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A SEMANTIC DESCRIPTION OF THE COMBINABILITY BETWEEN VERBS AND NOUNS (ON MATERIAL FROM BULGARIAN AND ENGLISH)

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Abstract. This paper represents a methodology for defining restrictions on the semantic combinability between different semantic classes of verbs and the sets of nouns corresponding to the elements of their conceptual frame (i.e. the major participants in the situation described). Our observations focus on verb synsets from WordNet and their assigned FrameNet frames which mutually inform each other. We analyse the semantic information typical for each of the studied verb classes and define semantic restrictions on the nouns they combine with. The theoretical and empirical value of the provided semantic representations and restrictions lies in the enhanced modelling of verb-noun combinability which is universal enough to be applicable not only to the languages exemplified (English and Bulgarian), but (with possible modifications) to various other languages for which wordnets are available.

Keywords: Frame semantics; WordNet; FrameNet; VerbNet; semantic roles; semantic restrictions

1. Introduction

In this paper we analyse verbs from several major semantic classes in terms of the conceptual structure and the selectional restrictions imposed on the main participants in the situations described by these predicates. We take as a point of departure the verb senses as defined and organised in interrelated synonym sets (synsets) in WordNet and the conceptual frames developed in another semantic resource, FrameNet, which have been mapped to appropriate verb synsets. We then elaborate on the obtained representation through formulating stricter selectional restrictions on the major participants (roughly corresponding to a predicate's arguments), drawing on the analysis of individual verb synsets. In such a way, we are able to define conceptual models for the combinability between verbs and sets of noun synsets that lexicalise the main participants in their conceptual structure.

2. Methodology and resources

Below we briefly discuss the linguistic resources employed in the research, the data and the methodology used in the analysis.

Our observations are based on data from three lexical semantic and/or syntactic resources, WordNet, FrameNet and VerbNet, which have been previously aligned (Leseva & Stoyanova 2019).

WordNet (WN) (Fellbaum 1998) is a large lexical database that represents comprehensively conceptual and lexical knowledge as a network of nodes (synonym sets) interconnected through a number of conceptual-semantic and lexical relations. WN serves as a source of the verbs and nouns (we treat each synset as a whole) on which we found our analysis and the formulation of restrictions.

FrameNet (FN) (Baker et al. 1998, Baker 2008) represents lexical and conceptual knowledge as conceptual structures (frames) which describe particular types of objects, situations, or events along with their components, called frame elements, or FEs (Baker & Ruppenhofer 2002, Ruppenhofer et al. 2016). For our purposes, we deal particularly with the so-called core FEs (CFEs), which represent the most essential participants in a conceptual structure. In addition, part of the FEs are assigned semantic types which serve us to define relevant selectional restrictions.

VerbNet (VN) (Kipper-Schuler 2006) is a large verb lexicon in which verbs are organised into classes and each class is described in terms of the thematic roles of the arguments, the selectional restrictions imposed on them and the syntactic frames in which the verbs and their arguments are realised. In particular, we employ the semantic restrictions defined in VerbNet as they either correspond or are complementary with those provided in FrameNet.

The analytical comparison of the structural and semantic data derived from FrameNet and VerbNet leads to a more detailed description for each of the observed synsets in WordNet cast in the framework of frame semantics.

The data analyses are based on theoretical observations that underlie the conceptual representations provided in FrameNet (Baker & Ruppenhofer 2002, Ruppenhofer et al. 2016, among others), as well as in the framework of the Bulgarian FrameNet (Koeva 2010). The empirical observations are based on a selection of verb synsets from several semantic classes to which FN frames have been assigned; the frames are among the most frequent (the greatest number of synsets have been mapped to them).

In addition, we use a set of features and restrictions for the semantic description of FEs which are aligned to corresponding noun synsets or semantic categories in WordNet. These include categories such as Human, Volitional, Concrete, Content, Abstract, Eventuality, etc.[1)]

3. Semantic verb classes, conceptual frames and restrictions

In this Section we analyse verbs assigned some of the frames under discussion and describe their selectional restrictions. We consider primarily

the typical cases, whereas non-typical ones are tackled on the level of individual verbs.

