

Semantic Annotation of Verbs of Contact in Bulgarian

Maria A. Todorova

Institute for Bulgarian Language, Bulgarian Academy of Sciences

maria@dcl.bas.bg

Abstract

The paper presents the work on the selection, semantic annotation and classification of a group of verbs of contact as defined in the Bulgarian WordNet (i.e. verbs assigned the semantic primitive 'verb.contact') which belong to the general lexis of Bulgarian. I describe in brief the selection of the verbs to be analyzed according to two different criteria: (i) statistical information from corpora; (ii) membership of the verbs to the WordNet Base Concept set and information about their age of acquisition (AoA). The focus of the work is on the process of semantic annotation of the verbs, using combined information from two language resources – WordNet and FrameNet. The verbs of contact extracted from WordNet are assigned semantic frames from FrameNet and then grouped into semantic subclasses on the basis of their place in the WordNet hierarchy and the semantic restrictions imposed on the frame elements denoting the verbs' principal participants along with their syntactic realization. I offer some conclusions on the classification of 'verbs of contact' into semantic subtypes.

1 Introduction

Verb classes are sets of verbs sharing similar semantic properties, such as the membership to a common semantic domain or similar argument realization and semantic interpretation. Fillmore (1970) emphasizes the importance of verb classes in various tasks including the study of the patterns of shared verb behavior; the organization of the verb lexicon; the identification of grammatically relevant elements of meaning.

WordNet and FrameNet are large lexical resources that provide semantic information about verb classes. WordNet (WN) (Fellbaum, 1999) represents a multilingual conceptual network of synonym sets (synsets) linked by means of semantic relations such as hypernymy, antonymy, etc.

FrameNet (FN) (Baker et al., 1998) represents the semantics of lexemes by means of schematic representations (frames) describing objects, situations, or events and their components (frame elements) in the apparatus of Frame Semantics.

The aim of this paper is to present an ongoing work on the semantic annotation and classification of a subset of Bulgarian 'verbs of contact' that belong to the general lexis of Bulgarian. The goal of these efforts is to contribute both to the enrichment of the Bulgarian WordNet with Conceptual frames (Koeva, 2020) and to the enlargement of the Bulgarian FrameNet, and hence – to the creation of a linked semantic and syntactic resource.

Verbs of Contact In general, the notion of CONTACT is understood as a “conceptual core element” of a predicate (Juffs, 1996). The set of verbs of contact in WordNet features the ones included in the relevant lexicographer's file, one of 15 files in which the verbs in WordNet are grouped according to the semantic domain to which they pertain, and is defined as “verbs of touching, hitting, tying, digging” (Miller et al., 1990). It is also the largest of them, consisting of more than 820 synsets including event and action verbs that share the semantic component of CONTACT or IMPACT. This type of verb set cast taxonomic framework by means of the hyponymy (troponymy) relation, which covers a number of different manner relations (Fellbaum, 1990). The semantic definition of the class is fuzzy and does not really summarize the semantics of all the verbs it contains.

The remainder of the paper is organized as follows. Section 2 describes the data used in the process of annotation – a set of verbs of contact from WordNet and a set of semantic frames from FrameNet. Section 3 presents a revision of the related descriptions and classifications of the verbs under consideration. Section 4 discusses the semantic features of

verbs of contact and their lexical semantic subtypes. Sections 5 and 6 offer details on the process of annotation of verbs of contact with semantic frames, while Sections 8 and 9 sum up the observations on the results and suggest directions for future work.

2 The data analyzed

The analyzed verbs and the corresponding semantic descriptions were extracted from the interrelated language resources: WordNet (Fellbaum, 1999) and FrameNet (Ruppenhofer et al., 2016). The combined information available in the resources results in a rich representation of the paradigmatic and syntagmatic aspects of lexical semantics (Baker and Fellbaum, 2009). The implementation of the mapping of FN frames to WN synsets is described in detail in Stoyanova and Leseva (2020). The selected set of verbs (i.e. the WN verbs of contact) was subsequently filtered so as to include only verbs belonging to the general lexis of Bulgarian.

