Olga Lyashevskaya[1]

FREQUENCY DICTIONARY OF INFLECTIONAL PARADIGMS: CORE RUSSIAN VOCABULARY[2]

A new kind of frequency dictionary is a valuable reference for researchers and learners of Russian. It shows the grammatical profiles of nouns, adjectives and verbs, namely, the distribution of grammatical forms in the inflectional paradigm. The dictionary is based on data from the Russian National Corpus (RNC) and covers a core vocabulary (5000 most frequently used lexemes).

Russian is a morphologically rich language: its noun paradigms harbor two dozen case & number forms and verb paradigms include up to 160 grammatical forms. The dictionary departs from traditional frequency lexicography in several ways: 1) word forms are arranged in paradigms, and their frequencies can be compared and ranked; 2) the dictionary is focused on the grammatical profiles of individual lexemes rather than on overall distribution of grammatical features (e.g. the fact that Future forms are used less frequently than Past forms); 3) grammatical profiles of lexical units can be compared against the mean scores of their lexico-semantic class; 4) in each part of speech or semantic class, lexemes with certain biases in grammatical profile can be easily detected (e.g. verbs used mostly in Imperative, in Past neutral, or nouns used often in plural); 5) the distribution of homonymous word forms and grammatical variants can be followed in time and within certain genres and registers. The dictionary will be a source for research in the field of Russian grammar, paradigm structure, form acquisition, grammatical semantics, as well as variation of grammatical forms.

The main challenge for this initiative is the intra-paradigm and inter-paradigm homonymy of word forms in corpus data. Manual disambiguation is accurate but covers ca. 5 million words in the RNC, so the data may be sparse and possibly unreliable. Automatic disambiguation yields slightly worse results, however, a larger corpus shows more reliable data for rare word forms. A user can switch between a 'basic' version which is based on a smaller collection of manually disambiguated texts, and an 'expanded' version which is based on the main corpus, the newspaper corpus, the corpus of poetry and the spoken corpus (320 million words in total).

The article addresses some general issues such as establishing the common basis of comparison, a level of granularity of grammatical profile, units of measurement. We suggest certain solutions related to the selection of data, corpus data processing and maintaining the online version of the frequency dictionary.

Key words: frequency dictionary, grammatical profile, inflection, grammatical homonymy, grammatical variation, Russian, Russian National Corpus

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[1] National Research University Higher School of Economics, Moscow / University Helsinki; Phone: +7 906 798 60 21; email: olesar@gmail.com; www: http://olesar.narod.ru.

1. Toward the lexicon-oriented grammar

Some time ago, object-oriented programming revolutionized the world of computer technologies, software industry and the interfaces of web resources. A long list of step-by-step instructions that automated everything was replaced with sets of objects with shared attributes and behavior. It is now objects that monitor the environment for events and trigger assigned functions. The metaphor of rules and objects can be easily applied to the grammar of natural language. What if the grammar is a self-organizing community of words rather than a general who leads the battle? What if the local grammars these words evoke are more efficient and powerful? Could we prove that the local effects are still systematic and not random? This article reports on an experimental frequency dictionary which aims to provide evidence to answer these questions.

A pilot frequency dictionary shows the inflectional paradigm structure of 5000 most frequent Russian nouns, adjectives and verbs. It follows a series of frequency dictionaries based on data from the Russian National Corpus (cf. Lyashevskaya and Sharoff 2009, a general frequency dictionary of 50 thousand words, and online grammatical and collocational dictionaries at http://dict.ruslang.ru). Our lexico-grammatical dictionary presents a comprehensive account of how inflection works, thus filling the gap between lexical frequency and grammatical frequency data.

