The Annotation of Thematic Structure and Alternations face to the Semantic Variation of Action Verbs.
Current Trends in the IMAGACT Ontology

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Abstract

We present some issues in the development of the semantic annotation of IMAGACT, a multimodal and multilingual ontology of actions. The resource is structured on action concepts that are meant to be cognitive entities and to which a linguistic caption is attached. For each of these concepts, we annotate the minimal thematic structure of the caption and the possible argument alternations allowed. We present some insights on this process with regard to the notion of thematic structure and the relationship between action concepts and linguistic expressions. From the empirical evidence provided by the annotation process, we discuss the very nature of thematic structure, arguing that it is neither a property of the verb itself nor a property of action concepts. We further show what is the relation between thematic structure and 1- the semantic variation of action verbs; 2- the lexical variation of action concepts.

Keywords: thematic structure, semantic roles, action verbs, action concepts

1. Introduction

In the last decades, great attention has been devoted to the development of computational verb lexicons in the field of natural language processing. Verbs are indeed the core of the sentence to which the other elements relate. VerbNet is a well-known outcome of this kind of effort, which has provided a comprehensive account of possible syntactic frames and argument structures associated with verbs (Kipper-Schuler, 2005). More recently, Uresova et al. (2018) started the implementation of a bilingual verb lexicon based on synonym relations. General information about verb lemmas can be found also in other lexical resources, such as FrameNet (Fillmore et al., 2004), PropBank (Palmer et al., 2005) among many others.

The IMAGACT ontology of actions[1] (Moneglia et al., 2012b; Panunzi et al., 2014) inserts itself in this trend, offering a multilingual repository of action verbs. The ontology consists of fine-grained categorization of action concepts, each represented by prototypical visual scenes in the form of short recorded videos or 3D animations. IMAGACT defines the meaning of an action verb through a set of scenes in the ontology, rather than towards dictionary definition or propositional representations within decompositional approaches (Dowty, 1979; Rappaport Hovav and Levin, 2012). Each action concept can be referred to one or more verbs (within and across languages). Moreover, action verbs are frequently general and refer to a set of action concepts. The visual representations convey information in a language-independent environment, modeling concepts without the bias coming from a monolingual approach.

In this paper, we present some insights on the semantic annotation of the IMAGACT ontology. For each action concept, we annotate the thematic structure (henceforth TS) and argument alternations for each of its linguistic captions. The resulting annotation can be inspected also from the ac-

tion verb point of view, looking at its possible thematic configurations throughout the different concepts it can refer to. Starting from the empirical evidence provided by the annotation process, we reflect on the very nature of thematic structure, arguing that it is neither a property of the verb itself nor a property of the action concept. Moreover, we highlight what we can learn about the semantic variation of action verbs and the lexical variation of concepts from the annotation of TSs. It is possible indeed to inspect not only all the possible TSs for a given verb but also the TSs associated with a specific action concept. We believe that this is an additional value of the ontology and we show how it helps in understanding the relationship between the conceptualization of events and their linguistic encoding.

2. The IMAGACT ontology of actions

The IMAGACT multilingual Ontology of Actions contains 1010 scenes that represent the action concepts most commonly referred to in everyday language. Each scene is conceived as a prototypical instance (Rosch, 1983) of an action concept and constitutes the basic entity of reference of the action ontology. The scenes represented have been derived from occurrences of action verbs[2] in two large spoken resources of English and Italian (Moneglia et al., 2012a). After this initial phase, the linguistic annotation for many other languages has been obtained through competence-based judgments by native speakers (Brown et al., 2014; Pan et al., 2018; Moneglia et al., 2018).

The database evolves continuously: at present, it contains around 8700 verbs from 15 languages[3].

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[1] http://www.imagact.it/

[2] Only in their basic, physical meaning, so excluding all metaphorical and phraseological uses. We refer the reader to Frontini et al. (2012; Moneglia et al. (2012a) for a description of the infrastructure and the annotation procedure; to Gagliardi (2013; Gagliardi (2014) for a summary of inter-annotator agreement values for this procedure.

