Research article

Automatic Detection of Sound Repetitions in Verse: Realising the Syllabocentric Approach in the *Phonotext* Program

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Abstract. The article presents approaches to the automatic detection of sound repetitions and the measurement of sound coherence in Russian poetic text basing on the syllabocentric concept of the sound texture of the verse, which distinguishes the phonosyllabeme as its main operational unit and determines the main types of relations between the elements of repetition — equiphony and metaphony — and also allows describe the text in its unity of sound-segmental and rhythmic structure. The paper considers the linguistic prerequisites, main algorithms and methods, which form the basis of the *PHONOTEXT* computer program (web application), which automatically analyzes and visually forms the picture of the sound composition of the text presenting its quantitative characteristics. The basic operations of the program are described in detail, as well as the mathematical formulas used to identify the structure and carry out mathematical measurement of sound repetitions in Russian poetic speech. The article discusses the results of the program's use for the comparative study of poetry and prose, individual works and individual styles of Russian poets. In particular, the data obtained using the Phonotext program allows us to speak of a tendency towards syntagmatic consolidation of the phonosyllabeme and intensive granulation of the sound texture of the text in the individual style of Osip Mandelstam as the evidence of his striving for poetic morphologization of the elements of sound repetition, it also shows a tendency towards the use of the dominant sound theme as a means for cohesion of a complex syntactic and compositional whole, in contrast to Vladimir Nabokov's idiostyle, which is characterized by its orientation towards splitting up the elements of repetition, with a relatively chaotic interaction and spreading of consonances over the text and their low activity as a means of syntagmatic segmentation and consolidation of the text. The prospects for the development of the Phonotext program are described for identifying the relations of segment-sound and prosodic parallelism in speech (relations of equirhythmy and equiphony, including rhyme), which will provide an automatic presentation of a complete picture of the sound composition, the interaction of its main forms in the text and its further functional description.

Keywords: linguistics, digital technologies, automatic analysis, sound repetition, Phonotext program, metaphony, potential syllable, phonosillabeme, verse, Russian poetry

Introduction

Although a keen reader is aware of the value of the verse sound structure, its linguistic mechanisms are still have been poorly studied until now. Discourse on the "mystery" of verse, starting with school textbooks and manuals doesn't go without mentioning sound repetition — "alliteration and assonace" (nothing to say about rhyme), but it implies the attempt to prove why this given repetition is particularly crucial and unique in every specific case. Academic poetics the basis of which were foregrounded by the Russian school of formalism in the 20th century as well as by its successors and opponents both in Russia and abroad, and at present it gained a vast number of useful evidence in the field of studying sound structure of poetry and prose (B.M. Eichenbaum, O.M. Brik, S.I. Bernstein, A.M. Peshkovskij, R.O. Jakobson, V.N. Toporov, M.L. Gasparov, S.N. Muravjev, T.M. Nikolayeva, V.V. Merlin, L. Pscholovska, N.A. Kozhevnikova, M. Gautier, E. Dahl, and others). However, the task to determine the fundamental principles and main units of texual sound composition is still unsolved. With general consent to treat repetition as "a common principle of every poetic technique" (Polivanov 1963), at present, there are two corner problems to understand the verse sound texture, which aren't solved yet: what is namely repeated in verse at a sound level to organize a text, and what sould be considered as the evidence of functional value of this or that sound means. The major obstacle to investigate textual sound structure makes the lack of the detailed procedure to detect sound repetitions. If elaborated, such procedure could serve as the basis to create algorithms of automatic text analysis to identify textual structural and functional meaningful sound links.

Application of computational methods and the corpus linguistics experience open new prospects to self-operating study of compositional-and-sound structure of the verse, to present the objective view of sound links in the text. Serious steps were undertaken in this direction within the frames of a number of recent projects and publications [1—6, etc.]. One has to admit the importance of putting forward the task to detect sound repetions as the means to support "close reading" of the *Poemage* project (http://www.sci.utah.edu/~nmccurdy/Poemage/) [see: 7—8]. Nevertheless, the task to fix the whole complex of meaningful sound links in the verse hasn't been solved yet until now.

This study proposes the theoretical bases to approach automatic technique to detect sound links in Russian verse, and for the first time, puts forward the detailed description of methods and algorithms to create the *PHONOTEXT* program (web-application) — https://phonotext.syllabica.com/ [9], designed to explicate the system of sound repetitions in the verse structure as well as in the structure of any text in Russian, and English, and Latin considered in terms of functional value of meaningful sound similarities and contrasts to determine the formal character of sound links and measuring textual sound coherence.

Methodological and theoretical background

The presented method of automatic recognition of sound repetitions in Russian verse is based on the syllabocentric concept of sound org. verse, the fundamental provisions of which in the most complete form were developed in the monograph and dissertation of G.V. Vekshin in 2006 [10] and the works preceeding those ones [11—12], later improved in a number of articles [13—21].

