

NININS 2020**International Scientific Forum «National Interest, National Identity and National Security»****ANALYSIS OF METAPHORICAL CONSTRUCTIONS IN
TEXTBOOKS ON THE RUSSIAN AS FOREIGN LANGUAGE**

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Abstract

A new and interesting concept in the linguistic didactics that is currently being developed in global research and starts to attract attention of Russian authors is that of metaphorical competence of foreign language learners. In conjunction with the problematic question of semantical reference of metaphors, it constitutes a notable area to be studied and analyzed. As a part of a greater project dedicated to this area, we have performed initial referential and typological analysis of metaphorical constructions found in texts and exercises of three major series of textbooks on Russian as a foreign language. Each series thus received early evaluation in terms of how actively it contributes to the development of metaphorical competence in students of Russian as a foreign language. And as a part of this effort, we have reviewed and classified in accord with different aspects of semantical reference a total of 367 metaphorical constructions and were able to distinguish 45 types of basic semantical concepts that these constructions were carrying. Further research is planned with the ultimate objective to evaluate the importance of development of metaphorical competence within the context of foreign language learning in application to the Russian language for students of higher education institutions.

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1. Introduction

Metaphors have been attracting attention of linguists and other researchers for many years. For example, in the field of cognitive linguistics a list of notable and frequently cited authors would include, but not be limited to Lakoff and Johnson (1980). Findings in this area have a lot of potential and practical applications; for instance, indirect meanings constitute a considerable obstacle for machine interpretation and understanding of texts in natural languages.

One of such applications lies in the area of language teaching and learning. Native speakers are used to relying on metaphorical constructions that are tightly linked with their culture and its traditions. However, for a foreign learner such constructions might be counter-intuitive and generally unclear due to a different cultural background. It thus comes as no surprise that in the latest years we have observed a considerable number of research articles dedicated to analysis of metaphors in the context of linguistic didactics. Interesting recent examples are Birdsell (2018); Kelso (2018); Pérez (2019). The concept of ‘metaphoric(al) competence’ can be found in such papers in particular and is generally understood as the students’ ability to perceive and produce metaphors in a second or foreign language.

We have also noticed that certain authors address the referential aspect of metaphors. In some articles, they claim that the phenomenon of reference is still not sufficiently researched in modern linguistics or is even ignored (Raskin & Chernouski, 2017). This aspect is indeed of particular interest, and we believe that it could produce meaningful results not only in the narrow area of language learning but also in the field of semantics and semiotics in general. As it is pointed out in (Stepanova et al., 2018), the way in which humans relate language signs to real world phenomena and objects is still not entirely clear.

As a part of a research project that is currently carried out by the Department of Russian Speech Culture within the Humanities Institute of the North Caucasus Federal University, our team has decided to analyze a set of popular textbooks on Russian as a foreign language and review their usage of metaphorical constructions. This particular paper will be focused on a relatively narrow task of collecting samples of metaphors and reviewing them in accord with their references and types.

2. Problem Statement

As far as we are aware, the idea of development of metaphorical competence in students of second or foreign languages is a relatively new and not yet sufficiently explored field in linguistic didactics. Certain research that we have mentioned in the *Introduction* suggests that it might play a notable role in the process of language learning and to an extent define the students’ efficiency in understanding and using the foreign language. If there is considerable influence, then this factor must be evaluated and properly accounted for.

However, research efforts related to metaphorical competence are mostly focused on English as a second or foreign language. This is a logical consequence of obvious circumstances such as a wide spread of English studies across the globe. In its turn, scientific thought on application of this concept to other languages has only started emerging. Thus, there is still room for findings on development of metaphorical competence in terms of Russian as a foreign language. It is not yet fully known whether

popular and widely used methodical literature, such as textbooks, for learners of Russian actually contributes to formation of this aspect of language acquisition; this constitutes the narrow problem of this paper.

The greater problem that our research project is aimed at could be phrased as follows. The influence of students' levels of metaphorical competence in the Russian language on their academic and communicative achievements has not yet been fully estimated either. It is thus necessary to determine types of metaphorical expressions that have not received sufficient coverage in manuals for learners of the Russian language, develop additional methodical and didactical materials for students. One must also introduce these materials into teaching practice to ensure improved development of metaphorical competence, and lead the students through further comparison of language proficiency against students who had usual training.