As a general practice, most frequency dictionaries present distribution of lexical data either at the level of tokens or at the lemma level (cf. Leech et al. 2001, Davies and Gardner 2010 for English, Davies 2005 for Spanish, Čermák et al. 2010 for Czech, Sharoff et al. in press for Russian, etc.). In addition, the number of words in different part of speech classes can be given. However, hardly any frequency dictionary of the morphologically rich languages includes information about the structure of the paradigm and grammatical form frequencies. The only exception we are aware of is Šteinfeldt 1963/1970 where the frequency of 961 Russian nouns in each case and number form as well as distribution of some verbs in tense and mood is calculated.

As for grammatical frequency data, despite the fact that the task of constructing the frequency Russian grammar has long been recognized and promoted in the literature (Mustajoki 1973, Ilola and Mustajoki 1989, Baerman et al. 2010), the quantitative research is mostly focused on the non-lexical units: part of speech classes, grammatical classes (e. g. hierarchies of case marking, agreement markers, etc.), as well as morphemes (Šajkevich et al. 2008).

Our project shifts the focus from the distribution of grammatical classes and categories to particular word forms as structured by the inflectional paradigm. Of particular concern are words with certain biases in grammatical profile, e.g.

- verbs used mostly in the imperative;
- verbs never used in the past neutral;
- nouns used often in the plural;
- nouns with low rate of the nominative forms, etc.

The dictionary will be a source for many of the future research in the area of Russian grammar, paradigm structure, grammatical semantics, as well as variation and alternation of grammatical forms (Graudina et al. 1976). It will provide a detailed account of gradual nature of some important phenomena such as singularia and pluralia tantum. Data from the RNC provide a great opportunity to answer many research questions, taking into account current technologies of corpus linguistics.

This article presents a short introduction in the structure of Russian paradigms (Section 2), examines the background to the lexico-centric approach to the frequency grammar (Section 3), discusses various types of information available in the dictionary (Section 4), and some issues associated with the processing and interpretation of the frequency data (Section 5 and Conclusion).

2. The structure of Russian paradigms

The data set in the dictionary is based on the morphological standard of the RNC (Lyashevskaya et al. 2005) which generally follows the paradigm inventory developed in the grammatical dictionary (Zaliznjak 1974). The dictionary takes into account only single-word forms, not paraphrastic forms such as, for example, the conditional forms with the particle *by*, imperfective future and passive participle construction with the auxiliary *byt'* 'to be', analytical forms of the comparative degree, etc.

The paradigm of Russian nouns has up to 17 cells: two grammatical numbers multiplied by six major cases (the nominative, the genitive, the dative, the accusative, the instrumental and the locative) plus five minor forms which some words take in the singular: the so-called 'second' genitive, the 'second' accusative, the 'second locative', vocative, and the adnumerative.

The adjectival paradigm has at least 32 cells: 26 inflected long forms (three genders in the singular and the plural multiplied by six cases; in addition, the masculine and the plural adjectives distinguish two types, animate and inanimate, of accusative forms), four short forms (three genders in the singular and the plural), and two comparative forms. Zaliznjak's grammatical dictionary (Zaliznjak 1974) and the morphological standard of the RNC excludes from the standard paradigm some archaic short forms with case endings and the superlative forms which has the same declension as the full forms. Russian pronouns and numerals function either as nouns or as adjectives.

There is a considerable syncretism within the nominal paradigm. Some case forms are fairly homonymous, e.g. the accusative and the nominative forms of inanimate nouns, the accusative and the genitive forms of animate nouns (except for the feminine singular that has six distinct case forms), the genitive, dative, instrumental and locative forms of many adjectives in the singular, etc.

The paradigm of verbal forms has less cohesion among its forms than the declension of nouns. Imperfective and perfective verbs are considered to be separate lexical units and have slightly different paradigm structure. The non-past forms express present tense for imperfective verbs and future tense for perfective verbs and distinguish three grammatical person and two numbers. Past tense has four forms, three genders in the singular and the plural. Imperative forms distinguish first and second person, and singular and plural, plus a minor inclusive form. The non-past and past forms are usually used in the active-middle voice; passive forms formed with the reflexive *–sja* affix are almost non-existent but potentially double the number of indicative forms. The imperfective has two gerunds for present and past tense, whereas perfective verbs form only the past gerund. Imperfective verbs can have up to four participles (the present active, past active, present passive and past passive participles), whereas perfective verbs have two (the past active and past passive participles). Each participle can have a full complement of twenty-four adjectival full forms and four short forms. The infinitive has only one form and is a basic dictionary form of the verb.