Selection of General Lexis Verbs in Bulgarian

The general verb lexis of Bulgarian was selected for the purposes of the theoretical semantic description and typology of verb predicates belonging to the basic conceptual apparatus of the language under consideration (Stoyanova and Leseva, 2020; Todorova et al., 2022). The collection was excerpted from a set of 44,000 English verbs selected according to the AoA (age of acquisition) criterion (Brysaert and Biemiller, 2017) and a subset of verbs derived from the Bulgarian WordNet (BulNet) (Koeva, 2010), a lexical-semantic network for Bulgarian modeled on the Princeton WordNet (Miller et al., 1990; Miller, 1995). The 44,000 English verbs are related to the synonym sets that contain the corresponding verbs in BulNet. The verbs are also assigned: (i) a relevant label in case the corresponding synsets belong to the list of the so-called base concepts, or BCS¹, a subset of concepts that reflect the basic conceptual stock across languages; (ii) frequency information on the use of the verbs derived from the Bulgarian National Corpus (Koeva et al., 2012). The verbs are additionally evaluated by linguists, who, according to the available information from various resources and their intuition as native speakers, determine whether a concept expressed by a synonym set is part of the

¹The set of base concept synsets has been defined by the teams participating in the EuroWordNet and the BalkaNet projects <http://globalwordnet.org/resources/gwa-base-concepts/>

general lexis of Bulgarian and which of the literals (members of a synset) are the main representatives of the relevant sense². This procedure resulted in a list of 2,027 general-lexis verbs, 381 of which belong to 133 synsets assigned the prime *verb.contact*. These 381 verbs constitute the starting set selected for annotation with semantic frames, that is being carried out at the moment. The main goal of the analysis is to propose a classification of the verbs of contact in Bulgarian on the basis of the description of their frame elements, their selectional restrictions (represented in terms of semantic classes of nouns) and syntactic expression.

3 Related Work

Verbs of contact are heterogeneous and overlapping as a semantic class and thus less studied than other verb classes. They have been an object of research for English Fillmore (1970); Levin (1993); Fellbaum (1990) and Chinese (Gao and Cheng, 2003). Fillmore (1970) focuses on two large classes of verbs of contact, *break* and *hit*, whose members share elements of meaning and patterns of behavior. A class of contact verbs was also defined by Levin (1993) in her semantic classification on the basis of a number of alternations reflecting the correlation between the semantics and the syntactic behavior of the verbs and the interpretation of their arguments. In particular, Levin (1993): (148-156) defines a class of *Verbs of contact by impact* with a number of subclasses: *Hit verbs*; *Spank verbs*; *Swat verbs*; *Non-agentive verbs*. Dimitrova-Vulchanova and Dekova (2009) represent a corpus and an empirically-derived classification of *verbs of contact by impact* using the Sign model formalism. Individual subtypes of the class were also described by some authors: *physical contact verb* (Gao, 2001) and *Hit and Spank verbs of contact by impact* from Gao and Cheng (2003). These descriptions and classifications partially overlap with the classification adopted in WordNet; their correspondences in FrameNet are less hierarchically structured. Previous work on the conceptual semantic annotation of Bulgarian verbs involves the analysis of verbs of change (Stoyanova and Leseva, 2021) and verbs of communication (Kukova, 2020). Different stages of the study of semantic

²The selection and evaluation of the verbs that form the set of general lexis of Bulgarian has been performed by the team of linguists at the Department of Computational Linguistics of the Institute for Bulgarian Language at the Bulgarian Academy of Sciences.

features and selectional restrictions relevant to the semantic description of Bulgarian verbs and their frame elements are explored in (Leseva et al., 2020, 2021). Verbs of contact have not been described for Bulgarian so far.

4 Semantic Features of Verbs of Contact

In this Section I use the semantic characterization of verbs of contact and their division into subclasses proposed by Fellbaum (1990) with a view to the WordNet hierarchy, in combination with additional semantic information from FrameNet.