3.1. Verbs of placing, removing, filling and emptying

The verbs analysed in this section cover verbs of placing, removing, filling and emptying. The relevant FN frames (Placing, Filling, Removing and Emptying) share common FEs and restrictions. As a whole, these frames involve the movement of a thing or a substance, the Theme, to a particular place, the Goal, or from a particular place, the Source, both of which may be further specified as being a Container or a Surface of some kind, in some cases in an abstract or metaphorical sense. The entity that brings about the situation may be a volitional Agent or a non-volitional Cause. Apart from a person, an Agent may be a quasi-human entity, such as a social group, an organisation or the like, an animal that may be construed as capable of intent or purpose, or an automated (self-operating) device. Causes are typically inanimate entities or eventualities that bring about the situation.

The definition of each frame along with the relevant general restrictions for the CFEs are presented below. Restrictions on CFEs are often represented as a union of classes (∪)[2)]. In some cases, the classes are not necessarily disjoint, i.e. they may overlap or even be related as a class and a subclass; although that may seem redundant, listing subclasses or subtypes of restrictions can be informative when applying them to particular verbs or verb classes.

FN Frame 1. Placing: An Agent (or a Cause) places a Theme at a location, the Goal. The Theme is under the control of the Agent/Cause at the time of its arrival at the Goal[3)].

– **Agent:** Volitional
– **Cause:** Physical_entity ∪ Eventuality
– **Theme:** Physical_entity
– **Goal:** Physical_object, predominantly (Container ∪ Surface)

FN Frame 2. Filling An Agent (or a Cause) fills a container or covers areas (the Goal) with some thing, things or a substance (the Theme).

– **Agent:** Volitional
– **Cause:** Physical_entity ∪ Eventuality
– **Theme:** Physical_entity
– **Goal:** Physical_object, predominantly (Container ∪ Surface)

The main difference between the two frames, which share all of their CFEs, is on the perspective adopted – Placing differs from Filling in that it focuses on the Theme being moved towards the Goal (Example 2a, 2b) rather than on the effect exerted on the Goal as a result of the movement (Example 2c, 2d).

Example 2

(2a) [The man]$_{\text{AGENT}}$ **packed** [the food]$_{\text{THEME}}$ [in plastic boxes]$_{\text{GOAL}}$.
(2b) [Човекът]$_{\text{AGENT}}$ **опакова** [храната]$_{\text{THEME}}$ [в пластмасови кутии]$_{\text{GOAL}}$.

(2c) [The girl]$_{\text{AGENT}}$ **filled** [the bottle]$_{\text{GOAL}}$ [with water]$_{\text{THEME}}$.
(2d) [Момичето]$_{\text{AGENT}}$ **напълни** [бутилката]$_{\text{GOAL}}$ [с вода]$_{\text{THEME}}$

In addition, as may be confirmed by examples from different languages, such as the parallel sentences in English and Bulgarian (Example 2), both the conceptual representation in terms of frames and the semantic restrictions imposed on the FEs hold cross-linguistically (possibly with modifications).

Example 3 represents a part of a WN subtree stemming from the synset *{put:1, set:1, place:1, pose:5, position:2, lay:1}*[4] which includes some of its hyponyms assigned the FN frame Placing. The semantics of the top synset illustrates the general restrictions of the frame while the hyponyms allow narrower specifications.

Example 3. Verb synsets assigned the FN frame: **Placing**
(3a) – *{put:1}*[5] 'put into a certain place or abstract location'
(3b) – *{jar:5}* 'place in a cylindrical vessel'
(3c) – *{bottle:2}* 'put into bottles'
(3d) – *{barrel:1}* 'put in barrels'
(3e) – *{insert:2}* 'place, fit, or thrust (something) into another thing'
(3f) – *{ground:3}* 'place or put on the ground'

(1) Restrictions on the FE Agent and Cause: part of the illustrated verbs impose the general restrictions for the Agent, including animate Agents capable of volition and self-operating devices (3a, 3e, 3f), while other verbs are limited to human or quasi-human entities (groups or organisations) or possibly also automated devices (3b, 3c, 3d); the Cause is selected by the verbs in (3a, 3e, 3f) and is very unlikely for the rest.