3. Why mean frequencies may not always help

When linguists talk about the frequency grammar they presumably refer to a specific type of quantitative data like the frequency ratio of part of speech classes, frequency hierarchy of cases and other grammatical categories. The topic of case-frequency distribution is particularly popular in Russian linguistics: Kopotev 2008 cites three studies that were published during three years in 1959-1961; and there are much more recent publications that report research results based on various digitized text samples.

Kopotev 2008 draws attention to the stability of frequency data in large and small corpora (cf. Table 1). The first two sets of data are based on the modern corpora (RNC and HANKO) while the two others are drawn from the earlier frequency dictionaries based on datasets smaller than 0.5 MW. Kopotev concludes that the modern corpora agree quite well in the assessment of mean probability of case occurrences, and the differences lie in the structure of text collection in terms of genres.

	Nom	Gen	Dat	Acc	Ins	Loc
Russian National Corpus	27.06%	29.23%	5.98%	18.66%	8.44%	10.63%
Corpus HANKO	24.30%	32.62%	5.50%	17.73%	8.08%	11.78%
Josselson 1953	38.80%	16.80%	4.70%	26.30%	6.50%	6.90%
Šteinfeldt 1963	33.60%	24.60%	5.10%	19.50%	7.80%	9.40%

Table 1. The frequency distribution of six Russian cases in (Kopotev 2008: 142).

However, the principle 'choose genitive if not sure' may easily mislead if a student of Russian as a foreign language has to choose an appropriate case for the word *shepot* 'whisper'. Table 2 shows that the frequency distribution of cases within some nominal paradigms deviates significantly from a typical pattern.

	Nom	Gen	Dat	Acc	Ins	Loc	Total (F.abs)
shepot 'whisper'	10.9%	3.7%	0.9%	8.3%	**75.6%**	0.6%	349
poza 'posture'	15.9%	6.3%	0.8%	19.0%	4.0%	**54.0%**	126
tropinka 'walking path'	27.6%	2.0%	**52.0%**	5.1%	5.1%	8.2%	98

Table 2. The grammatical profile of the nouns *shepot* 'whisper', *poza* 'posture', *tropinka* 'walking path' (case forms in singular).

As early as in 1974 J. Greenberg proposes a hypothesis that different semantic groups may have different distribution of cases (both with prepositions and without them; Greenberg 1974/1991). Choice of Russian as an object of study is not accidental: his hypothesis testing is carried out on the data from the aforementioned frequency dictionary (Šteinfeldt 1963, source corpus 0.4 MW). Greenberg classifies one half of the nouns into twelve categories (animal, body parts, time periods, etc.) and calculates the average frequency of each group for each case. As expected, the place names are used mostly in the accusative and locative form while the dative shows a higher value in

personal pronouns (1st and 2nd person), see Table 3. However, not every episode is explained that easily.