Lexical Semantic Subtypes Being the largest class of verbs in WordNet, the set of contact verbs is well-represented in the selection of Bulgarian general lexis verbs – nearly 7% of the whole set. Most of the contact verbs are hypernyms of the following central verb concepts: *fasten*, *attach*, *cover*, *cut* and *touch*, which results in a large tree structure within the set (Fellbaum, 1990). Based on the WordNet hypernym relation, the following subgroups of contact verbs have been defined:

- (a) Verbs encoding force, intensity, or iteration of the action (*hit*).
- (b) Verbs of holding (*grab*, *squeeze*, *pinch*) and touching (*paw*, *finger*, *stroke*, *poke*).
- (c) Verbs involving an instrument or material argument (*paint*).
- (d) Verbs involving a body part argument indicating what kind of contact action the body part is typically used for: shoulder (*support*, *carry*); elbow (*push*); finger, thumb (*touch*, *manipulate*).

5 Annotation of Verbs of Contact and Semantic Frames Assignment

The annotation of Bulgarian contact verbs with semantic frames and the description of their semantic features – i.e. their frame elements³ and the relevant semantic restrictions is part of the description of Conceptual frames in Bulgarian. Conceptual frames are abstract structures, that describe a particular types of situations or events, along with its participants and properties Koeva (2020). The annotation is carried out by means of a software system called BulFrame specifically designed for the definition and description of conceptual frames (Koeva and Doychev, 2022) The semantic restrictions imposed on the verb's arguments were aligned

³elements which correspond to core FEs in FrameNet are semantically essential components of a frame that can be recovered from the context

with (a) particular subtree(s) of noun synsets in WordNet and draw on previous efforts described in Leseva et al. (2018). The annotation of the selected verbs includes the following steps:

- (a) Each verb is assigned a FrameNet frame (as is), a FrameNet frame that has been modified to better reflect the semantics of the verbs under discussion or a newly formulated frame.
- (b) The restrictions which are relevant for the entire frame are examined and revised if needed; these restrictions have been defined on the basis of the combined semantic information from WN and FN.
- (c) For each core frame element in a given frame a linguist checks the validity of the general selectional restrictions assigned to it. At this stage the linguist is able to verify the accuracy of the frame-to-synset assignment and to make changes if necessary. The restrictions assigned to a frame give a first approximation of the semantic specification of the frame elements. When a general restriction is assigned, all hyponyms of the noun synsets, representing the roots of the relevant subtrees⁴, are potential candidates for the FE in context.
- (d) Each verb is examined individually in order to specify additional selectional restrictions from WordNet if needed. Specific restrictions on the lexical realization of the FEs are represented as individual WN synsets.

6 Annotation of Verbs of Contact – Semantic Classes, Semantic Frames and Restrictions

In this Section I provide an analysis of the verbs of contact which have been assigned one of a number of selected frames denoting contact and a description of their selectional restrictions. The semantic restrictions describing the compatibility between semantic classes of verbs and nouns corresponding to their arguments proposed in Leseva et al. (2019) are aligned with the noun synsets representing the roots of the subtrees.

The grouping of *verbs of contact* into subtypes is based on the hypothesis that verbs with similar meanings have characteristic argument realization patterns shared by their members. It is necessary to take into account the semantics of a verb's arguments in order to determine whether a particular verb construction is acceptable. 31 frames were

⁴A root is a node in the WordNet structure represented by a synset whose meaning constitutes a category under which more specific senses are subsumed

assigned to verbs of contact included in the selection of Bulgarian general lexis verbs so far. The contact predicates are divided into 2 subgroups that combine semantic components of *Contact via Motion* and *State Verbs for Physical Contact*. The most typical arguments in their semantic frames are Theme, Force, Body Part, Source, Frequency, and Instrument. Some of the frames are analyzed and commented below with a view to the assignment of more refined selectional restrictions.

6.1 Verbs of Physical Contact via Motion

This group includes the verbs assigned the following FN frames: *Becoming attached*, *Body movement*, *Breaking off*, *Cause fluidic motion*, *Closure*, *Destroying*, *Detaching*, *Dispersal*, *Filling*, *Fluidic motion*, *Food gathering*, *Gathering up*, *Grinding*, *Make noise*, *Manipulate into shape*, *Placing*, *Removing*, *Reshaping*, *Undressing*, *Processing materials*.