(2) Restrictions on the FE Theme: generally the Theme is a physical entity, which in some cases may be further specified as being a substance or food (3b) or a liquid or drink (3c, 3d).

(3) Restrictions on the FE Goal: the Goal is a Container, which may be narrowly specified to a particular entity (or a small class of entities), such as a jar (3b), a bottle (3c) or a barrel (3d) or may select for the more general restrictions defined for the frame – Physical_entity (3e) or Surface (3f).

The other pair of frames describe the opposite activities: Removing as opposed to Placing, and Emptying as opposed to Filling.

FN Frame 3. Removing: An Agent or a Cause causes a Theme to move away from a location, the Source.
– **Agent:** Volitional
– **Cause:** Physical_entity ∪ Eventuality
– **Theme:** Physical_entity
– **Source:** Physical_object, predominantly (Container ∪ Surface)

FN Frame 4. Emptying: An Agent or a Cause empties a container or clears a designated Source by removing the Theme from the Source.
– **Agent:** Volitional

– Cause: Physical_entity ∪ Eventuality
– Theme: Physical_entity
– Source: Physical_object, predominantly (Container ∪ Surface)

Similarly to Placing and Filling, the difference between Removing and Emptying lies in the fact that the two types of situations have a different focus – the Theme (Example 4a, 4b) or the Source (Example 4c, 4d).

Example 4
(4a) [The child]$_{\text{AGENT}}$ **took out** [the present]$_{\text{THEME}}$ [from the box]$_{\text{SOURCE}}$.
(4b) [Детето]$_{\text{AGENT}}$ **извади** [подаръка]$_{\text{THEME}}$ [от кутията]$_{\text{SOURCE}}$.
(4c) [The woman]$_{\text{AGENT}}$ **cleaned** [the walls]$_{\text{SOURCE}}$ [of the dirt]$_{\text{THEME}}$.
(4d) [Жената]$_{\text{AGENT}}$ **почисти** [стените]$_{\text{SOURCE}}$ [от мръсотията]$_{\text{THEME}}$

The synsets that are deeper in the hierarchy (the hyponyms) may impose greater restrictions on the CFEs. Example 5 below represents a subtree stemming from the synset *{empty:1}* that includes several of its hyponyms which are all assigned the FN frame Emptying.

Example 5. Verb synsets assigned the FN frame: **Emptying**
(5a) – *{empty:1}* 'make void or empty of contents'
(5b) – *{clear:23}* 'remove the occupants of'
(5c) – *{drain:3}* 'empty of liquid; drain the liquid from'
(5d) – *{bleed:5}* 'drain of liquid or steam'
(5e) – *{hollow:2}* 'remove the interior of'
(5f) – *{knock out:5}* 'empty (as of tobacco) by knocking out'

While the top *{empty:1}* more or less imposes the general restrictions of the FN frame Emptying, its hyponyms exhibit a variety of restrictions on the FEs:

(1) Restrictions on the FE Agent and Cause: while most of the illustrated verbs require a volitional Agent that may be a quasi-human entity (a group or an organisation) or an automated device, some select specifically for human Agents (5f) and/or organisations (5b). Unlike *{empty:1}*, the remaining verbs are unlikely to appear with a Cause instead of an Agent.

(2) Restrictions on the FE Theme: generally the Theme is a physical entity (5a), which is further specified as a person or a group of people (5b), a liquid (5c), a liquid or gaseous substance (5d), a solid object or substance (5e), tobacco (5f).

(3) Restrictions on the FE Source: the Source is generally a Container (rather than a Surface), which for some of the verbs may be a very particular entity, such as a building (5b) or a pipe (5f).