	No. of types	No. of tokens	Nom	Gen	Dat	Acc	Ins	Loc
1. All nouns	9.073*	102.173	33.6%	24.6%	5.1%	19.5%	7.8%	9.4%
2. Common nouns	9.073	89.384	28.3	26.0	5.0	21.8	8.6	10.3
3. Proper nouns	?	12.789	76.3	13.5	5.5	1.1	1.4	2.2
4. Personal common individual	119	11.769	54.1	22.5	6.9	7.0	8.0	1.5
5. Personal collective	29	2.565	23.9	48.0	4.2	9.6	6.2	8.3
6. Animal	9	746	35.6	28.4	3.8	21.6	6.0	4.6
7. Body parts	31	3.318	18.2	9.9	3.2	36.5	20.3	11.9
8. Concrete count	116	5.475	23.0	20.7	4.3	32.0	9.4	10.5
9. Concrete mass	25	1.565	21.3	31.6	2.2	24.3	13.6	6.9
10. Non-enduring objects	31	2.127	34.5	19.0	4.1	21.5	10.8	8.8
11. Abstract qualities	21	1.295	33.3	24.9	3.8	17.4	12.3	9.0
12. Place nouns	87	7.747	11.8	30.6	6.0	24.4	3.3	23.8
13. Place institutions	17	2.445	13.0	40.9	2.3	17.8	1.8	24.1
14. Time periods	8	2.998	12.8	37.5	2.0	36.0	3.4	8.3
15. Measures	7	480	2.7	85.4	0.8	5.2	1.2	4.6
16. First and second person pronouns	4	15.901	51.8	21.8*	14.5	9.5	2.2	0.2

Table 3. The relation of Russian case frequencies to semantic features (adopted from Greenberg 1974/1991: 210).

(Rice and Newman 2005) and (Newman 2005) make the observation that the distribution of grammatical variation may be present within the lexical groups. They focus on the notion of inflectional islands (or the skewedness of the frequencies of certain inflectional forms according to the corpus data), and their source corpus is BNC. Rice and Newman notice that the frequencies of English *think*, *know* and *mean* at the inflectional level is very different even though the meaning of three verbs appear very similar. They claim that the large inflectional islands help to gain insight into what is believed to be semantic differences.

The concept of grammatical profile is introduced in (Janda and Lyashevskaya 2011) as the relative frequency distribution of the inflected forms of a word in a corpus. On the one hand, it presents a more elaborated version of Rice and Newman's ideas for rich inflectional paradigms that involves many forms and complex grammatical

oppositions[3]. On the other hand, it follows the behavioral profile approach proposed by (Divjak and Gries 2006) as a tool to study the semantic and functional reasons for discrepancies of corpus frequencies. Whereas Divjak and Gries indiscriminately take a vast range of morphological, syntactical, lexical and semantic factors and build the hierarchical structure based on their contribution to the frequency patterns, the grammatical profile explores only inflectional data. Our study of aspect, tense, and mood forms in (Janda and Lyashevskaya 2011) shows, inter alia, the predictable frequency effects in the imperative form of the imperfective verbs that refer to a frame of being a guest. The imperatives do not provide new information, but rather express standard polite formulae such as *razdevajtes'* 'take off your coat'), *sadites'* 'sit down', *zakusyvajte* 'eat chasers', *zakurivajte* 'please smoke', etc. The infinitive perfective forms are often used with the verbs like *vospolnit'* and *sootnesti*, which in turn prefer the constructions with tentative verbs and adverbs describing the difficulty or importance of an achievement.

(Kuznetsova 2013) studies the ratio of the masculine and feminine forms used in the past. Kuznetsova analyses the class of typically 'feminine' and typically 'masculine' verbs: whereas verbs of sewing, knitting, embroidery, darning and so on are associated with feminine forms, verbs that describe being a leader or negatively evaluated behavior like drinking or spitting are found in a 'masculine' list (see Table 4).

lemma	fem	masc	neut	fem:masc	role
način'stvovat' 'be chief'	2	124	0	0	leader
predvoditel'stvovat' 'chair'	3	77	0	0	leader
otrjadit' 'dispatch'	5	126	3	0	leader
pomilovat' 'pardon'	6	140	2	0	leader
knjažit' 'reign'	3	56	1	0.1	leader
predsedatel'stvovat' 'chair'	16	222	1	0.1	leader
kurirovat' 'supervise'	12	165	7	0.1	leader
…	…	…	…	…	…
ograbit' 'rob'	13	260	6	0.1	criminal
xuliganit' 'behave like a hooligan'	2	33	0	0.1	criminal
umyknut' 'walk away with'	2	29	0	0.1	criminal

Table 4. Verbs associated with masculine roles (data from Kuznetsova 2013, Table 9).