Verbs of contact denoting attaching, detaching, placing, removing, filling and emptying share common frame elements and restrictions. As a whole, these frames involve the movement of an entity (the Theme) either directed to (Goal) or originating from (Source) to a particular place. Their core frame elements share similar general restrictions – their Agents are volitional; the Cause denotes a physical entity or eventuality; the FE Item is a physical object, the Goal – a physical entity or container and the Connector – a physical entity. The semantics of the point of physical contact defines two main subgroups:

- verbs of contact on or along a surface (as the verb root *triya:2*⁵ (*rub:2 eng-30-01249724-v*) ‘move over something with pressure’ and its hyponyms – *brush:7*; *gauge:6*; *scrub:3*; *smear:4*; *scrape:1*, etc.
- verbs of contact with a container (as the verb roots *palnya:1* (*load:3 eng-30-01490336-v*), *izprazvam:8* (*empty:7 eng-30-01488313-v*) and their hyponyms

As shown in Example 1 below many verbs impose narrower selectional restrictions that elaborate on the more general ones assigned to the frame⁶.

⁵The Bulgarian examples transliterated in Latin script are followed by their correspondences in the Princeton WordNet

⁶The BulNet aligned with the English WordNet and other languages is available online on <http://dcl.bas.bg/bulnet/>

Example 1:

(a) the verb *tovarya:1* (*load:2 eng-30-01489989-v*) ‘fill or place a load on’ is assigned the FN frame **Filling** which relates to “... *filling Containers and covering areas with some thing(s) or substance – the Theme. The area or container can appear as the direct object with all these verbs, and is ... the goal of motion of the Theme*”.⁷ The analysis of the usage examples available for the verb show that the general selectional restrictions specified for the frame Filling are sufficient for the semantic description of the synset under consideration. In particular, the selectional restrictions for the Agent correspond to the WN root synset *person:1* (*eng-30-00007846-n*); the ones defined for the FE Theme correspond to the WN root synset *physical object:1* (*eng-30-00002684-n*) or *entity:1* (*eng-30-00001740-n*) and those specified for the Goal match the synset *container:1* (*eng-30-03094503-n*)

(b) the verb *lakiram:1* (*varnish:1 eng-30-01269008-v*) ‘cover with varnish’ imposes more specific restrictions to its core FEs. The Agent is a volitional human being, a qualified person, while the Theme is a particular kind of substance best described by means of the synset *lak:1* (*varnish:2 eng-30-04521987-n*) and the Goal is a *physical object:1* (*eng-30-00002684-n*) or a *surface:1* (*eng-30-08660339-n*).

In addition, in many cases, part of the synsets sharing the same FrameNet frame belong to the same (or to a semantically close) WordNet subtrees. In these cases the topmost synset more or less complies with the restrictions for the frame, whereas its hyponyms may impose more specific requirements (see Example 2 below).

Verbs of Bodily Contact include the verbs assigned the FrameNet frame **Manipulation** which describes “... *the manipulation of an Entity by an Agent. Generally, this implies that the Entity is not deeply or permanently physically affected, nor is it overall moved from one place to another*”. Example 2 illustrates the more specific restrictions specified for the core FEs of verb synsets assigned the frame Manipulation which are hyponyms of the synset *hvashtam:7*.

Example 2:

hvashtam:7 (*hold:13 eng-30-01216670-v* ‘have or hold in one’s hands or grip’)

(a) hyponym: *stiskam:2* (*grasp:3* ‘hold firmly’)

⁷<https://framenet.icsi.berkeley.edu/>

(b) hyponym: *pritskam se:1* (*clutch:4* ‘hold firmly, usually with one’s hands’)

(c) hyponym: *lyuleya:3* (*cradle:2* ‘hold gently and carefully’)

(d) hyponym: *sklyuchvam:6* (*interlace:2* ‘hold in a locking position’)

(e) hyponym: *ulavyam* (*trap:4* ‘hold or catch as if in a trap’)

The restrictions on the FE Agent of the root verb and a part of its hyponyms differ: for some verbs the Agent is a volitional human being corresponding to the WN root synset *person:1* (eng-30-00007846-n), e.g. (2b), (2d), while in other cases the verbs may allow their Agent to be an animal (2a), (2b), corresponding to the WN root synset *animal:1* (eng-30-08660339-n) or FE Body part, corresponding to (body part:1 eng-30-03183080-n), as in (2e).