The syllabocentric approach to the sound organization of the text rests upon the generally accepted position of linguistic theory, stating a syllable to be the elementary constitutive speech unit, its most simple move beyond which talkspurt development is impossible. Sound chain of the verse is granulated according to its syllabic and prosodic structures while its nucleus elements are syllable-forming segments (in Russian, those are just vowels) and apical parts of prosodic contours of a higher level, and the process of syllabification represents itself as a rotation of rises and falls, "summits" and "dales" of the contour, where its segmentation is a result of the meaningful segmental units overlapping the syllabic continuum [22; 24]. Beyond the syllable as the main measurement of the verse it seems impossible to detect any other sound and rhythmic associations and parallels as any sound repetition is inevitably and naturally a syllable repetition [25—27]. Attempts to apply the dualistic approach to discriminate repetition units [28], which implicitly rely on the supposition that in the speech circuit, a syllabic association needs the quality congruence not only for consonants, but also for vowels, contradict such facts of versification as dissonance rhyme or vowel alliteration [29], which leads to unreasonable

isolation of rhythmic and sonic speech formation in verse studies. For the speech processing, vowels are crucial for the contour summits apart from their quality. The positional adjunction of the consonsnts to the peaks of the syllables, their similar placement, alignment or grouping around the peaks regardless to the quality of vowels is enough to associate consonant series in poetry (at this, qualitative coincidence of vowels optionally strengthens syllabic associations, and in the case of intent similar lining of a vowel, vocal series could be perceived as a syllabic repetition, already independent of the quality of consonants and thus forming assonance). The apprehension of alliteration as an elementary repetition of consonants, regardless to the syllabic position of a consonant, at the very start of a word as well (or within the frame of the first syllable of a word), in isolation from the contours of syllable and phonetic word makes the concept of alliteration principally non-working, against the alliteration interpretation as a syllabic repetition [17; 30; 31].

Compositional significance of separatey taken syllabic groups is provided by means of analogy and contrast in the sound chain, where a syllable is positionally in-built in the prosodic contours of a word, phrase and text, and as a result, the sonic links of an utterance are transfered into the relations of segmental units, foregrounding those ones, sophiaticate them and rearrange syntactical and morphological relations thus providing aesthetically essential multidimensionality of the verse form [32; 33].

The core of the syllabocentric approach lays in the introducing of the unified syllabic criterion to any observation of the sound patterns in poetry (in other terms, to it's phonics, orchestration, euphony, and the like). Syllable is acknowledged to be an elementary compositionally significant phonic segment (as well as it was long time ago recognized for metrics and rhythmics), as a non-discrete speech unit treated irrespectively of the syllabic division factors (it's really significant in case of the so-called "wave" languages, including Russian [23]). In this respect, we introduce the operational concept of a potential syllable, which denotes any piece of speech chain consisting of a vowel and its complete consonant environment (a number of consonants around a vowel up to preceding and succeeding vowels). In compliance with it, every and each potential syllable in its consonant part, appears partially overlapping the neighboring potential syllables (SP). Comparability and commensurability of those simple steps and their contacts and combinations generate syntagmatically coherent and semantically oriented (by means of morphology and syntax) sound texture of a poem. In virtue of the qualitative repetitions and positional parallels, in the sound and segmental-syllabic circuit of the verse, its certain pieces and layers are "snatched out" or foregrounded and stand out as *tertium comparationis* for the units of a higher level. Wherefore, the repeated consonant series and combinations around its vowel within a potential syllable, which make up the basis of the repetition, are being highlighted by the reader's ear.

Such basis is made up of: the vowel as the syllable bond, regardless of its quality, and those in-coming to SP consonants (single or consonant series or groups of free arrangement within SP), actualized by the repetition itself. Those repeated units, phonosyllabes, reduced to the general invariant phonosyllabeme, are forming chains in the verse providing emphatization, integration, delimitation and syntagmatic correlation of segmental units such as those belonging both to the verse (line, strophe, etc.), and language proper (morpheme, word, and word form, word collocation, sentence and other ones). When repeating, two-member repeating groups of consonants do not go beyond one potential syllable, i.e., according to V.V. Merlin, "the consonants included in the repetition cannot be separated in the members of the repetition by more than one vowel" [34. P. 163]. Three-consonant repetitions do not go beyond two adjacent potential syllables.

Thus, the sound structure the text is formed by the influence of the operational unit, the phonosyllabeme realized as a set of its variations — phonosyllabes. The position of segmental sound units (starting with syllabic position of sound), their quality regarding the position become the main measurement of the structuiral significance of the repetition elements. Against this background, onomatopoetically meaningful and connotative phonosemantic speech features are viewed as additional and just episodically functioning text-forming factor. We assume that sounds repeat not because they mean anything, but they do mean anything because they repeat and form substantial and correlative configurations, which in the text are positionned and appositionned in a certain manner. This helps overcome the method of total counting resting against the simple idea of "accumulating" sounds and their characteristics in the text, i.e. the method foregrounded on the isolation of discrete consonants and vowels as if scattered-free within the verse, and also relying on the supposition of the aesthetic significance as a feature derived from frequency characteristics [14; 33; 35. P. 226—231; 36—38].

Key terms and concepts

In the verse sound structure, there are two basic types of relations demonstrating different functional perspective. The first type makes up the echo-repetition, i.e. structural and positional parallelism starting from segmental-and-prosodic analogies in the speech chain, — those are the relations of equirhythmy (positional parallelism) and equiphony, proper to the rhyme, in particular (the analogy of qualitative sound filling of similar and congruent syllabic, rhythmic and other positions). The second type makes up the metaphonical, inverse relations, based on the asymmetry of segmental-syllabic contours and reverse sound order, whereas the qualitative coincidence of sounds within the syllable-building groups (i.e. within SP) overcome parallelism, providing a free interchange of consonants within a single SP or contacting syllables. Metathesis, operating by integral segmental inverse consonant-vocal

configurations, autonomizes phonosyllabeme and granulates the sound chain in a peculiar way (see in Russian: *волги вал* [volgi val], etc. and *лоно волн* [lono voln]. The pattern of metathesis within the syllablelike unit (phonosyllabeme) forms a kind of sound plastics, the play of sound gestures of the verse. Thus, the sound texture of "Italian Spring" — a sketch by Fedor Tyutchev — is formed by means of the following phonosyllabic bands and links (see: Fig. 1. Including the variation of the last line).