What is most surprising about the Russian lexical system is that there are no nouns such that their grammatical profile would correspond to the 'average' profile of the substantives, verbs with the 'average' proportion of tense-person-number forms and so

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[3] The grammatical profile approach was also applied to Old Slavonic data (Eckhoff Janda 2013). See also (Janda et al. 2013) on constructional profiles and radial category profiles, (Janda and Lyashevskaya to appear) on semantic profiles and (Kuznetsova 2013) on collostructional profiles, the other quantitative approaches to explaining the RNC data developed by the CLEAR group at the University of Tromsø.

on. In order to make Greenberg's hypothesis work, we must assume that when we explore the lexical space we deal with multiple overlapping classes, complex superposition of semantic features, syntactic and structural properties. All this collectively affect the frequency output.

Greenberg was looking for the 'magic' ratio, which would allow the word to refer to a particular semantic class; no wonder that he never succeed to find it. Now, from the viewpoint of cognitive semantics, his observation can be reinterpreted as a semantically motivated shift of grammatical forms frequencies. Let us take three examples. A high ratio of the instrumental case forms in the paradigm of the noun *shepot* 'whisper' can be explained as the overlap of the lexical semantics (whisper as a way of speaking) and the semantics of its grammatical form (the instrumental of manner). The overlap between the stative semantics of the noun *poza* 'posture' and the semantics of placement in the locative prepositional group *v* 'in' + S.loc explains the peak on the locative case forms, cf. *v poze (lotosa)* 'in the lotus position'. The nouns that refer to path/trajectory are most typical fillers of the prepositional group *po* + S.dat 'along (a path)', and hence there is prevalence of the dative forms in the noun *tropinka* 'walking path'.

4. Frequency information in the dictionary

4.1. Small and expanded dataset

There are two sets of frequency data in use in the dictionary. The 'small' version is based on the manually disambiguated subcorpus and contains more accurate annotation from the point of view of grammatical homonymy. However, since the subcorpus is as small as 5 MW, the chance to meet some rare grammatical forms is very low or they do not occur at all. As a result, if a particular word form is not frequent, its distribution within the paradigm may not be reflected properly in the 'small' version.

The 'expanded' version is based on the collection of four RNC corpora which is 60 times larger than the manually disambiguated subcorpus. The disambiguation of lemmas, part of speech and grammatical features is done by the computer, so the attribution of homonymous tokens (e. g. the accusative form that mirrors the genitive animate form) is less reliable. Both versions are imperfect but the user can choose between them according to the task at hand.

4.2. The level of granularity of grammatical profile

The most detailed level of granularity available in the data is not necessarily the most optimal one. Given the number and structure of forms, grammatical profiles can be shown at varying levels of resolution.

The user can evaluate certain grammatical distinctions for their relevance for his/her research task and collapse them within the grammatical profile. For example, there can be a cluster of full passive participle forms within the verbal paradigm (distinction in case, number, gender and animacy is collapsed), a cluster of four forms of the past tense (distinction in number and gender is collapsed), a cluster of all singular forms of the noun as opposed to a cluster of all plural forms (distinction in case is collapsed).

As a move in the opposite direction, the grammatical profile of nouns can be extended with the distributional pattern of prepositions which are used with each case. This is done since the research practice suggests that the most fine-grained level of inflectional profiling is not enough: when the case forms are used alone, or used with different prepositions, their meaning and syntagmatics change dramatically.