Additionally, a secondary problem that is of certain interest for us is the need to perform wider studies of the referential aspect of metaphors in the context of language acquisition and interpretation. This connection between linguistic didactics and cognitive / applied linguistics is still not completely described; however, it may be resourceful not only for foreign language studies, but also for certain areas of robotics, machine learning, and artificial intelligence.

3. Research Questions

Consideration of the problems has led us to formulation of questions that represent our primary and secondary objectives, as well as our intentions concerning the work towards possible solutions.

The primary research questions of this certain paper are as follows:

1. What metaphorical expressions are used in exercises and texts of major popular Russian series of textbooks on Russian as a foreign language?
2. Upon analyzing the metaphorical expressions and their contexts, what types of the expressions can be differentiated in accord with their semantical reference?
3. What exact types of the metaphorical expressions are the least and the most frequent in exercises and texts of major popular Russian series of textbooks on Russian as a foreign language?

4. Purpose of the Study

By means of combining the previously described problems with research questions, we achieve the ability to establish and formulate the purpose of our research effort.

The immediate purpose of this study is to collect metaphorical expressions from exercises and texts of major local series of textbooks on Russian as a foreign language, analyze the foundations of metaphorical transitions and define the semantical reference of each expression. The aim was to perform typological classification of the metaphorical expressions in accord with their previously defined semantical references, determine amounts and frequency of each type of expressions in each series, and subsequently attempt initial evaluation of each series in regard to development of metaphorical competence in students of Russian as a foreign language.

5. Research Methods

We have chosen to analyze three major series of textbooks on Russian as a foreign language that are popular and frequently used in educational practices of Russian universities in general and of the North Caucasus Federal University in particular. These sets of academic instructions, texts and exercises cover a wide scope of language mastery levels, starting from Elementary (A1) and following up to Intermediate/Upper Intermediate (B1/B2), and we find their applications in basic Russian training of foreign students who need to obtain certain language proficiency prior to beginning their studies. Due to the fact that authors aimed at persistent longitudinal acquisition of the language, these series of textbooks provide solid material for evaluating the gradual increase in the amount and quality of tasks, exercises, and lexical material designed for development of metaphorical competence in foreign students.

The analyzed series are *Doroga v Rossiyu [Road to Russia]* by Antonova, Nakhabina and Tolstykh (9th edition, in 4 volumes); *Zhili-Byli [Once Upon a Time]* by Miller, Politova and Rybakova (7th edition, in 2 volumes); *Poekhali [Let's Go]* (volume 1 by S. Chernyshov, 7th edition; volumes 2.1 and 2.2 by S. Chernyshov and A. Chernyshova, 2nd edition). Texts and exercises in the textbooks were scanned for metaphorical expressions (i.e., those that had indirect meanings based on similarity); the expressions were written out along with their physical contexts and then classified by types in accord with their respective semantical reference. In this certain study, we have determined to use the notion of reference to address the foundations on which metaphorical transitions take place. For example, a phrase such as *sour smile* would be classified as referring to 1) facial expressions and 2) taste. We admit that this use of the term 'reference' might not be entirely accurate, as it is usually associated with concrete real objects a speaker is talking or writing about. However, such an approach would not allow us to provide any typological classification of metaphors, as they would all refer to different concepts, subjects, phenomena etc. described in each individual text. This situation is more or less inevitable due to the fact that almost any modern learning book in a foreign language contains a patchwork of separate texts that are not related to each other.

As far as our definition of metaphorical expressions is concerned, we find it necessary to note that it has intentionally been given a wide scope. From the point of view of a native speaker, some expressions are not perceived as metaphorical any more due to the fact that their transition-based meaning has since been frequently used and become more or less commonplace. However, for a student of a foreign language such constructions would require actual use of metaphorical competence to understand the transition and internalize the concept. This approach is consistent with other papers on the topic of metaphorical competence that we mentioned in the *Introduction*.