Fig. 1. Phonosyllabic repetitions in Fedor Tyutchev's poem "Italian Spring"

The series of metaphonic repetitions establish interword associations (*бла*гоуханна — *бели*зна — *обли*ла, embracing the strophe; бе**лизна** — **зе-лень**); integrate word rows: *све*тла, уж *с фев*раля *весна в са*ды; *мин***даль** *мг***новенно**; project the headline adjective-attribute и*таль*янская onto св*етла* and мин*даль*; and the key noun is entwined in the texture of all the four lines: ВЕСНА —> благоуханНА И СВетла — ВЕСНА — мгноВЕННО Зацвела — белиЗНА ВСю зелень, повсеместно «разливая» *весну*.

The three-consonant repetitions observed here are of a syllabic nature, as well as the two-consonant ones: the arena for the spread of three-consonant and multi-consonant repetitions is two or more adjacent potential syllables: in Tyutchev, vesnA — naIsv — vesnA — vEnnoz — iznAv(su). Thus, the **phonosyllabic complex** (FC) is formed. (At present, the program shows these cases of repetitions only where FC is formed by a ligature of two phonosyllabs, and in the future it is planned to introduce a separate function for detecting multisonant polysyllabic repeatitions by the program.)

Regardless of the prospect of poetic morphologization and lexicalization of sound repetitions, inversive "twists" of phonosillabeme and phonosyllabic complexes, perceptible against the background of syntagmatic expectation, perform an emphatic, as well as connective-integrative and delimitative role — the functions of isolating, combining and dividing the speech chain, likening the means of the super-segment language and some sort of punctuation marks.

The arrangement of phonosyllabes in the verse, the sentence and the correlation of their contours prove to be the spring of syntactical deployment. Parallelism of segmental and prosodic structures emphasizes the vital momemt of their loosening. In particular, it forms such a type of metaphony as metatony — the stress shift, the change of position in a prosodic contour of a word, line, etc. (A.S. Pushkin: *Татьяна то вздохнёт*, *то ухнет*...; O. Mandelstam: *Когда душе и туропкой и рубкой* and so on.).

Semantic resources of metaphony are already provided by the speech-chain phonosyllabic graining itself, which opens the opportunity of both interaction and "opposition" of a phonosyllabe with a morphemic row, turns a phonosyllabic repetition into a means of poetic morphology of the text [see: 39. P. 246; 40]. Metaphony gives an opportunity to lexicalize a phonosyllabeme and phonosyllabic collocations, particularly making them the instrument of a semantic metamorphosis of a word and its "grammatical-and poetic analysis" [41. P. 640], bringing in figura etymologica, paronomasia (annomination) and anagram. Chains of repetitions enter a complex game of direct and inverted parallelism, accelerations and decelerations. Open and hidden structures, setting and deceiving structural anticipations and making up textual syntagmatics result in syntax, and actual, topic-comment one, as well [42], and thanks to the influence of sound emphases, associations and divisions in a verse, it becomes the core translator of the sound structure into semantic sphere. To a wide extent, those relations embody the mechanism of violation and complication of the tendency to complete paralleluism in the verse against the requirements of adequacy, proportion and comparability, in the limit giving complete parallelism and battology [43. P. 271—276], the mechanism of the rhythm influence against the scansion. Being deeply engrained in the language nature, the mechanism of metaphony reveals itself not only in poetry (most comscienciously, in interchangeable rhyming and morphological analysis of a word, e.g., A.S. Pushkin's *бар*ство — *раб*ство or E.A. Poe's *raven* — *never*more), but also — and even in a rather firmer form, limiting the transposition within the area of a single potential syllable, — in the metathesis regularities in the history of language, in phonotactics imprints [44. P. 31], in slang, dialect [45] and linguistic game word transformations, in children's speech metathesis [18]. Our interpretation of a sound repetition as a metaphonic one (and further on — the verse sound texture as a result of metaphony and equiphony interaction) is firstly foregrounded within O. Brik's conception and its further tradition as described in his classical work [46] to tackle the sound repetition phenomenon as the interchangeable repetition, opposing the inertia of echolike repetition, in particular referring to the logic of elementary rhyme. In the frames of our study, principle additions and amendments introduced into technique and method to describe sound repetitions in the interpretation by O. Brik, are detailed both in [16] and comments to the work "Sound Repetitions" [46].

At present, the program helps apply the automatic detection of one out of two basic types of sound associations, forming the sound composition of a text, — relations of metaphony, asymmetrical sound repetitions which are to the fullest extent connected with the sound repetition phenomenon and, in the verse structure, oppose trivial rhythmic and sound parallelism — rhyme and quasirhyme rollcalls (the relations of equirhythmics and equiphony).

From the methodological point of view the basic algorithm to dicriminate metaphorical repetitions relies on the two notions of "non-canonical, or non-academic phonetics" [47] or metaphonology [48], projected on the sphere of versified speech: besides the notion of a potential syllable, one uses the notion of a poetic phonemotype. The substantiation of the notion is given in [10] involving the grapheme factor while perceiving written speech and the phonemic principle of Russian spelling, and diversified, multiform experience of written speech analysis in linguistic poetics, psycholinguistics and phonosemantics (see: generalized sounds of O.M. Brik, soundletters of A.P. Zhuravlev [49], graphophonemes of V.P. Grigiryev [40], phonemotypes of S.V. Voronin [50] and others; compare [51—53].