[3] Besides English and Italian, the list of fully mapped language

IMAGACT can be queried in multiple ways. First, an action verb lemma can be searched to obtain the list of action concepts it refers to. This describes the semantic variation of a verb. Second, two verbs from the same language or from two different languages can be compared (fig 2), looking at the scenes that both can refer to (the column in the center in fig 2) and at those they separately describe. Third, a single action concept can be selected to look at the different verbs with whom it is associated in one or two languages. In fig 1, for example, the scene representing the action of pressing a button is shown together with its linked verbs in English (on the left) and Italian (on the right). Lastly, actions can be searched among 9 classes, based on the informative focus of the action:

- Perspective centered on the Actor:

    - Actions referring to facial expression
    - Actions referring to the body
    - Movement in space

- Perspective centered on the Actor-Theme relation:

    - Modifications of the object
    - Deterioration of the object
    - Forces on the object

- Perspective centered on the Theme-Destination relation:

    - Change of location of the object
    - Setting relations among objects
    - Actions in inter-subjective space

3. Minimal Thematic Structure Annotation

Computational lexicons frequently provide information about the thematic structure and syntactic frame of verbs (see e.g. VerbNet (Kipper-Schuler, 2005), FrameNet (Fillmore et al., 2004) and PropBank (Palmer et al., 2005)). In these resources, the different entries of a verb are associated with their possible thematic structures and possible alternations are listed. Particularly, VerbNet has been built around the syntactic frames of verbs, following the identification of verb classes done by Levin (1993). This kind of annotation has shown to be useful for the development of statistical approaches for Semantic Role Labeling (Gildea and Jurafsky, 2002) and numerous NLP applications (e.g. information extraction (Surdeanu et al., 2003), summarization (Melli et al., 2006), and machine translation (Boas, 2002)).

Usually, for a given verb, semantic roles are annotated, in order to specify the semantic relationship between the predicate and its arguments. In the IMAGACT ontology, we annotate the caption associated with a specific action concept in its minimal form. By minimal thematic structure, we refer to the simplest structure that is sufficient to interpret a verb as an instance of a specific action concept. The caption should indeed disambiguate the verb in referring to the specific scene represented.

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comprehends Arab, Chinese, Danish, German, Hindi, Japanese, Polish, Portuguese, Serbian, Spanish, Greek, French and Urdu.

The annotation interface allows us to select each argument in a caption and to assign a thematic role to it. An example of the result of this procedure is shown in fig. 3.

The set of semantic roles, based on those used in VerbNet (Kipper-Schuler, 2005), comprehends 13 roles, which are described as follows:

- Theme (TH): the subject/object that is undergoing to the event/action/motion denoted by the verb, both for a participant that change location and for a participant that change state (it comprehends both "theme" and "patient" roles);

- Agent (AG): an animate subject that intentionally performs the action denoted by the verb;

- Causer (CA): a "non-intentional agent", such as machines and natural forces;

- Experiencer (EX): an animate subject that actively receives sensory or emotional input;

- Actor (AC): a participant that simultaneously play the roles of both Agent/Causer/Experiencer and Theme;

- Instrumental (IN): the medium used by an agent to act;

- Source (SO): the starting point of the motion or the origin of the action (it comprehends both "source" and "origin" roles);

- Destination (DE): the endpoint of the motion or the entity that benefits from the action (e.g. a change of possession; it comprehends "goal", "destination", "direction", "beneficiary" and "recipient" roles);

- Location (LO): the place where the event/action/motion denoted by the verb occurs; also used for the path of the motion (it comprehends "location" and "path" roles);

- Time (TI): the time at which the event/action/motion occurs;

- Measure (ME): an expression of extension, range or degree along a dimension (length, weight, duration, cost, etc.)

- Unspecified reference (UN): an object of reference involved in the event/action/motion denoted by the verb, not identifiable in any other of the thematic roles proposed in the tag-set.

- Coagent (CO): a participant who performs the action denoted by the verb together with the main agent

Given this setting, we obtain a representation of the different thematic structures (based on different verbs) that may describe the action concept. Moreover, similarly to other resources, we can look at the different thematic structure shown by a single verb (with reference to the different action concepts it may refer to).