It is necessary to remark that we intentionally ignored set expressions, idioms and other phraseology that is reproduced in a fixed form and is supposed to be learned 'by heart' as is. Even though such expressions are often based on metaphorical transitions, they have long since turned into clichés. We wanted to focus on less standard, 'freer' phrases that require certain linguistic efforts and are able to change their physical contexts. The principal criterion that we used for differentiation is more or less standard. If the word that carries out the metaphorical transition cannot be replaced by a similar one, then a word combination is considered as a set expression. And if there are several parallel combinations, then

a phrase is regarded as one having enough semantical and syntactical freedom to be separated from the body of phraseological units. For example, phrases such as *to fall ill* or *to catch cold* would therefore be marked as idioms, as there are no alternatives – ‘to rise ill’ and ‘to grab cold’ are not possible, the combinations are contextually bound. In its turn, the aforementioned *smile* could be *warm* or *cold* (temperature), *bitter* or *sweet* (taste), *radiant* or *dim* (visual perception), and thus these combinations would be classified as contextually unbound. It could be argued that this criterion has some roughness in it, but we believe that it is sufficient for our immediate study purposes.

A partial consequence of this previously described approach was our decision to pay more attention to adjectival and nominal constructions (i.e., those where the metaphorical transition is expressed by an adjective or a noun). We believe that they are more adjacent to the notion of similarity conveyed by metaphors (due to the fact that similarity is usually based on comparison of objects’ attributes), and that their degrees of contextual freedom tend to be greater in comparison with verbal constructions – the other frequent type of metaphorical expressions. Adjectival adverbs and adjectivized participles have also been included, whereas verbal constructions were placed aside for further separate research.

Each expression was then described by means of defining the types of 1) what exactly undergoes indirect comparison (we named it *Source*), 2) the *Target* of comparison, and 3) the basis of metaphorical transition (the *Attribute*). For example, if we consider the phrase *heavy duty*, then the source is ‘Activity’, the target is ‘Object’, and the attribute is ‘Weight’: someone’s activity is compared to a physical object on the basis of supposedly having certain mass.

6. Findings

Upon collection and preliminary processing of linguistic material from the major textbooks on Russian as a foreign language, the following categories and types were defined to be used in ‘source’, ‘target’, and ‘attribute’ fields of statistical tables for metaphorical expressions. It is crucial to note that all entries in the table below are translated from the Russian language, as they were used to process Russian linguistic material; they might not be consistent with English metaphors and are only provided as illustrations (Table 01). Names and contents of suggested types are based on data provided in a semantical dictionary of the Russian language (Shvedova, 2003).

Table 1. Nomenclature of referential types

Categories and types	Contents	Manifestations
	Entities	
Subject	Any living being that is able to act	Human; animal
Human	Any action or attribute that is only associated with humans	Friend; certain person
Plant	Any notion associated with vegetation	Flower; defoliation
Object	Any physical body	Rock; table
Body part	Any separate fragment of a subject’s body	Lips; leg
Substance	Any notion related to matters and essences	Air; soil
	Actions and processes	
Event	Any time-based finite set of actions with a result	Life; fight
Activity	Any process performed over time by a subject or an object	Studying; blossoming

Facial expression	Any meaningful movement of a subject's face	Smile; frown
Endowment	Anything related to giving or donation	Gifted
Thinking	Any mental activity of a person	Outlook; thought
Speech	Anything related to manner and content of discourse	Words; text
Physical phenomena and properties		
Weight	Any mass-based attribute	Light; heavy
Dimension	Any attribute based on single dimension	High; far; wide
Magnitude	Any idea based on several dimensions	Large; volume
Material	Anything that is used to make something	Food; durable; gold
Exterior	Any non-specific visual aspect of an object or a subject	Dusty; grey-haired
Light	Any visual aspect associated with emission of light	Star; brilliant
Combustion	Any attribute associated specifically with burning	Fire; flaming
Shape	Any visual aspect related to a geometrical form	Ring; circle
Freezing	Anything related to transfer between solid and liquid forms	Melting; ice
Sound	Any attribute related to acoustics	Quiet; loud
Softness	Any attribute associated with mellowness of surface	Rough; tender
Filling	Any notion related to containment	Full; empty; dry
Openness	Any aspect associated with the notion of closure	Open; enclosed
Firmness	Any form of resistance to physical force	Firm; sturdy
Freshness	Any aspect of being new and ready for consumption	Fresh; stale
Strength	Anything related to a subject's physical strength	Strong; weak
Structure	Any part of a subject's or an object's constitution	Branch; foundation
Fluidity	Any aspect of being able to flow	Stream; source
Temperature	Anything associated with heat	Hot; cold
Clarity	Any idea associated with contamination	Clear; transparent
Density	Any aspect related to an object's density	Tight; loose
Psychics and feelings		
Relationship	Any form of persistent interaction between individuals	Friendship
Taste	Any attribute related to gustation	Bitter; sweet
Emotional experience	Any emotion or inner feeling	Love; happy
Abilities	Any description of a subject's competence	Smart; stupid
Character	Any aspect of a subject's persistent psychical traits	Kind; evil
Abstract notions		
Age	Anything related to a subject's age	Old; young
Function	Any notion related to an object's purpose	Displaying; unlocking
Phenomenon	Any abstract notion of an objective process	Wind; music
Information	Anything associated with knowledge, including media	Newspaper; data
Concept	Any abstract notion based on generalization	Level; measure
Set	Any finite and complete combination of elements	World; nature; fleet
Multitude	Any number-based aspect of quantity or quality	Rich; diversity