3.2. Verbs of communication

Verbs of communication cover predicates denoting interaction and exchange of messages of various modality. In particular, here we analyse verbs for stating, telling, and expressing direct and indirect judgement.

In general, the conceptual structure of verbs assigned the frames Statement and Telling represents the (volitional) act of delivering a Message, possibly on some Topic by a Speaker to an Addressee. As these verbs usually select to express either a Message or a Topic at a time, the two FEs share the same semantic restrictions defined as cognitive Content, which may be an entire proposition. The Speaker is generally a human or a quasi-human entity, and the Addressee is a Sentient being. The means of the transmission of the Message (various kinds of equipment or modes of transferring information) is also part of the core conceptual description.

FN Frame 5. Statement: A Speaker addresses a Message to an Addressee using language or signals. Instead of (or in addition to) a Speaker, a Medium may also be mentioned. A Topic may be stated instead of a Message.

– **Speaker:** Volitional_human_entities
– **Message:** Content
– **Topic:** Content
– **Medium:** Medium_or_channel
– **Addressee (non-core):** Sentient

FN Frame 6. Telling: A Speaker addresses an Addressee with a Message, which may be indirectly referred to as a Topic. Instead of (or in addition to) a Speaker, a Medium may also be mentioned.

– **Speaker:** Volitional_human_entities
– **Message:** Content
– **Topic:** Content
– **Medium:** Medium_or_channel
– **Addressee:** Sentient

The two frames describe similar situations where the former (Statement, 6a, 6b) is oriented to the Content being transmitted, while the latter (Telling, 6c, 6d) is focused on the Addressee.

Example 6

(6a) [The government]$_{\text{SPEAKER}}$ **explained** [its actions]$_{\text{MESSAGE}}$ [to the public]$_{\text{ADDRESSEE}}$ [in a TV statement]$_{\text{MEDIUM}}$.

(6b) [В телевизионно обръщение]$_{\text{MEDIUM}}$ [правителството]$_{\text{SPEAKER}}$ **обясни** [пред обществеността]$_{\text{ADDRESSEE}}$ [скорошните си действия]$_{\text{MESSAGE}}$.

(6c) [In last night's emission]$_{\text{MEDIUM}}$ [they]$_{\text{SPEAKER}}$ **told** [the public]$_{\text{ADDRESSEE}}$ [another lie]$_{\text{MESSAGE}}$.

(6d) [В снощните новини]$_{\text{MEDIUM}}$ [те]$_{\text{SPEAKER}}$ [ни]$_{\text{ADDRESSEE}}$ **дезинформираха** [с поредната си лъжа]$_{\text{MESSAGE}}$.

Example 7 represents a subtree stemming from the synset *{announce:2, declare:2}*, where the synsets under discussion are assigned the frame Statement.

Example 7. Examples of verb synsets assigned the FN frame: **Statement**

(7a) – *{announce:3}* 'make known; make an announcement'

(7b) – *{trump:1}* 'proclaim or announce with or as if with a fanfare'
(7c) – *{post:3}* 'publicize with, or as if with, a poster'
(7d) – *{placard:1}* 'publicize or announce by placards'
(7e) – *{sound:12}* 'announce by means of a sound'

(1) Restrictions on the FE Speaker: The verbs select for the general restrictions for the Speaker, that is Volitional_human_entities, particularly persons, groups or organisations.

(2) Restrictions on the FE Medium: Apart from (7a), where the verb complies with the general restrictions, the remaining synsets require very specific types of Medium, such as music (7b), posters (7c) or placards (7d), sound signals (7e).

(3) Restrictions on the FE Message/Topic: The verbs under discussion impose the general semantic restrictions on the Message and the Topic frame elements.

(4) Restrictions on the Addressee: The general restriction for the Addressee is to be a Sentient being (a person or an animal) that is potentially able to perceive the Message.