In what follows, we report an overview of these two kinds of inspections of the TS annotation, showing what it is possible to observe once the annotation is completed. With examples from the English and Italian languages, we inspect
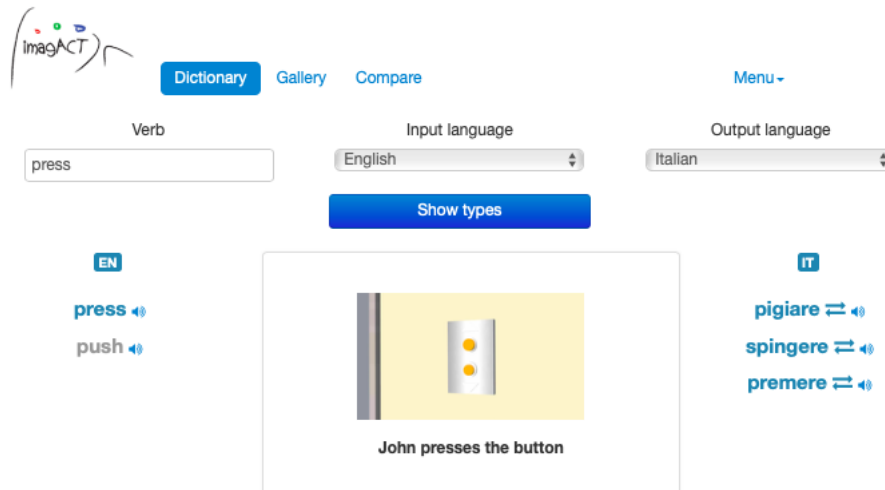
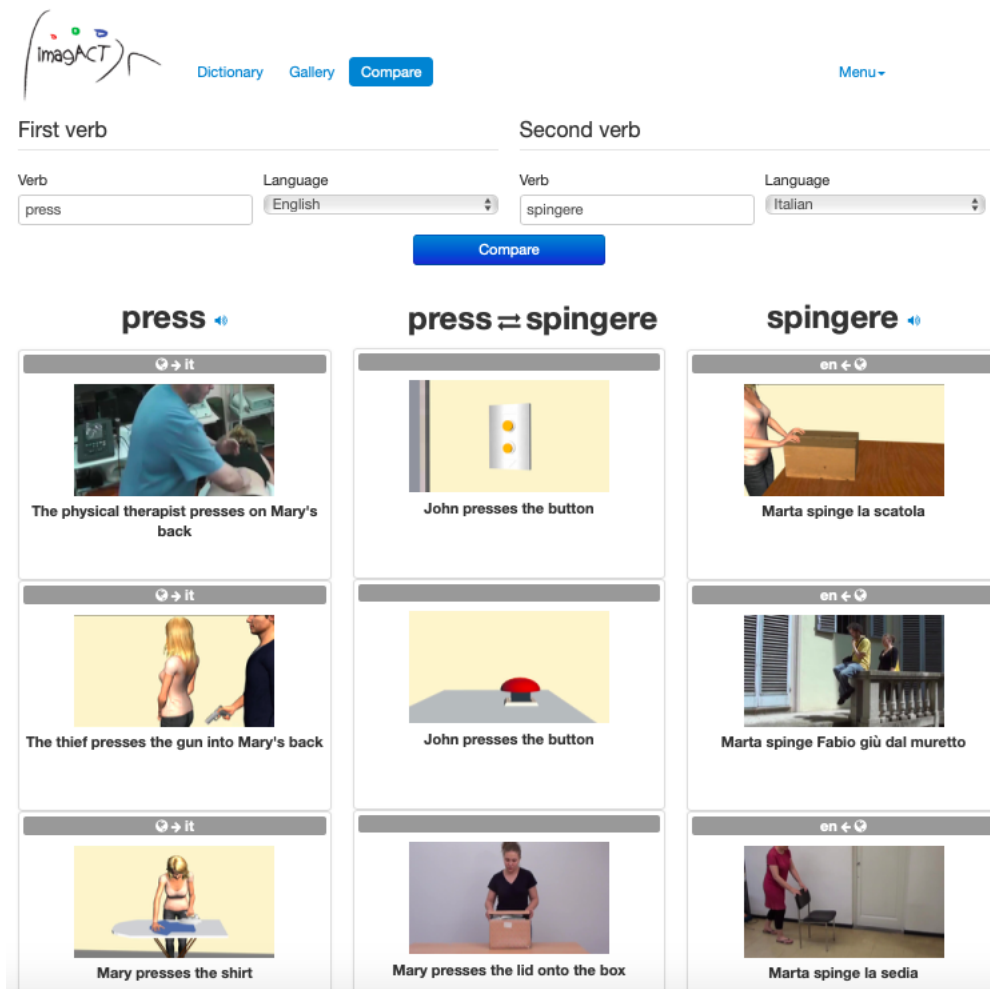Figure 1: An example of action concept in IMAGACT.