According to this approach, in Russian poetic speech one can distinguish 12 consonant phonemotypes (consonant "poetic phonemes" concerning one of V.V. Grigoryev's sdtatements): 1) <п> — <п'>, <б> — <б'>; 2) <ф> — <ф'>, <в> — <в'>; 3) <т> — <т'>, <д> — <д'>; 4. <с> — <с'>, <з> — <з'>; 5. <ц>; 6) <н> — <н'>; 7) <м> — <м'>; 8) <л> — <л'>; 9) <р> — <р'>; 10) <j'>; 11) <ш>, <ж>, <шш'>, <жж'>, <ч'>. 12. <к>, <г>, <х>.

It means that, e.g., in A.S. Pushkin's lines: *Прогля**нет д**ен**ь *как будто поневоле* / **И** *скроется* **з**а *край* **окру**ж**ных** **гор** — by virtue of poetic equivalence <г> and <к>, <т> and <д'>, <н> and <н'> being the variations of the Russian ГVР phonosyllabeme, are detacted the Russian phonosyllabes рог, и|-крО, а|крА, гОр, and for the НVД phonosyllabeme the variations нет, дЕн be considered (in phonosyllabic transcription firmness-softness of consonants is not reflected, and sonant or non-sonant consonants, no matter positional devocalization or vocalization, is concerned only there where it is represented with a proper grapheme assuming these differences have no important influence on the speech phonosyllabic graining).

To analyze the relations of equirithmics and equiphony (segmental and prosodic parallelism) in the verse, the notion of the phonemotype is not sufficient enough, as there are actualized more particular sound characteristics, phonologically significant for the proper language (e.g., firm or soft sounds, sonant or non-sonant sounds, and other). At this, syllablelike multiconsonant repetitions both inversive and echolike structures (in Russian: *люблю твой* **стро**гий, **стро**йный *вид*), are effectively distinguished by the program, though the factor of segmental-and syllabic parallelism to detect such repetitions as a constitutive means are not yet considered. The system of

automatic recognition of echo-like sound repetitions, including rhyme-forming ones, based on accent differentiation of phonosyllabs (in the future — taking into account the "rhythmic status of accent units" [54. P. 88—94] within the framework of the Phonotext project has been developed and is undergoing computer implementation.

PHONOTEXT technology

Algorithms to detect metaphony

The functioning of the *PHONOTEXT* web-application presumes the following main operations:

1. Assume the text and process it to make the initial segmentation according to the potential syllable criterion;

2. Narrow down segmental units of the Russian spelling (graphemes) to phonemotypes on the prinsiples and rules of the Russian spelling;

3. Serach and automatic detecting of syllablelike repetitions;

4. Establish the associative strength of repetitions;

5. Filtering results according to the meanings of operators of the basic formula;

6. Draw and present the results in the visual-interactive and textual-numerative form.

The initial text segmentation includes, firstly, detecting all *potential syllables of maximal format* (further on $Sp(max)$)), and, secondary, dissociating every Sp(max) into all possible within its limits two-consonant combinations (syllablelike consonant groups — SCG). (At present, only two-consonant combinations are dissociated, but later dissociation of one- and multiconsonant combinations are supposed to be detected). The results of this processing are presented in the Table 1 as the case of the opening line of N. Gumilev's poem «Лес» (lit.: "Forest"); in Russian: *В том лесу белесоватые стволы...* (these data is available for the user in the link of «SP(max) / combinations»):

Table 1

Highlighting two-consonant syllable combinations in a potential syllable (Sp(max))

Text	в том лесу белесоватые стволы										
Sp(max)	в|том	м|лес	су|б	|бел	лес	сов	ват	тыj	je|ств	|ствол	лы
2-consonant combinations	в|то	м|-ес	су|б	бел	лес	сов	ват	*тыj*	*je|-т*	с--ол	
	в|-ом	Лес							je|с	т-ол	
	ом|л	*м|ле*							je|--в	вол	
	том								*е|ст*	*ст-о*	
	то-|л								*е|с-в*	*с-во*	
	в|-о-|л								*е|-тв*	*тво*	

The example contains 11 Sp(max) and in their frame 27 SCG (the signs of phonosyllabic transcription used: | — word boundary; — — epenthesis; () — for vibrant elements). Due to the fact that the repetition of one phonotype within the limits of the potential syllable causes variations in the presentation of the consonant group, there's previewd the opportunity to consider it twice: *слез* gives *сле* and *лез* (it's fixed as a **vibrant combination** of the first type — the **consonant** one: *сле(з)*, which later by means of equiphonic relations could be actualized as one of the variations, e.g., in the rhyme *лес — слез*).

In case consonant clusters appear in the intervocal position there's fixed the vibration of the second type — the **vocal** one: in collocation *в том лесу* the *мл* cluster "serves" to form two potential syllables *том|л* and *м|лес* (written as: *ом|л(е)*). Finally, the collocation *белесова**тые** **ст**волы* due to "symmetrical" positioning of the T phonemotype in the two ajoining syllables with the possibility to distribute j among different potential syllables, there's fixed the vibration of the third type — the syllabic one, influencing the further actualization of the consonant group as *тыj* and je|-*т* (written as: *тыj(е|-т)*).