The frames Judgment_communication and Judgment_direct_address discussed below relate to communicating judgment of an entity instead of merely information. In both frames a Communicator, typically a volitional human entity, such as a person, a group or an organisation, makes a judgment about an Evaluee, which may be a Sentient being, but also any cognitive Content. The judgment is expressed to an Addressee (Judgment_communication) which may coincide with the Evaluee (Judgment_direct_address). The judgment may relate to a particular Topic and may be made using a kind of Medium; both FEs are specified as in frames 5 and 6. In addition, when a Communicator is not expressed, there may be an Expressor, a body part or an action of a body part (*gaze*, *look, nod*, etc.) that conveys the judgment. Finally, the Reason for the judgment is also part of the conceptual description.

FN Frame 7. Judgment_communication: A Communicator communicates a judgment of an Evaluee to an Addressee. The judgment may be positive (e.g. *praise*) or negative (e.g. *criticize*).

– **Communicator:** Volitional_human_entities
– **Topic:** Content
– **Addressee (non-core):** Sentient
– **Expressor:** Body_part ∪ Human_act
– **Evaluee:** Sentient ∪ Concrete ∪ Content
– **Reason:** Content
– **Medium:** Medium_or_channel

FN Frame 8. Judgment_direct_address: a Communicator judges the Addressee and then communicates that appraisal directly to the Addressee. The judgment is given for a particular Reason or about a particular Topic.

– **Communicator:** Volitional_human_entities
– **Topic:** Content
– **Addressee:** Sentient
– **Expressor:** Body_part ∪ Human_act
– **Evaluee = Addressee:** Sentient
– **Reason:** Content
– **Medium:** Medium_or_channel

Apart from the fact that the latter frame requires the Evaluee and the Addressee to be the same entity (8e, 8f) and the former allows it (8a, 8b) but does not require it (8c, 8d), the two frames are quite similar. In the cases where the two FEs coincide (Evaluee = Addressee), the stricter selectional restriction (Sentient) is applied.

Example 8

(8a) [He]$_{\text{COMMUNICATOR}}$ **praised** [her]$_{\text{EVALUEE}}$ [to her colleagues]$_{\text{ADDRESSEE}}$ [for her great efforts]$_{\text{REASON}}$.

(8b) [Той]$_{\text{COMMUNICATOR}}$ [я]$_{\text{EVALUEE}}$ **похвали** [пред колегите ѝ]$_{\text{ADDRESSEE}}$ [за положените усилия]$_{\text{REASON}}$.

(8c) [She]$_{\text{COMMUNICATOR}}$ **recommended** [her new washing machine]$_{\text{EVALUEE}}$ [for its quietness]$_{\text{REASON}}$.

(8d) [Тя]$_{\text{COMMUNICATOR}}$ **препоръча** [пералнята си]$_{\text{EVALUEE}}$ [като много безшумна]$_{\text{REASON}}$.

(8e) [The director]$_{\text{COMMUNICATOR}}$ **congratulated** [the students]$_{\text{EVALUEE=ADDRESSEE}}$ [for their success]$_{\text{REASON}}$.

(8f) [Директорът]$_{\text{COMMUNICATOR}}$ **поздрави** [студентите]$_{\text{EVALUEE=ADDRESSEE}}$ [за успеха им]$_{\text{REASON}}$.

Example 9 illustrates several hyponyms of the synsets *{praise:1}* and *{knock:6, criticize:1, criticise:1, pick apart:1}*, respectively, where the synsets under discussion are assigned the frame Judgment_communication.

Example 9. Examples of verb synsets assigned the FN frame: **Judgment_communication**

(9 a) – *{praise:1}* ‘express approval of’
(9 b) – *{laud:1}* ‘praise, glorify, or honor’
(9 c) – *{commend:3}* ‘express a good opinion of’
(9 d) – *{rave:1}* ‘praise enthusiastically’
(9 e) – *{eulogize:1}* ‘praise formally and eloquently’

(9 f) – *{criticize:1}* ‘find fault with; express criticism of; point out real or perceived flaws’
(9 g) – *{disparage:1}* ‘express a negative opinion of’
(9 h) – *{attack:6}* ‘attack in speech or writing’

(1) Restrictions on the FE Communicator: The Communicator selects for the general restrictions defined for this frame element, typically a volitional human or quasi-human entity.

