution; 2. Classes of vowel and consonant phonemes; 3. Allophone distribution; 4. Positional distribution of allophones; 5. The degree of consonant coefficient; 6. The average syllable length in phonemes; 7. The average word length in phonemes; 8. The average word length in syllables; 9. Syllable distribution; 10. Frequent and non-frequent syllable succession; 11. Vowel and consonant correlation of the first syllables and not-the first syllables; 12. Vowel harmony correlation of the hard, soft and neutral vowel groups.

4.4.2. Phonetic Model of Buryat Text

The information on the statistic data of the above mentioned twelve parameters were taken into account during the development and analysis of the phonetic model of the text. The text is composed in compliance with the methodology of S.B. Stepanova [11]. The text contains 402 words, 2002 phonemes (1210 consonants and 992 vowels), 50 sentences of different communicative types. The phonetic model of the text is recorded in the realization of the four standard speakers. The variability of phonetic properties of sound units realized in the phonetic model of the text is being studied. The phonetic properties of sound units in coherent speech is the least investigated aspect of phonetics of the Buryat language.

5. Conclusion

This paper describes the attempt of the complex research of phonetic aspect of the modern Buryat language. During the research: 1. A phonetic database of modern Buryat language including of 5 390 sound units for the first time is created. 2. The acoustic quantitative and qualitative characteristics of sound units of language are received. The variability of acoustic parameter of phonetic properties of sound units in the context of a syllable, a word, a text is studied. 3. The rules phonemic and phonetic transcription are developed on the basis of the symbols of the International Phonetic Alphabet. 4. The algorithms for automatic transcription of the Buryat written text are developed. 5. The statistical characteristics of the distribution of language units were received on the basis of automatic transcribing. 6. The phonetic model of the Buryat is created. 7. The data on phoneme variability in connected speech are received. 8. The nature of word stress is studied.

6. Acknowledgments

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