4.3. Homonyms and grammatical variants

The user can restrict the output to the relevant subset of grammatical forms. Two look-up tables are pre-defined: a subset of inflectional forms that have a homonym within or outside the paradigm (see Ventsov, Kasevich 2004 on intra-paradigm and inter-paradigm homonymy in Russian) and a subset of graphically distinct variants of a grammatical form. The dictionary shows:

1) the ratio of graphically identical forms within one paradigm, e. g. *soldat* 'soldier', Nom. sg. VS Gen. pl. VS Acc. pl., and 2) the ratio of each homonymous forms that belongs to the selected paradigm and those that belong to other paradigms, e. g. *zaplyv*, which is a form of the verb (*zaplyt'* 'swim away; be swollen shut') and the noun (*zaplyv* 'a swim'), see Table 5;

Word form	Lemma	PoS	Classif.	Inflect.	F.abs	%
zaplyv	zaplyt' 'swim away; be swollen shut'	V	intr, pf	gerund, past, act	4	2.24%
zaplyv	zaplyv 'a swim'	S	inan, m	Nom. sg.	100	56.18%
zaplyv	zaplyv 'a swim'	S	inan, m	Acc. sg.	74	41.57%

Table 5. Ratio of the homonymous forms in the newspaper corpus: *zaplyv*.

3) the ratio of occurrences of grammatical variants, i.e. forms that have the same grammatical annotation (e. g. compar. *silnej* VS *silnee* 'stronger', Ins. pl. *dverjami* VS *dver'mi* 'doors'), etc.
4) graphically distinct 'major' and 'second' substantive cases and adjectival comparative forms (these forms have slightly different annotation according to the RNC standard, cf. Gen. sg. (*bez*) *tolka* and Gen 2. sg. (*bez*) *tolku* 'no use (doing smth.)'; compar. *silnej* and compar. 2 *posil'nej*, compar. *silnee* and compar. 2 *posilnee* 'stronger').

4.4. Grammatical profiles in time and genres

Information about the shifts in grammatical profiles over the time is given in 10-year intervals, and in the corpus of modern newspapers these time spans are narrowed to 1 year. While the default dataset involves data from 1900 to 2010, the diachronic changes can be traced back to the 1800s.

The user can also follow the shift of distributional properties in different collections: in literary prose, poetry, periodicals, everyday communication, research and teaching materials, in other genres of non-fiction, in electronic communication, and in oral non-public speech.

4.5. Units of measurement

The user can choose one or several units to measure occurrences in the corpus:

– a number of documents

– an absolute frequency of occurrences (F.abs) and the total corpus size (absolute scale is required for further use in statistical toolkits)

– a relative frequency in ipm (items per million)

– a hierarchy (or a ranked list) of grammatical features like the following

Loc> Gen> Nom> Acc> Dat> Ins

– a percentage distribution (see Table 6)

	Nom	Gen	Dat	Acc	Ins	Loc	Total (F.abs)
sg	98	128	29	170	137	14	576
pl	4	9	3	7	2	2	27

	Nom	Gen	Dat	Acc	Ins	Loc	Total (%)
sg	17,0%	22,2%	5,0%	29,5%	23,8%	2,4%	100,0%
pl	14,8%	33,3%	11,1%	25,9%	7,4%	7,4%	100,0%

Table 6. Grammatical profile of the noun *vlijanie* 'impact'. Case distribution: absolute frequencies and percentage.

The question what benchmark should be used as a basis for comparison (100%) is not that straightforward. This can be the total of all word form frequencies; however, the paradigm itself sometimes is not stable. For example, perfective and intransitive verbs systematically lack certain participles and gerunds, and the morphological shape of an imperfective verb determines whether it can form these peripheral forms, too. What is more, one can claim that participles and gerunds are not members of the verbal paradigm but form two separate (adjective-like and adverb-like) part of speech classes. Thus the stable part of the paradigm includes three basic moods: the infinitive, the indicative, and the imperative. Relative adjectives are prevented from forming the short forms and the comparative (and superlative) degree, so the core part of the adjectival paradigm includes the long forms only. Still, the 'second' cases should not be excluded from the totals as they occupy roughly the same syntactic position as the 'major' cases. The user determines which part of the paradigm is to be rated as 100 per cent.