(2) Restrictions on the FE Evaluee / Addressee: The Evaluee selects for the general selectional restrictions, which may be Sentient, Concrete or Content. The Addressee is Sentient.

(3) Restrictions on the FE Topic: The Topic is some cognitive Content, which may involve positive (9a, 9b, 9c, 9d, 9e) or negative (9f, 9g, 9h) sentiment or judgment.

(4) Restrictions on the FE Reason: The Reason complies with the general restrictions for the element (Content).

3.3. Verbs of change

Verbs of change[6] describe a change induced in an Entity with respect to the Value of a particular property (Attribute) or the transition from one Initial_category to another, Final_category. The different subclasses of verbs corresponding to different frames are distinguished in terms of the Attribute, such as *temperature* (Cause_temperature_change), *phase* (Cause_change_of_phase), *strength* (Cause_change_of_strength), *consistency* (Cause_change_of_consistency), *size* (Cause_expansion), some general quantitative attribute (Cause_change_of_position_on_a_scale), or the resulting state or category, such as *dryness* (Cause_to_be_dry), *wetness* (Cause_to_be_wet), *sharpness* (Cause_to_be_sharp), *fragmentation* (Cause_to_fragment).

The most comprehensive picture in terms of the number of CFEs is represented by the frame Cause_change. The remaining frames basically feature an Agent or (for most frames) an inanimate or non-volitional Cause that brings about the change[7], an Entity denoting the thing, object, person, abstract entity, etc. that undergoes the change, and possibly additional CFEs which to a greater or to a lesser degree correspond to core elements in the Cause_change frame (we also consider non-core elements that represent such correspondences). In some cases the more specific frame imposes a more specific restriction, e.g. the frames for concrete verbs such as Cause_change_of phase or Cause_to_be_dry do not appear with an abstract Cause.

FN Frame 9. Cause_change: An Agent or a Cause causes an Entity to change, either in its category membership (from an Initial_category to a Final_category) or in terms of the value of an Attribute (from an Initial_value to a Final_value).

– **Agent:** Volitional
– **Cause:** Physical_entity ∪ Eventuality ∪ Abstract
– **Entity:** Physical_ entity ∪ Eventuality ∪ Abstract
– **Initial category / Final category:** Content
– **Attribute**: Attribute
– **Initial value / Final value**: Quantity

FN Frame 10. Cause_change_of_position_on_a_scale: An Agent or a Cause affects the position of an Item on some scale (the Attribute) to change it from an initial value (Value_1) to an end value (Value_2).

– **Agent:** Volitional
– **Cause:** Physical_entity ∪ Eventuality ∪ Abstract
– **Item**: Physical_entity ∪ Eventuality ∪ Abstract
– **Attribute**: Attribute
– **Value 1 / Value 2 (non-core)**: Quantity

FN Frame 11. Cause_change_of_phase: A Cause or an Agent causes a Patient to undergo a change of phase. The Result of the change may be given, along with the Initial_state and the Circumstances under which the change can occur.

– **Agent:** Volitional
– **Cause:** Physical_entity ∪ Eventuality
– **Patient:** Substance
– **Initial state / Result (non-core):** State

FN Frame 12. Cause_to_be_dry: An Agent or a Cause causes a Dryee (either a surface or an entire entity, inside and out) to become dry.

– **Agent:** Volitional
– **Cause:** Physical_entity ∪ Eventuality
– **Dryee:** Physical_entity

FN Frame 13. Cause_expansion: An Agent or a non-human Cause causes an Item to change its physical size. The Size_change of an Item may be explicitly indicated or characterized in terms of Initial_size and/or Result_size.

– **Agent:** Volitional
– **Cause:** Physical_entity ∪ Eventuality ∪ Abstract
– **Item**: Physcal_entity ∪ Abstract
– **Attribute**: Dimension
– **Initial size / Final size**: Quantity

FN Frame 14. Adjusting: An Agent changes a Part of a complex entity with regard to some Feature in order to achieve some Imposed_purpose affected by the Feature.