Figure 2: An example of verbs comparison in IMAGACT.

the semantic variation of some specific verbs and, also, the linguistic variation of a specific action concept.

3.1. Thematic structure and the semantic variation of verbs

The innovative methodology assumed by the IMAGACT ontology allows us to represent the meaning of an action verb through its referential properties, rather than by an
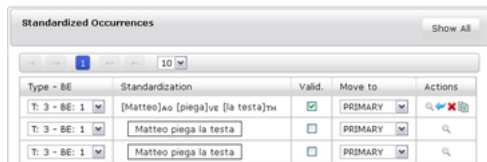
Figure 3: A screenshot of the thematic structure annotation interface.

intensional definition. We can thus analyze the semantic variation of a verb through the prototypical action concepts it has been associated to, rather than by a list of senses. Furthermore, the annotation of captions TSs brings us an inventory of the possible syntactic frames the verb occurs with.

From the annotation process of the IMAGACT verbs inventory, we observe that different possibilities occur:

- verbs may present only one TS;

- verbs may show different TS.

The first case is shown by so-called activity verbs, such as *to drink*, which present only one TS through their variation. In this case, this fact is linked to the low range of meanings associated with the verb. *To drink*, indeed, can be interpreted as having only one meaning. Its minimal TS will be always AG-V (since the theme is not necessary to correctly identify the action concept), no matter the kind of agents involved:

(1)   John drinks.
(2)   The cat drinks.
(3)   The horse drinks.

However, not only activity verbs can present only one TS. The verb *to close*, for example, shows a significant variation in the IMAGACT ontology (7 action types, four of them represented in fig. 4), but all types present the same TS (AG-V-TH).

Figure 4: Semantic variation of *to close*.

As an example of a verb with multiple TSs, consider the verb *to press*. It shows ten different action types in IMAGACT and it is possible to observe how concepts group based on their TS. Two action types (represented in table 1

and 2) share the Agent - Verb- Theme - Destination structure. In both cases, the Destination is necessary to represent the action concept, which cannot be identified otherwise. Both concepts concern the change of shape of the Theme, whose form is modified by the event. In this case, sharing the same TS is linked to a cognitive similarity of the action concept.

John presses the scraps into a block

AG-V-TH-DEST

to push, to compact

Table 1: *To press*, type *a*

Mary presses the fabric into a ball

AG-V-TH-DEST

to push, to squeeze, to compress

Table 2: *To press*, type *b*

A different set of concepts in the variation of *to press* shows the structure AG- V- TH, without the need for further arguments to explicitly disambiguate the action concept. These are represented in tables 3, 4, 5. They differ from concepts in tables 1 and 2 since they do not cause a change of shape of the theme, and this is mirrored by a difference in TS. However, despite the common TS, they present some cognitive features that clearly differentiate them. The action concept in table 3 implies an animate theme, contrary to actions in tables 4 and 5. These two latter concepts, moreover, differ from each other for the type of pressure, either in the form of a single impulse (table 4) or as a continuous scalar pressure (table 5).

The doctor presses the shoulder

AG-V-TH

to push, to poke

Table 3: *To press*, type *c*

John presses the button

AG-V-TH

to push

Table 4: *To press*, type *d*

These latter three action concepts are associated also by the different argument alternations they allow, contrary to the scenes in tables 1 and 2. Their thematic structures can be modified so that the arguments have different syntactic re-

John presses the pedal
AG-V-TH
to push

Table 5: *To press*, type *e*

lations with the verb. Specifically, they allow a conative alternation (Levin, 1993) and what we call theme-instrument alternation. The first one can be defined as "a transitivity alternation in which the objects of the verb in the transitive variant turns up in the intransitive conative variant as the object of the preposition in a prepositional phrase headed by the preposition at (sometimes on with certain verb of ingesting and the push/pull verbs)" (Levin, 1993, p.42).