When the initial text segmentation is accomplished, the program starts the search and evaluation of the links among the segments and directly detecting the repeated SCG in the given text. Detecting the Sp(max) two-consonant combinations actrualized by the repetition, leads to establishing of the two-consonant phonosyllabes nomenclature and their narrowing down to the invariant — the phonosyllabeme as a poetic quasimorpheme. In relations of repetition, phonosyllabes realizing the only one, unique phonosyllabeme form phonosyllabic chains (FC), which are to be specified in the text and proposed to a user.

Basic formula

Let's assume $\vec{v}$ is a sequence of phonosyllabes in a chain, then the strength of the $\sum(\vec{v})$ chain could be calculated as:

$$\sum(\vec{v}) = \sum_{i \neq j} P_{comb}(v_i, v_j) \tag{1}$$

while P_{comb} **— Proximity of combinations** — denotes the degree of closeness of the two SCG (in s.u.), or the strength of their interaction. The FC general strength is thus calculated by summing up the strength of all the binary collocations within the chain with the complete enumeration of separate twin links:

$$\sum(a, b, c) = P_{comb}(a, b) + P_{comb}(b, c) + P_{comb}(a, c)$$

where **a,b,c** are the chain links (phonosyllabes) in the given text continuity.

FC consisits of only syllablelike consonant groups (SCG), supported by the repetition, i.e., active phonosyllabes, so among all paired comparison of the

SCG, one needs to find those, which have the P_{comb} parameter over zero, relying on the formula:

$$P_{comb}(a, b) = IAS_{summ}(a, b) \cdot \left(\frac{1}{St(a)} + \frac{1}{St(b)}\right) \cdot \sum_{i=1}^{N}\sum_{j=1}^{N} P_{el}(x_i, y_j) \quad (2)$$

where $IAS_{summ}(a, b)$ — **Summary Index of Assotiative Strength** is the summarized index of the associative strength of the two SCG (in s.u.);

$St(x)$ — **Structure** is the SCG structure (in s.u.);

$P_{el}(x, y)$ — **Proximity of elements** denotes the degree of closeness of the two compared SCG elements (in s.u.).

Let's explain the constituents of this formula.

Primarily the most significant parameter of the formula is the last one, P_{el}, responsible to denote the strength of the interaction of the two SCG elements, which is calculated according to the following formula:

$$P_{el}(x, y) = \left(\frac{1}{D_{el}(x, y)} + \frac{1}{D_w(x, y) + 2}\right) \cdot \frac{1 + \delta_x^y}{1 + InD(x) + InD(y)} \quad (3.1.)$$

where x, y are the elements of the SCG compared; ;

$D_{el}(x\,y)$ — **Distance between elements** — denotes the distance between the elememts x and y in the speech chain (as a number of elements);

$D_w(x, y)$ — **Distance between words** — is the distance between words, containing x and y elements (as a number of syllable boundaries);

$InD(x)$ — **Distance from initial** — the element x farness from the true beginning of a word (it's determined by the ordinal number of the element);

δ_x^y — is a parameter of *qualitative* closeness показатель *качественной* of the compared SCG elements.

Each time we're having here three elements on each side: 2 consonants and 1 vowel, however only the consonant similarity is significant to continue analysis, while the vowel similarity seems optional (assuming the increasing degree of relatedness activated by the SCG repetition). For each consonant of the first SCG there should be found one combination with the consonant of the second SCG with the strength be measured > 0. Such condition could be observed only in the case when both consonants are either equivalent, i.e. they belong to the same phonemotype ($\delta_x^y = 0$), or fully identic ($\delta_x^y = 1$). If consonants belong to different phonemotypes, the indicator is $\delta_x^y = -1$, and the closeness degree of the elememts (P_{el}) equals zero. The indicator δ_x^y for the two vowels couldn't be < 0 (the occurrence of the summit of the syllabic element is the obligatory SCG feature and, further on, the phonosyllabe), and in case of their identity, it also equals 1 (=1).

The growth of the rest three indicators (D_{el}, D_w, InD) of the formula (3.1.) would diminish the closeness of the SCG elements — here we consider distancing of phonosyllabes from one another and their position in a word, besides both of them influence the strength of the association. We'd like to remark that for vibrant groups, the strength of the SCG constituents interaction couldn't be estimated as in their composition, those ones have at least one common consonant element which means they couldn't be correlated on the distance indication between the elements (D_{el}). Therfore the qualitative equivalence of SCG consonant elements is a prerequisite condition to register a sound repetition, and the stronger those elements congregate as (δ_x^y, and also the closer they are to one another in the speech chain (D_{el}, D_w), the higher would be the total degree of their closeness — $P_{el}(x, y)$.

Let's return to the formula (2) and discuss the indicators $IAS_{summ}(a, b)$ and $St(x)$. The summary index of the associative strength is an accessory multiplier, dependent on the individual SCG strength. Together with the structure, it answers the question about the quality of the SCG itself, its inner characteristics and is compounded according to the following formula:

$$IAS_{summ}(a, b) = 10 \cdot IAS(a) \cdot IAS(b) \cdot (1 + Last(a) + Last(b)) \qquad (3.2.)$$

where ***Last (x)*** is the positional index, accepting the value =1, when the SCG occupies the marginal position in a line, and =**0**, if not;

IAS(x) — Index of Assotiative Strength is the index of the SCG potentially associative strength *x* (IAS-1), the volume of which is determined by assigning to the SCG indexes for the presence/absence of a number of indexes in it.