– **Agent:** Volitional
– **Part**: Physical_entity ∪ Abstract
– **Feature**: Attribute
– **Final value (non-core)**: Quantity

Example 10 illustrates three of the discussed frames: Cause_change_of_phase (10a, 10b), Cause_change_of_position_on_a_scale (10c, 10d), and Adjusting (10e, 10f).

Example 10

(10a) [The warm weather]$_{\text{CAUSE}}$ **melted** [the ice]$_{\text{PATIENT}}$ [to slush]$_{\text{RESULT}}$.

(10b) [Топлото време]$_{\text{CAUSE}}$ **разтопи** [леда]$_{\text{PATIENT}}$ [до киша]$_{\text{RESULT}}$.

(10c) [The state]$_{\text{AGENT}}$ **increased** [the funding]$_{\text{ATTRIBUTE}}$ [to 2 billion]$_{\text{VALUE 2}}$.

(10d) [Държавата]$_{\text{AGENT}}$ **увеличи** [финансирането]$_{\text{ATTRIBUTE}}$ [на 2 милиарда]$_{\text{VALUE 2}}$.

(10e) [The cook]$_{\text{AGENT}}$ **adjusted** [the oven]$_{\text{PART}}$ [to 250 degrees]$_{\text{FINAL VALUE}}$.

(10f) [Готвачът]$_{\text{AGENT}}$ **нагласи** [фурната]$_{\text{PART}}$ [на 250 градуса]$_{\text{FINAL VALUE}}$.

Illustrations for the definition of selectional restrictions with respect to verbs of change are given in Examples 11 and 12. Example 11 represents a WN subtree stemming from the synset *{dry:1; dry out:1}* which along with all its hyponyms is assigned the frame Cause_to_be_dry.

Example 11. Examples of verb synsets assigned the FN frame: **Cause_to_be dry**

(11a) – *{dry:1}* 'remove the moisture from and make dry'

(11b) – *{rough-dry:1}* 'dry without smoothing or ironing'

(11c) – *{air:3}* 'expose to warm or heated air, so as to dry'

(11d) – *{drip-dry:1}* 'dry by hanging up wet'

(11e) – *{spin-dry:1}* 'dry (clothes) by spinning and making use of centrifugal forces'

(11f) – *{blow-dry:1}* 'dry hair with a hair dryer'

(11g) – *{tumble dry:1}* 'dry by spinning with hot air inside a cylinder'

(11h) – *{spray-dry:1}* 'dry by bringing into the form of spray, through contact with a hot gas'

(11i) – *{parch:1; sear:1}* 'cause to wither or parch from exposure to heat'

The general restrictions state that the activity of drying is performed either by a volitional Agent or by an inanimate or non-volitional Cause, and the Dryee is a surface or an entity (11a). The additional more specific restrictions distinguish the hyponyms from the hypernym, and concern the semantics of one or more of the FEs:

(1) Restrictions on the FE Agent and Cause: most of the verbs select for an Agent (rather than for a Cause), which in some cases is restricted to a volitional human (11b–11d), while in others – maybe either a human Agent operating on a specific type of machine or the machine itself (11e–11h); (11i) preserves the selectional restrictions of the hypernym.

(2) Restrictions on the FE Dryee: several hyponyms involve the drying of clothes and fabrics (11b, 11c, 11d, 11e, 11g), while (11f) refers specifically to hair

and (11h) involves the drying and pulverising of fluids or non-solid substances, including foods. Some examples preserve the original general restrictions (11i).

The examples in (12) illustrate the frame Adjusting and include *{adjust:1}* and several of its hyponyms.