It is evident that degrees of specification vary in different sections of the table. For example, *Physical phenomena and properties* are represented in more detail. We opted for a wider scope of narrower types in order to single out more possible aspects of the semantic reference and, consequently, possible variants of metaphorical transitions with respect to concrete tasks of language learning. It would have been easy to merge *Light* with *Sound*, or *Weight* with *Temperature*, but from the viewpoint of

second or foreign language acquisition these types of meaning transfer are notably different and should be treated separately.

We can now proceed with the statistical data themselves.

In *Doroga v Rossiyu*, a total of 371 contexts was written out of the 4 volumes in the series. Volume 1 (Elementary) only contained one metaphorical expression; volume 2 (Basic) – 62; volume 3 (Intermediate) – 117; volume 4 (Upper Intermediate) – 223. 176 metaphorical expressions were classified as verbal and separated for future research. The remaining 195 combinations constituted the body of material for statistical analysis. In *Zhili-Byli*, 65 contexts were marked as verbal whereas the remaining 69 were analyzed for this certain study; the total number of samples found in 2 volumes was thus equal to 134. Volume 1 (Elementary) had 5 metaphorical expressions in total; volume 2 (Basic) contained the rest. In *Poekhali*, 103 non-verbal contexts of metaphorical expressions were collected from 3 volumes and underwent further typological evaluation. The total number of contexts was equal to 162; in volume 1 (Elementary) there were 38 contexts, in volumes 2 and 3 (Basic) – 38 and 86, respectively.

The table below contains numbers of contexts per category for ‘source’, ‘target’, and ‘attribute’ fields respectively. For practical convenience, typological categories were sorted alphabetically. *D* stands for *Doroga v Rossiyu*, *Z* – for *Zhili-Byli*, *P* – for *Poekhali* (Table 02). Certain narrower types that may be considered relevant for objectives and tasks of Russian linguistic didactics were grouped alongside larger adjacent notions in the ‘Notable subtypes’ column wherever it is possible. It should be noted that certain contexts contained several metaphorical expressions and / or belonged to several types simultaneously.

Table 2. Statistical data per referential types and textbook series

#	Types	Notable subtypes	Source contexts			Target contexts			Attribute contexts		
			D	Z	P	D	Z	P	D	Z	P
1		-	3					1	1	2	
2	Abilities	Strength		1	1			15	2	3	
3		-	29	7	10		2	7	5	2	
4		Facial expressions	3	1							
5	Activity	Speech	6	4	2						
6		Thinking	2	1	4						
7	Age			1				6	1	31	
8	Character		7	3	5			6		3	
9	Concept		12	3	8	6					
10	Emotional experience		7	9	12			11		1	
11	Event		40	3	12						
12		-						11	8	2	
13		Combustion						3	3		
14	Exterior	Freezing						1			
15		Light	2	1				11	2	4	
16		Shape						4	2	3	
17	Function							9	7	7	
18	Information		5	1	2						
19		-						25	2	16	
20	Magnitude	Dimension	1					27	10	7	
21		Weight						37	4	3	