Table 2

IAS-1: Index of Assotiative Strength

Feature		Index, s.u.	
		if a phonosyllabe has or hasn't got the feature	
		Yes	No
with the epenthesis		0	5
with inner word boundary		0	2
segmental structure	CVC	3	
	CCV	2	—
	VCC	1	
with j as a part		0	4
in initial		1	0
Total (max)		15	

Giving the SCG the index for the presence/absence of the epenthesis as an integrated part, the number of inserted units is not taken into consideration. This

condition compensates the SCG structural index which is estimated by multiplying distances between the elements of this very group according to the following formula:

$$St(a) = \prod_{i=1}^{2} D_{el}(x_{i-1}, x_i) \qquad (3.3.)$$

As in the formula (3.1.), the growth of the distance index between the elements ($D_{el}(x,y)$) — in this case for a single SCG — finally brings the weakening of the closeness degree of the two phonosyllabes (see: the formula (2)). Thus, St(*лес*) = 1*1 = 1 s.u., and St(*с--ол*) = 3*1 = 3 s.u (zero distance is valued as 1 s.u.).

One of the principle operations done by the web-application concerning the SCG associative strength index ($IAS(x)$) is *filtering results*. Already emphasized and valued phonosyllabic chains undergo additional selection according to the index of the potential associative strength, assigned to each chain link. At the stage of text digitizing, a user can set the lower and upper boundary of the filter (IAS-1 is set in the multiple form of 10, which is why the maximal amplitude varies from 0 to 1), weakening or strengthening the requirements for each phonosyllabe on the presence/absence of features mentioned above, i.e. main requirents concern the consolidation degree of each chain link. Phonosyllabes with the IAS-1 lower or higher to the set filter boundaries are not detected; and as a concequence, the picture of sound repetitions is modified. So, if once again to turn to the N. Gumilev's line *В том лесу белесоватые стволы...*, already analyzed in *PHONOTEXT*, the program will draw different pictures of sound repetitions dependent on the filter value (Fig.2).

Fig. 2. Picture of sound repetitions highlighted by the "Phonotext" web service in the initial verse of Nikolay Gumilyov's poem "Forest" at different levels of filtration

Phonosyllabic chains are arranged in decending order of their associative strength (Σ), and the indexes of the avarage degree of the chain links closeness

between ($\bar{\lambda}$) and their number in the chain (N) are demonstrated. Fig. 1 explicates how at tightening the filtering, phonosyllabes (*в*|-*о*-|*л*, *то*-|*л* and other) of IAS-1 beyond the lower filter boundary are 'flunking', and because in three cases marked they make up one of the two links of minimally possible chains, the chains thenselves are decending. The filter could withdraw not quite strong parts of vibrant groups (thus, *э*|-*тв*(*о*) turns into *тво*). As the associative strength of chains is only given with respect to the emphasized phonosyllabes, in consequence of the filtering, its values might change, and in this case, chains themselves would occupy other positions on the list.

Results and discussion

The principle purpose of the *PHONONEXT* program is to be a research tool, a form of quick and, by its criteria, methodically verified uniform analysis of the verse sound composition. In a great many works which undertake such analysis, there aren't just proposed and discussed methods to detect repetitions, but within the frames of one and the same text, the foregrounds to reveal those are disbalanced. The value of the *PHONOTEXT* program is due to the fact that the background for its algorithms makes up exclusively formal features abolishing the influence of the individual perception of the picture of the repetitions and the impact of personal impression of the text together with its means and the entire volume of its semantics. Obviously, in such an impersonification of treating the textual sound patterns, one can preview some negative factors, as in any case, when a machinen replaces a man. The program does't lay claim to the text interpretation proper, but just presents the objective picture of the repetitions as a reason for interpretation.

The carried out testing of the program and discussing it in the professional community help see this developed tool as a kind of philological prompter to analyzing and reading as if a guide making a man pay attention to those things which could be ommited in course of reading [8. P. 237—238]. The program does't presume fragmentary review and presents the sound structure of a text not like separate rollcalls but like the dense sound texture with the repetitions to thread and form the wording texture. According to the evaluation of E.D. Tolstaya, "the conception <...> allows speak not only of the pointlike repetition of separate sounds, but of indescrete, single sound irradiation: it absorbs both vowels and consonants in direct and indirect order" [55]. In the opinion of T.M. Nikolayeva, the given approach being primarily employed in phonostylistics of the versified speech, "in essence, … it is completely foregrounded on the significance of the repetitions and their aesthetical value (mainly in the sound aspect)" [56. P. 56—58]. The picture of the repetitions presented by the program means opens for a researcher the opportunity of more comprehensive functional analysis and understanding the text as an aesthetical phenomenon. Therefore, the possibility to measure the sound text coherence and

the quantitative representation of its sound texture paves the way to obtain exact data of the character and density of the sound texture both of separate texts and those ones belonging to massive corpuses with tagging them according to various genre and style parameters.

Obviously, the most impostant task of the program is to help establish essential differences in the verse and prose sound structures, fiction and non-fiction speech. Preliminary results obtained on a rather small number of texts already give the evidence of the vivid advantage of the versified speech over the prosaic one according to the degree of sound coherence (in the programme, it reflects the value of the parameter *General strength of repetitions* which is formed by summing up the strength values of all FC detected in the text). Automatic processing was used to analyze two corpuses of texts — poetical and publistic ones (by 20 units of each), containing texts of approximately similar volume (500 ± 100 symbols). Using the method of binary oppositions we got 400 collocations. The strength of repetitions of 231 samples (58%) was higher in poetical texts; the analogous comparison of the English language corpuses using the English version of the program revealed the advantage of poetry in 249 instants (62%). In future, the data can be refined with the development of corpuses and the use of new opportunities of the program as to the analysis of the FC length and the frequency of phonemotypes used.