The restrictions on the FE Entity also are not consistent in all the discussed members of the tree – Entity may be either an animate (2g) or an inanimate physical object (2d).

Verbs of Contact by Impact include the verbs assigned the FrameNet frames **Impact** defined as: “While in motion, an Impactor makes sudden, forcible contact with the Impactee, or two Impactors both move, mutually making forcible contact” as well as **Destroying**: A Destroyer (a conscious entity) or Cause (an event, or an entity involved in such an event) affects the Patient negatively so that the Patient no longer exists. Their core FEs share similar general semantic characteristics, so no more specific selectional restrictions can be defined – the Impactor and the Impactee may be physical entities or eventualities, devices or persons, as shown in Example 3. It illustrates verbs belonging to the WN subtree stemming from *udryam:6* (*hit:13*), eng-30-01236164-v ‘hit against; come into sudden contact with’ which are assigned the FN frame *Impact*.

Example 3:

udryam:6 (*smash:9* eng-30-00126236-n ‘collide or strike violently and suddenly’)

(a) hyponym: *sblaskvam* (*shock:6* ‘collide violently’)

(b) hyponym: *razbivam se:2* (*crash:6* ‘undergo damage or destruction on impact’)

The verbs in this example impose less rigid restrictions on their FEs – the Impactor and the Impactee correspond to physical entities.

6.2 State Verbs of Physical Contact

This group includes the verbs assigned the following FN frames: *Being wet*, *Distributed position*, *Posture*, *Spatial contact*, *Surrendering possession*, *Surrounding*, *Scouring*. These frames describe an Agent (Protagonist), Item, Theme, Figure or another entity’s being on, in or in contact with an area or a substance (Location).

Example 4 shows verbs from the WN subtree stemming from *lezha:3* (*lie:2* which are assigned the FN frame **Posture**: *An Agent supports their body in a particular Location. The LUs of the frame convey which body part is the Point of contact where the Agent is supported, what orientation the body is in, and some overall arrangement of the limbs (especially the legs) and the torso.*

Example 4:

lezha:3 (*lie:2*, eng-30-01547001-v ‘be lying, be prostrate; be in a horizontal position’) (a) hyponym: *peka se :1* (*sunbathe:1* ‘expose one’s body to the sun’)

(b) hyponym: *iztyagam se:1* (*sprawl:1* ‘sit or lie with one’s limbs spread out’)

(c) hyponym: *izlyagam se:1* (*recumb:1* ‘lean in a comfortable resting position’)

(d) hyponym: *pokrivam:1* (*overlie:2* ‘lie upon; lie on top of’)

(e) hyponym: *lezha buden:1* (*lie awake:1* ‘lie without sleeping’)

(f) hyponym: *pochivam:3* (*repose:6* ‘lie when dead’)

(g) hyponym: *pripicham se:1* (*bask:1* ‘be exposed’)

The verbs belonging to the subtree under consideration impose more specific selectional restrictions on their Agent: for some of them it may be a volitional human being corresponding to the WN root synset *person:1* (eng-30-00007846-n) (4e), (4f) as well as an animal (4a), (4b), (4c), (4d), (4g), aligned with the WN root synset *animal:1* (eng-30-08660339-n). The FE Location is an adjunct in Bulgarian and can be omitted, and is thus not discussed here.

7 Syntactic Patterns

The observations on the syntactic behavior of the studied verbs led to the delineation of several general syntactic constructions within the group:

(a) *NP*(*pro-drop subject*) *Verb* *NP*(*direct object* – *Theme*) *PP*(*non-obligatory indirect object* –

to/on/over Destination) This syntactic structure is typical for verbs selecting a Theme as an object, for instance *razleya* (*pour*) – *Razlya chaya po masata*. (*‘She poured the tea over the table’*).

(b) *NP(pro-drop subject) Verb NP(direct object – Destination) PP(non-obligatory indirect object – with Theme)*. This pattern is found with verbs taking the FE Destination as an object, for instance *namazha* (*spread*) – *Namazha filiyata s maslo*. (*‘She spread butter on the slice’*).