− form1:form2 ratio (the proportion of use of the two forms with respect to each other, see Table 7)

Lemma	Form1: partcp act praes	Form1: F.abs	Form2: partcp pass praet	Form2: F.abs	Form1 :form2 ratio	Total
trebovat' 'require, demand'	trebujuščij	83	trebovannyj	0	∞	83
vesti 'lead, conduct'	veduščij	119	vedennyj	1	119.00	120
goret' 'burn'	gorjaščij	108	goretyj	1	108.00	109
znat' 'know'	znajuščij	88	znato	2	44.00	90
igrat' 'play'	igrajuščij	47	igran	3	15.67	50
govorit' 'speak, talk'	govorjaščij	60	govoreno	5	12.00	65
pisat' 'write'	pišuščij	32	pisan	35	0.91	67
bit' 'beat, hit'	b'juščij	20	bityj	42	0.48	62

Table 7. Ratio of the active present participles to the passive past participles in a sample of verbs.

− quintile scores of word forms (see Table 8)

Quintile scores are categorical values that allow users to track profile patterns as compared to activity of the part of speech class. Table 8 shows the quintile scores for the semantic group of vehicles. Quintiles divide scores of all nouns in a particular case into five equal groups ranked from lowest (very rare, *a*) to highest (very frequent, *e*). For example, the frequency the dative forms of the noun *parohod* 'steamboat' is found in the lowest group 0% to 20% (*a*), the score of the accusative forms falls into the group

20% to 40% (*b*), the score of the instrumental forms falls into the group 40% to 60% (*c*), etc.

Lemma	Nom	Gen	Dat	Acc	Ins	Loc	Total (F.abs)
metro 'underground'	a	e	d	a	a	e	185
korabl' 'ship'	e	c	b	b	a	c	231
gruzovik 'truck'	e	d	c	b	b	c	134
parohod 'steamboat'	e	e	a	b	c	d	121
автомобиль 'car'	d	d	c	b	b	d	441
poezd 'train'	e	c	c	b	b	d	618
samolet 'plane'	d	c	d	c	c	d	385
tramvaj 'tram'	d	b	c	d	c	d	198
lodka 'boat'	d	c	b	d	b	d	280
vagon 'coach'	a	d	d	c	a	e	473
velosiped 'bicycle'	b	c	a	d	b	e	206
avtobus 'bus'	d	b	c	c	b	e	281
taksi 'taxi'	c	a	b	e	a	e	174

Table 8. Quintile scores of case forms in the semantic group of vehicles. The profile of each noun is compared against the case profile of all nouns.

4.6. Comparison of words and classes

The data in the dictionary can be zoomed in and zoomed out to get a better view of trends in the lexical class and in the part of speech class. There are three levels of data representation. At the first level, the grammatical profiles of individual lexemes are presented; at the second level, the data are generalized into the profiles of lexico-semantic classes (e. g. verbs of motion, names of instruments, etc.; cf. the RNC classification, http://ruscorpora.ru/en/corpora-sem.html); at the third level, information is given about the major lexical categories (e. g. relative adjectives, transitive verbs), part of speech classes and grammatical categories.

5. Corpus data processing

The main part of the dictionary is based on the corpus collection which spans from 1900 to 2010. The diachronic part involves data starting from the 1800s. Data for the 'small' dictionary were collected in the RNC gold standard collection (5.4 million tokens) where lexico-grammatical homonymy was disambiguated manually. Data for the

'expanded' version of the dictionary were taken from the main corpus, newspaper corpus, the corpus of poetry, and spoken corpus of the RNC (320 million words in total).

First, the statistics of word forms were collected. The functional style and genre of each text, as well as time of creation was registered while processing the corpus. The database was indexed by lexical and grammar features (lemma, part of speech, inflectional attributes). We marked lexico-semantic classes according to the RNC classification; capitalized/non-capitalized and other variants of spelling. Second, we collected 2- and 3-gram statistics that shows the prepositional-case preferences of nouns and pronouns.