22		-	3	1	1	16	6	5	7	4
23	Material	Freshness							4	4
24		Softness							4	
25		Temperature	2						3	4
26	Multitude	-	3						3	2
27		Set	11	1		1				
28	Object	-	22	10	34	129	33	45		
29		Body part	16	4	3	1	3	2		1
30	Phenomenon		19	8	2	1	3	2		
31	Relationship	-	7		3				2	2
32		Endowment							3	1
33	Sound		2	2					1	
34		-							4	1
35	Structure	Filling							7	3
36		Firmness							4	2
37		Openness							3	2
38		-	2		1	39	10	38		
39	Subject	Human	10	6	1	6	5	10		
40		Plant	1			2		1		
41		-	2		2	8	6			
42	Substance	Clarity							3	4
43		Density							2	
44		Fluidity		1					1	1
45	Taste								6	1

For *Doroga v Rossiyu*, the following observations can be made:

i) The most frequent sources of transitions, i.e., phenomena that undergo metaphorical comparisons, belonged to such types as ‘Event’, ‘Activity’, ‘Object’, ‘Phenomenon’, and ‘Body part’.

ii) The absolute majority of targets, i.e., phenomena that ‘sources’ were indirectly compared to, belonged to the ‘Object’ type, followed by ‘Subject’ and ‘Material’.

iii) The most actively used types of attributes that served the purpose of metaphorical transitions were related to ‘Weight’, ‘Dimension’, and ‘Magnitude’, followed by ‘Strength’.

A rough derivation would be that a typical metaphorical expression found in *Doroga v Rossiyu* would indirectly compare a process to an object on the basis of its weight or size, or compare a phenomenon to a subject on the basis of its strength. This would include combinations such as *heavy labor* or *strong character*. Of course, these are only illustrations; it is beyond doubt that other combinations are equally possible.

In *Zhili-Byli*, several dominating categories can also be distinguished:

i) The ‘sources’ do not manifest any considerable dispersion, but the leaders of the group are ‘Object’, ‘Emotional experience’, and ‘Phenomenon’, closely followed by ‘Activity’ and ‘Human’.

ii) The greatest amount of ‘target’ contexts is associated with ‘Object’ and ‘Subject’ types.

iii) ‘Attribute’ contexts are rather equally distributed among types, thus being similar to ‘sources’; the top 3 entries are ‘Dimension’, ‘Exterior’, and ‘Function’.

An interesting peculiarity of *Zhili-Byli* is its relatively active use of metaphorical expressions where emotional experiences undergo indirect comparisons to material objects. The contexts also indicate

that activities are exclusively compared to objects and materials in this series of textbooks. A ‘typical’ construction would thus look like *thin feelings*.

For *Poekhali*, principal characteristics are as follows:

i) The most notable types of phenomena that are compared to other notions via metaphorical transitions are ‘Object’, ‘Emotional experience’ and ‘Event’, followed by ‘Activity’.

ii) The scope of possible entities that indirect comparisons were aimed at is rather limited and includes 7 entries. The greatest frequency was determined for the ‘Object’ type; ‘Subject’ was actively used either. The third popular category was ‘Human’.

iii) The set of attributes was dominated by ‘Age’ and ‘Magnitude’.

Therefore, *Poekhali* makes larger and more extensive use of metaphorical expressions where objects are compared to subjects on the basis of age. Phrases such as *old town* or *old car* were very frequent. Even though such combinations might look trivial, we still find them worthy of notice, as they might not be immediately clear for a foreign student who is a representative of a different culture. A native speaker of the Russian language would naturally say *my old car* referring to the vehicle they have sold to purchase another, even if their previously owned asset does not actually have many years in existence.

Further comparison of all gathered data suggests that students who use the three major series textbooks on Russian as a foreign language are all being increasingly exposed to metaphorical expressions as the language mastery level rises. It should also be remarked that starting with Basic level (A2), the authors of the textbooks begin adding dedicated exercises based on contrast between direct and indirect meanings. However, the nature and contents of metaphorical expressions vary. Students of *Doroga v Rossiyu* would encounter a lot of weight-based transitions and learn to understand indirect comparisons of events to other phenomena. Those who work with *Zhili-Byli* would mostly face phrases where objects undergo comparison, as well as see a greater number of dimension-based transitions expressed by adjectives such as *long* or *deep*. Learners using *Poekhali* would be more familiar with metaphorical expressions based upon rethinking of age.