(c) *NP(pro-drop subject) Verb NP(direct object – Location/Container) PP(non-obligatory indirect object – with Theme)*. This type of structure is typical for verbs selecting the FE Location/Container as an object as in *natovarya* (*load*) – *Natovariha kamiona s kutiite* (*‘They loaded the truck with the boxes’*).

8 Results and Discussion

The annotation results presented in the paper are preliminary as they are part of a work in progress. A total of 381 contact verbs were assigned 26 FN frames, most of which have been manually checked and assigned general selectional restrictions. The description of the syntactic properties and the definition of more specific selectional restrictions for each verb are still in process, covering mainly the root synsets (Section 6).

The contact verbs were grouped in two main subcategories – Verbs of Physical Contact via Motion and State Verbs of Physical Contact with different subgroups according to the features *manner* and *point of the contact*.

The process of annotation raises some interesting questions regarding the language-specific lexicalization patterns of some Bulgarian verbs as compared with their English counterparts. The syntactic expression of some of the FEs differs in the two languages. The obligatoriness of the syntactic realization depends on the point of contact between the core frame elements. The English verbs of contact that encode one of the frame elements in their morphological structure – e.g. the instrument (knife), the resultant shape (slice), the covering material (paint), the container (box, bag), etc. – have different lexicalization in Bulgarian. Not all the Bulgarian correspondences have the frame element incorporated in their word structure. For example the English verb *cream: 3* (*eng-30-01364483-v* ‘*put on cream, as on one’s face or body*’) – has no one-word correspondence in Bulgarian and is

translated as the expression *namazvam s krem: 1*, where *krem* is the Theme, compare: *She creamed her face* (*Destination*) and *Namazha s krem* (*Theme*) *liceto si* (*Destination*).

On the other hand some of the Bulgarian verb hyponyms express a specific manner by means of prefixation, e.g. *razryzvam: 2* (*cut: 35 eng-30-01552519-v* ‘*cut into pieces*’). Such predicates lexicalize a meaning component which specifies a scale of motion or state and contact and do not have full one-word correspondences in English. These and other similar cases have necessitated the modification of FN frames or the definition of further specifications.

The above observations led to the hypothesis that different word formation mechanisms across the languages, such as derivation, compounding and conversion as well as lexical gaps, reflect differences in the semantic structure of lexemes.

9 Conclusions and Future Work

The research described in this paper is part of an effort towards the enrichment of the set of Bulgarian general lexis verbs derived from the Bulgarian WordNet with frame semantics from FrameNet and the definition of multifunctional relations between the verbs and the noun classes representing the selectional restrictions imposed on their participants. I also advance a number of observations on the interaction between syntax and semantics with reference to the behavior of Bulgarian verbs of contact, their arguments and their ontological place in the hierarchy of the BulNet structure. As the proposed analysis is based on multilingual resources such as WordNet and FrameNet some of the observations may also be useful for other languages and may contribute to the implementation of NLP applications aimed at automatic semantic analysis, word sense disambiguation, language understanding and generation, machine translation, etc.

Acknowledgments

The research presented in this paper is carried out as part of the scientific programme under the project *Enriching the Semantic Network Wordnet with Semantic Frames* funded by the Bulgarian National Science Fund (Grant Agreement No. KP-06-N50/1 of 2020).