The lists of 1) tokens that have more than one grammatical tagset (grammatically ambiguous forms) and 2) grammatical tagsets that correspond to more than one token (grammatical variants and distortions) were complied. Each case in (1) was marked as inter-paradigm or intra-paradigm homonymy. We assessed the reliability of grammatical annotation provided by the tagger. The disambiguated version of four corpora was created with the help of two programs - the light parser that relies on heuristics and the HMM module which is trained on the gold standard RNC collection. A subset of n-grams with conflicting annotation was further evaluated and corrected manually.

The major problem for disambiguation tools was inherently overlapping paradigms, such as the paradigms of the masculine and feminine variants of the noun *rojal'* 'grand piano' that share most of the forms and differ in the instrumental singular, cf. *rojalem* m. and *rojal'ju* f. The feminine variant was mostly used in the 19th c. and the contemporary dictionary built in the tagger does not include it. The form *rojal'ju* f. was detected as not-in-dictionary form and assigned the correct feminine tagset. At the same time, all plural forms got only masculine tagsets, and the dative and locative singular forms *rojali* got a masculine tagset with wrong gender, case and number attribution (nom. pl. or acc. pl.). Thus the dictionary contains the defective paradigm of the feminine noun *rojal'* and the full paradigm of the masculine noun with overweighed proportion of plural forms.

Another example is the adjectives *zapásnyj* 'emergency' (as in *zapasnyj vyhod* 'back door') and *zapasnój* 'reserve' (as in *zapasnoj igrok* 'reserve player') which share most of the forms and partly share contexts and meaning. Both paradigms are stored in the tagger dictionary but their disambiguation is poor since the algorithm is not tuned to such a tiny difference (note that it is not always possible to choose the tagset manually).

New approaches to disambiguation would solve the problem of overlapping paradigms in the future; in the pilot version of lexico-grammatical dictionary such cases are marked as 'weakly reliable'.

6. Conclusion

The dictionary is addressed primarily to those who study and learn Russian grammar. It will be valuable to researchers interested in inflection and grammatical semantics, to editors and teachers who deal with grammatical variability. Nevertheless, it is noteworthy that the 'lexico-centric' approach, in spite of resource consumption and sparsity of data, proves to be helpful in natural language processing, too. As some recent experiments have shown, estimating the lexical probabilities can improve the results of HMM disambiguation module for Russian by 3% (Danilova et al. 2013). The online output of the dictionary can be freely downloaded in a spreadsheet format for further use in any kind of theoretical and practical activity.

The digital form of the dictionary allows us to continuously improve it. First, we are planning to develop the functionality to meet the linguistic community needs: to visualize graphically the data, to plug in external dictionaries, e. g. the dictionary of grammatical variants, the morphemes and word-formation dictionary, etc. Second, we will keep improving data quality as we collect users' feedback and error reports and improve grammatical disambiguation of the RNC data. Third, we will evaluate inclusion of new data and new distributional patterns (one of them is a set of author attributes). This yields that data becomes more sparse, so work with small frequencies requires special care and handling techniques to avoid skewedness and extreme ratios.

The main challenge though is to understand how to use the measures, how to interpret the data, how to transfer the obtained probabilities to other corpora and resources, and how to make accurate claims and predictions about functioning of inflectional forms in general. The proposed project is a first experiment in making a large lexico-grammatical reference resource and, therefore, it will afford a good material for studying the reliability of corpus data. There is no doubt that we need to better understand corpus data, the structure of corpora samples and how it is related to sustainability of the statistical data. We are to learn how to balance the samples of various time periods and genres, and the dictionary gives us a chance to experiment with rich lexical material so that adequacy of corpus data statistics would no longer be questioned.

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Olga N. Lyashevskaya

Professor, Faculty of Philology, National Research University Higher School of Economics, Moscow, Russia;

PhD student, University of Helsinki, Finland

Phone: +7 906 798 60 21

E-mail: olesar@gmail.com

www: http://olesar.narod.ru