The significant characteristics of the program's functional could be its application in comparative studies of various kinds: comparison of idiostyles, poetic trends and schools, studies of the dynamics of changes of authors' poetical technique in the plane of their work on the sound texture which could bring some ideas about the specifics of poetic mindwork in the least studied field of the consciensious control on poet's behalf. Thus, the *PHONOTEXT* program gave the opportunity to receive the data on the "graining" degree, granulation of sound texture, the orientation setting of structural consolidation and further morphologization of phonosyllabemes.

From this point of view, the already carried out study of V. Nabokov's and O. Mandelstam's poems [59] allowed us to reveal principally different approaches to compose the text. Two corpuses of poems of 30 units of each poet served as a material of the study. The corpuses were compiled regarding the strength indicators (General associative text strength, AS of the five first chains, AS of the first chain) and quantitative indicators (the number of links in the first five chains). The initial criterion made up the use of the firmness degree of the IAS-1 filter, with the three levels determined: **0... 1** (repetitions of any strength, including the minimal one)), **0,6... 1** (the phonosyllabes of the IAS-1 ≥ 9, including those appearing on the sound boundaries and of the minimal epenthesis), **0,7... 1** (phonosyllabes with the IAS-1 of ≥ 11, without any epenthesis), while the filtering firmness is proportional to the rize of requirements to the consolidation degree of phonosyllabes composing sound

chains. Three levels of filtering gave 900 results of paired oppositions on each of the indexes. The results are shown in Table 3 (bold scrip highlights the advantage in number of overbalances).

Table 3

**The results of paired comparison of the units of the verse corpuses
of Vladimir Nabokov and Osip Mandelstam according to various indicators**

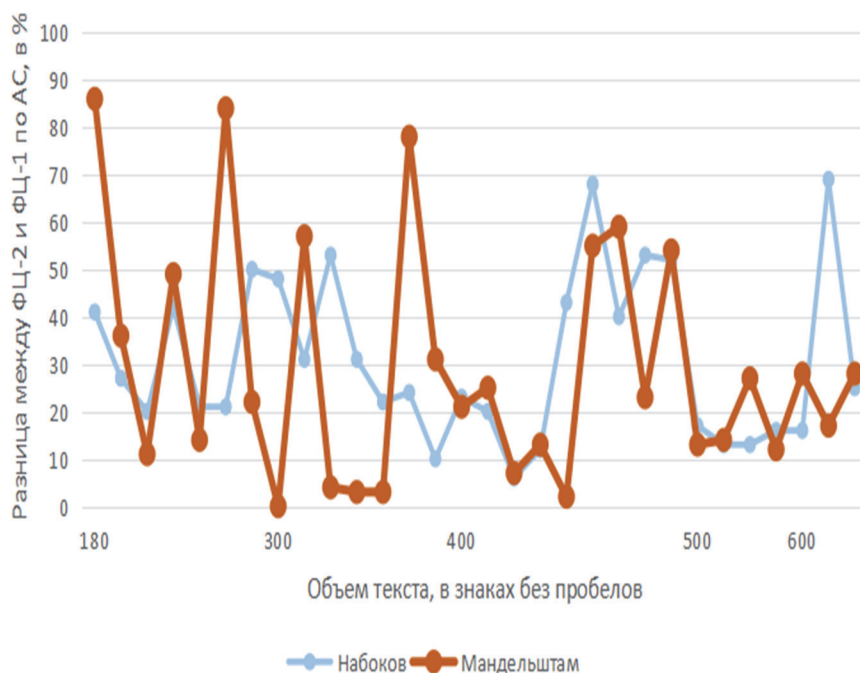| IAS-1 filter	Number of overbalances							
	AS gen		ASfc-5		ASfc-1		N phonosyllabes FC1-5	
	H.	M.	H.	M.	H.	M.	H.	M.
0… 1	443	**457**	**453**	447	415	**485**	**590**	410
0,6… 1	425	**475**	426	**474**	410	**490**	**464**	436
0,7… 1	326	**574**	420	**480**	406	**496**	443	**457**

Fig. 3. **The level of dominance of the first phonosyllabic chain relative to the second in the poems of Osip Mandelstam and Vladimir Nabokov**

As is seen, there's observed a vivid progression: the upgrading of requirements of the phonosyllabes consolidation (=filtering strengthening) is

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directly propotional to the growth of overbalances in Mandelstam's poems on all the parameters and especially those of strength. Let's remind: the more narrow is the filtering range, the less number of phonosyllabes of weak structure is detected and considered to estimate the associative strength. The progression demonstrates that the greater role in Mandelstam's poems belongs to the highly consolidated repetitions, while in the sound structure of Nabokov's poems, epenthized and lenghy, extended assonances are more significant, and if to stop AS considering and counting them, Nabokov's poems against Mandelstam's poems would essentially loose strength. (At that, the greatest disruption in overbalancing according to AS indicators is observed at **0,7...1** filtering: AS_{fc-1} is equal to 90, AS_{fc-5} is 60, $AS_{gen.}$ is 248!).