References

- C. F. Baker and C. Fellbaum. 2009. **Wordnet and FrameNet as complementary resources for annotation**. In *Proceedings of the Third Linguistic Annotation Workshop (LAW III)*, pages 125–129.
- C. F. Baker, Ch.J. Fillmore, and John B. Lowe. 1998. The berkeley framenet project. *COLINGACL '98: Proceedings of the Conference. Montreal, Canada*, pages 86–90.
- M. Brysbaert and A. Biemiller. 2017. **Test-based age-of-acquisition norms for 44 thousand English word meanings**. *Behavior Research Methods*, 49:1520–1523.
- M. Dimitrova-Vulchanova and R. Dekova. 2009. On the encoding of lexical information: Events and their lexicalization in English and Bulgarian. *Bulgarian Language*, LVI:84–96.
- C. Fellbaum. 1990. **English verbs as a semantic net**. *International Journal of Lexicography*, 3:278–301.
- C. Fellbaum. 1999. *WordNet: an Electronic Lexical Database*. MIT Press, Cambridge.
- Ch. Fillmore. 1970. The grammar of hitting and breaking. *R. A. Jacobs, P. A. Rosenbaum (Eds.), Readings in English Transformational Grammar*, pages 120–133.
- H. Gao. 2001. Notions of motion and contact for physical contact verbs. *eds Holmer A., Svantesson J., Viberg A. Proceedings of the 18th Scandinavian Conference of Linguistics*, 2:193–209.
- H. Gao and Ch. Cheng. 2003. Verbs of contact by impact in English and their equivalents in Mandarin Chinese. *Language and Linguistics*, 4.3:485—508.
- Al. Juffs. 1996. *Learnability and the Lexicon. Theories and Second Language Acquisition Research*. John Benjamin, Amsterdam.
- S. Koeva. 2010. Bulgarian wordnet - current state, applications and prospects. *Bulgarian-American Dialogues*, pages 120–132.
- S. Koeva. 2020. **Towards a semantic network enriched with a variety of semantic relations**. *Semantic Relations and Conceptual Frames*, Koeva, S. (ed.), pages 7–20.
- S. Koeva and E. Doychev. 2022. **Ontology supported frame classification**. *Proceedings of the Fifth International Conference Computational Linguistics in Bulgaria*, pages 203–214.
- S. Koeva, I. Stoyanova, S. Leseva, T. Dimitrova, R. Dekova, and E. Tarpomanova. 2012. The Bulgarian National Corpus: Theory and practice in corpus design. *Journal of Language Modelling*, pages 65–110.
- H. Kukova. 2020. Verbs for communication, frame elements and semantic restrictions (on BulNet synsets). *Proceedings of the International Annual Conference of the Institute for Bulgarian Language (Sofia, 2020)*, 2:233–241.
- S. Leseva, I. Stoyanova, H. Kukova, and M. Todorova. 2018. Integrating subcategorization information in wordnet’s relational structure. *Bulgarian Language*, 2:13–40.
- S. Leseva, I. Stoyanova, M. Todorova, and H. Kukova. 2019. A theoretical overview of conceptual frames and semantic restrictions on frame elements. *Linguistique Balkanique*, LVIII(2):172–186.
- S. Leseva, I. Stoyanova, M. Todorova, and H. Kukova. 2020. A semantic description of the combinability between verbs and nouns (on material from Bulgarian and English). *Chujdoezikovo obuchenie*, 47:115–128.
- S. Leseva, I. Stoyanova, M. Todorova, and H. Kukova. 2021. Putting pieces together: Predicate-argument relations and selectional preferences. *Koeva, S. (ed.) Towards a Semantic Network Enriched with a Variety of Semantic Relations*.
- B. Levin. 1993. *English verb classes and alternations: a preliminary investigation*. The University of Chicago Press, Chicago.
- G. A. Miller. 1995. Wordnet: a lexical database for English. *Communications of the ACM*, 38(11):39—41.
- G. A. Miller, R. Beckwith, D. Gross C. Fellbaum, and K. Miller. 1990. Introduction to wordnet: an on-line lexical database. *International journal of lexicography*, 3(4):235–244.
- J. Ruppenhofer, M. Ellsworth, M. R. L. Petruck, C. R. Johnson, C. F. Baker, and J. Scheffczyk. 2016. *FrameNet II: Extended Theory and Practice*. International Computer Science Institute, Berkeley, California.
- I. Stoyanova and S. Leseva. 2020. Beyond lexical and semantic resources: Linking WordNet with FrameNet and enhancing synsets with conceptual frames. *Koeva, S. (ed.) Towards a Semantic Network Enriched with a Variety of Semantic Relations*, pages 21–48.
- I. Stoyanova and S. Leseva. 2021. Semantic description of verbs for change and hierarchical organization of conceptual frames. In *Proceedings International Annual Conference of the Institute of Bulgarian Language "Prof. Lubomir Andreychin" (compilers – S. Koeva, M. Stamenov)*, volume 2, pages 76–85.
- M. A. Todorova, T. Dimitrova, and V. Stefanova. 2022. Research on the basic verbal vocabulary in Bulgarian for students in the initial stage of education through online games. *Pedagogika-Pedagogy*, XCIV:896–913.