Example 12. Examples of verb synsets assigned the FrameNet frame: **Adjusting**

(12a) – *{adjust:1}* 'alter or regulate so as to achieve accuracy or conform to a standard'

(12b) – *{zero:1}* '(adjust (an instrument or device) to zero value)'

(12c) – *{trim:9}* 'adjust (sails on a ship) so that the wind is optimally used'

(12d) – *{modulate:1}* 'adjust the pitch, tone, or volume of'

(12e) – *{tune:2}* 'adjust the pitches of (musical instruments)'

(12f) – *{harmonize:5}* 'bring into consonance or accord'

(1) Restrictions on the FE Agent: The verbs in this frame denote strictly agentive actions and do not allow a Cause frame element.

(2) Restrictions on the FE Part: The Part (Patient) can be a Physical object, typically an artifact (12a), or an Abstract entity (12a, 12f), or can be restricted to a more specific subset, e.g. devices (12b), musical instruments (12d, 12e) and/or voices (12d), or ship sails (12c).

(3) Restrictions on the FE Feature: This FE may be an Attribute or a set of Attributes (12a), which may be further specified, e.g. sound properties such as pitch, tone, volume (12d, 12e), other physical properties (12b, 12c), an abstract property (12f), etc.

4. Conclusions and future plans

This research is part of our work towards the creation of a relationally densely populated semantic network. This will be achieved by couching the combinability patterns between verbs and (classes of) noun synsets as semantic relations in WordNet.

The in-depth analysis of the typology of verbs contributes to acquiring more profound knowledge about the conceptual structure of predicates and the semantic restrictions they impose as well as their expression in terms of the compatibility between verb and noun classes. The research results provide a foundation for theoretical and applied studies of cross-linguistic (a)symmetries in the domain of syntax and semantics.

Moreover, even though the methodology and the results are considered mainly with respect to English and Bulgarian, conceptual knowledge and the frame-to-synset mapping are largely linguistically universal, so any number of languages for which wordnets are available and are mapped to the Princeton WordNet may be studied in the provided framework.

The results obtained are largely applicable in various fields of computational linguistics where solid semantic knowledge is required, such as semantic

analysis, word sense disambiguation, machine translation, among others. Moreover, the knowledge about verb frames, the compatibility between verbs and nouns and the restrictions on frame elements is valuable in first and foreign language learning as it provides a foundation for cross-linguistic comparison.

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NOTES

1. The restrictions used in the paper are the following: *Volitional*: entities with intentional control over the event, including animals capable of intention or purpose, some self-operating devices and machines; *Volitional_human_entities* restricts volitional entities to be human or quasi-human (organisations or the like); *Sentient* refers to animate, including quasi-human entities which are not causally or agentively involved in the situation described; *Physical_object*: naturally existing objects and artifacts; *Physical_entity*: *Physical_objects* and *Substances, Abstract*: any non-physical entity, concept, etc; *Eventuality:* acts, processes, events, natural phenomena, etc.; *Content*: messages, topics, the cognitive content of perceptions, cognitive activities, etc.; *Medium_or_channel*: means of communication; *Concrete*: any entity having physical existence; *Dimension*: a spatial dimension; *Human_act*, *Substance*, *Container*, *Surface*, *Location, Body_part*, *Quantity* are self-explanatory.
2. The symbol ∪ is used to denote union between the classes represented by the relevant selectional restrictions.
3. A full description of the relevant FN frames together with the respective frame elements is available at: https://framenet.icsi.berkeley.edu/fndrupal/framenet_search. The frame definitions presented here are modified, where necessary, for the sake of clarity given the smaller context.
4. The examples in the text use the notation of WN's synsets based on a lemma and a sense number, as presented at: http://wordnetweb.princeton.edu/perl/webwn.
5. For consideration of space in the tree examples we show only the first synonym in the synset.
6. Many verb classes exhibit pairs of causative and inchoative verbs. In FN this distinction is captured by pairs of causative and inchoative frames, such as *Attaching* > *Becoming_attached, Cause_change_of_consistency* > *Change_of_consistency*. Since there is a systematic correspondence between the FEs in the causative-inchoative counterparts (presence or lack of an Agent/Cause FE), we discuss only the causative structures.

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