At the same time, the numbers indicate that in all three scenarios, indirect comparisons to objects and subjects would be the most common, and upon some generalization it could be claimed that metaphorical expressions in major textbooks on Russian as a foreign language are usually based on physical attributes – mass, size, visual traits etc. We find it possible to assume that this sort of expressions is the easiest to be explained by teachers and grasped by students; they are likely to be rather universal across different cultures.

On the other hand, the data suggest that certain areas, mostly related to some physical and psychical processes, are not sufficiently covered in any of the three series. None of those made notable use of metaphorical expressions that would be to any extent based on mental abilities and intellect, traits of character in general, facial expressions, combustion or freezing, sound, taste, tactile feelings such as softness, pressure, or temperature. These areas might require additional attention in the process of formation of metaphorical competence in students of Russian as a foreign language.

7. Conclusion

The following conclusions, or answers to our research questions, can be made:

1. In exercises and texts of major popular Russian series of textbooks on Russian as a foreign language, 367 adjectival, nominal, and adverbial metaphorical expressions were identified and studied statistically. A comparably large group of verbal metaphorical expressions was singled out for future research.

2. Upon analyzing the metaphorical expressions and their contexts, three referential aspects were separated for each phrase: 'source' (the initial member of comparison), 'target' (the other member of comparison), and 'attribute' (the foundation of metaphorical transition). To describe each of the aspects, 45 typological categories were differentiated, following a dedicated semantical dictionary of the Russian language and taking into account specific traits and tasks of foreign language learning.

3. As a result of statistical research and analysis, it was determined that the most frequent types of metaphorical expressions found in exercises and texts of major popular Russian series of textbooks on Russian as a foreign language were related to objects, subjects, activities, events, dimensions, weight, material, magnitude, emotional experience, and age. The least frequent types were associated with freezing, density, fluidity, facial expressions, softness, endowment, plants, sound, structure, and openness.

The research project that we are aiming to perform has only been started. As a part of this conference presentation, we wished to share and discuss initial preliminary findings. It is beyond doubt that these results and conclusions are open for further addition, elaboration and analysis. The next immediate objective would be to process the bodies of verbal metaphorical expressions. In perspective, we will refine our results by means of student testing and corpus research, as well as make practical application of these results in development of tasks and exercises for students of Russian as a foreign language, aimed at more intense formation of metaphorical competence.

References

- Birdsell, B. J. (2018). Conceptual wandering and novelty seeking: Creative metaphor production in an L1 and L2. *Journal of Cognitive Science*, 19(1), 35–67. <https://www.researchgate.net/publication/325555019>
- Gutiérrez Pérez, R. (2019). The development of a metaphoric competence. A didactic proposal of educational innovation. *Innovation in Language Learning and Teaching*, 13(4), 1–27. <https://doi.org/10.1080/17501229.2018.1466891>
- Kelso, J. M. (2018). Boundaries and hybrid blends: How one multilingual narrator displays symbolic competence in a college writing class. *Linguistics and Education*, 45, 50–61. <https://doi.org/10.1016/j.linged.2018.03.002>
- Lakoff, G., & Johnson, M. (1980). *Metaphors We Live by*. The University of Chicago Press.
- Raskin, V., & Chernouski, L. (2017). Extending reference into cognitive computing: Through the eyes of ontological semantics. *Proceedings of 2017 IEEE 16th International Conference on Cognitive Informatics and Cognitive Computing, ICCI*CC 2017*, article no. 8109724, 16–21. <https://doi.org/10.1109/ICCI-CC.2017.8109724>
- Shvedova, N. Y. (2003) *The Russian semantical dictionary*. Azbukovnik.
- Stepanova, K., Klein, F. B., Cangelosi, A., & Vavrecka, M. (2018). Mapping language to vision in a real-world robotic scenario. *IEEE Transactions on Cognitive and Developmental Systems*, 10(3), 784–794. <https://doi.org/10.1109/TCDS.2018.2819359>