The leading role of the lengthy assonaces in Nabokov's poems speaks for the substantial compressing of the number of links in the five most strong FC along with the strengthening of filtering (N phonosyllabesin FC1-5), at that in 7 lines, weak phonosyllabes occupy over 40% of the number of links of the strongest chains and in four of those there are 20% against Mandelstam's 1st and 9th verses, correspondently. The numbers belonging to the first chain give the evidence about the orientation towards the morphologization of the phonosyllabeme, and about working with the phonosyllabeme as a poetical morpheme. Besides the lasting separation in its strength (70, 80, 90 positions), the appearance of the powered dominants is typical for Mandelstam's texts which is clearly seen if compare the distance at which the second strong chain legs behind the first one at the filter value of 0,7… 1 in his verses. (see above: Fig. 3).

Besides three examples of the radical difference in the associative strength (78, 84, 86%) between the 1st and 2nd chains, at this indicator Mandelstam's verses reveal 5 samples of the minimal differentiation (0—4%). So, the cohesion of his short poems (the volume of those is 400 signs without gaps) is provided with either one keynote — the dominant chain of repetitions while the other ones are materially weakened and play the role of episodic links (compare, e.g., *«Ты розу Гафиза колышешь…»* with К-Р dominant), or the poet completely denounced the keynote principle in favour of polyphony, when the poem's cohesion is supported by the interaction of chains, approximately equal in strength (compare, e.g., his poem «*Улыбнись ягненок гневный с Рафаэлева холста…*» with the equivalent chains of С—Т, К—Л, С—Л, К—Н). In longer poems, the keynote principle is used for the inner connection of compositional parts when each part uses its own keynote (compare with «*Стихи о неизвест-ном солдате*»), which emphasizes the keynote function in Mandelstam's poetry be the means to consolidate complex syntactical and compositional entities. We could observe nothing of the kind in the analyzed Nabokov's poems: here the sound chains are allocated over all the writing interweaving and breaking beyond the syntagmatic segmentation. Thus there appear the background to

consider Mandelstam's repetition of consolidated phonosyllabes be simultaneously the means of their morphologization and poetic semantization with the following effect of figura etymologica, on the one hand, and on the other hand, — the strongest means to interconnect phrases. In its turn, Nabokov's sound technique with the episodical use of phonosyllabic bands as a form of the linguistic game, are often at the brink of wordplay [60], and being prior to the sound repetitions, on the whole, it realizes the frame to their euphonic use with a relatively chaotic interaction and assonance effusion along the text indicating their moderate activity as a means of syntagmatic segmentation and text consolidation.

Conclusion

Sounds of a verse are not anything disperced over rhythm, syntax, lexis and morphology. They aren't a surface decoration, but the technique essentially forming the basis of poetic speech. For a poet, the choice of words is always the choice of plastic euphonic pattern (sound-and-syllable movement and the shape of prosodic contour), and a word chain in poetry is fundamentally a sound chain, organized as repetition series on the basis of sonic and prosodic similarities and contrasts. In any speech, and in the verse in particular a sound organically integrates with rhythm; the sound chain is interfused with syllabic and prosodic energy. Thus Mayakovsky reflecting on the process of the birth of a verse out of the "rhythmic roar" shows the way to search the rhyme of the word *sobriety* (in Russian: *trezvost*): "Taking the most characteristic sounds of the rhymed word «*rezv*», I repeat it to myself over and over again, listening to all associations: «*rez*», «*rezv*», «*rezerv*», «*vlez*», «*vrez*», «*vrezv*», «*vrezyvayas*». A happy rhyme has been found" [61. P. 106—107]. And it was found by the way of searching direct syllabic assonaces in combination with "folding", or inversive variations of the phonosyllabic whole: рEзв — зEрв — врEз — врEз(в) врEз(-в). So the rhythm is etablished and takes shape — and the rhytm is the basis of ane petic work, resounding through the whole thing. Gradually you ease individual words free of this dull roar. Several words just jump away and never come back, others hold on, wriggle and squirm a dozen times over, until you can't imagine how any word will ever stay in this place" [Ibid, P. 100].

Being the elementary movement of speech, a syllable is not only a means to organize segmental sound series, but a form in accordance with which the speech texture is grainulated. Elementary granula, the grain of the rhythmic-and-sound strcture of the poetic speech is a phonosyllabeme — a consonant-vocal extract of a potential syllable. actualized by repetition and variable as a series of phonosyllabes reducible to the invariant.

Syllabocentric conception of textual sound structure treating the verse as a phonosyllabic chain and describing this chain in terms of opposition of the two

types of associations — direct (equirhythmic/equiphonic) and inverse parallelism (metaphony) laid the basis to create algorithms of the *PHONOTEXT* computer program (web-application). Currently, the program developed by the authors of the article, designed to automatically detect sound repetitions in Russian verse and visualize the picture of the sound composition of the text, allows the expert to view the sound series most important for understanding the speech texture of the verse, and, thus, provides an attentive reading of the text and its philological analysis.

The program implements the ability to quantitatively measure the sound coherence of poetic speech by processing individual texts and large corpora, opening up the possibilities of a versatile comparative-typological study of the text phonostylistics based on objectively obtained data.

The above results of a comparative analysis of verse and prose, sound devices by O. Mandelstam and V. Nabokov allow us to draw conclusions that were previously inaccessible for empirical and computer research.

The main prospects for the development of the program imply the inclusion in its functionality the analyzer of equirhythmic and equiphonic relations in verse, including rhyme and internal-rhyme repetitions. Taking into account the peculiarities of poetic traditions and spelling principles, in addition to the Russian language, Latin and English versions of the program are being developed, which already allow us to speak about the fundamental importance of phonosyllabic repetitions and connections in other Indo-European versification techniques.

The *PHONOTEXT* program is the work-in-progress project, and its results may already be useful both for researchers and for any careful reader and connoisseur of poetic art.

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