- Type 3: The doctor presses the shoulder → The doctor presses on the shoulder

- Type 4: John presses the button → John presses on the button

- Type 8: John presses the pedal → John presses on the pedal

This alternation is not allowed for the action concepts in table 1 and 2, as the next sentences show:

- Type 1: *John presses at/on the scraps into a block.

- Type 2: *John presses at/on the fabric into a ball.

The alternation between the Theme and the Instrument is not listed in Levin (1993). In this case, the Instrument from sentence b (which can be seen as the result of a conative alternation) becomes the Theme in sentence c.

(4) a. The doctor presses the shoulder with his hand
     b. The doctor presses on the shoulder with his hand
     c. The doctor presses his hand on the shoulder

This alternation can be considered as a particular case of a *locative alternation*. In terms of Levin, the noun *shoulder* would represent the location argument, whereas *hand* would be considered the *locatum*. Also, in this case, the *theme-instrument alternation* does not apply to all types of the variation of *to press* but rather characterizes specific types.

(5) John presses the button → John presses the button with his finger → John presses his finger on the button

(6) *John presses the pedal → John presses the pedal with his foot → John presses the foot on the pedal

(7) *John presses the hand on the scraps

(8) *John presses the hand on the fabric

From the examples above, we have already seen from only 5 different action concepts that every concept is cognitively different for at least a specific property of the event. However, only some differences of features are mirrored by a
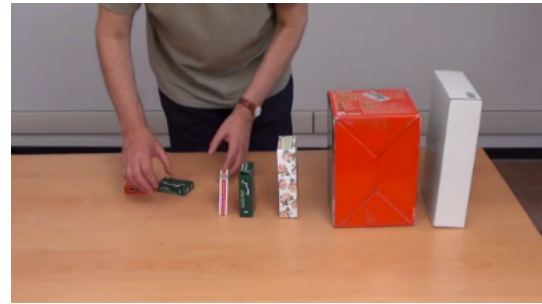

Figure 5: Frame from the scene "Maria puts the objects in order".

different linguistic encoding. Each language divides the cognitive space of actions in different ways, prioritizing some features instead of others. Moreover, we have seen that TS is not a property of the verb itself, but rather a property of the verb within the action concept.

In the next section, we will observe the relation between TS and specific action concepts.

3.2. Thematic Structure and the lexical variation of action concepts

The annotation of TS in IMAGACT brings us to an overview of TS for single action concepts, rather than only for the semantic variation of a verb. From the annotation done so far, we notice first, that the main trend among action concepts is to show the same TS among different verbs. This is mainly because we consider the minimal TS, i.e. the simplest structure that can disambiguate the linguistic caption, and it frequently contains the agent, the verb and the theme only.

However, a variety of different cases has been found in which multiple TSs can be observed among the various verbs associated with a specific action concept. These cases are frequently due to specific semantic features of one verb or, rather, to the different focus the verb brings. In what follows, we describe these cases observed during the annotation process:

1. verbs that lexicalize an argument (usually the manner, the theme or the destination) expressed by other verbs.

2. verbs that present the same arguments but with different thematic roles.

As an example of the cases in 1, consider the scene in fig. 5.

In Italian, in addition to the verb *mettere* ('to put'), this action concept can be described also with verbs like *disporre* ('to arrange'), *sistemare* ('to set'), but also with *ordinare* ('to put in order'). Consider the following sentences, which can all describe the scene under consideration.

(9) Maria mette gli oggetti in fila.
     (AG–V–TH–MANNER)
     'Maria puts the objects in line.'

(10) Maria dispone gli oggetti in fila.
     (AG-V-TH-MANNER)
     'Maria places the objects in line.'

(11)   Maria sistema gli oggetti in fila.
       (AG-V-TH-MANNER)
       'Maria arranges the objects in line.'

(12)   Maria   ordina gli oggetti.
       (AG-V-TH)
       'Maria puts in order the objects.'

The sentence in (12) differs from the others because it does not express the manner in its minimal TS. In fact, the verb *ordinare* (contrary to its English translation 'to put in order') incorporates in its semantics how the action is performed, without the need to express it separately (in what Talmy (2000) calls a *satellite*). It lexicalizes the manner component, similarly to what well-known *manner of motion* verbs do (e.g. *to run*). However, other components of meaning (in addition to the manner) can be lexicalized in a verb, and thus TSs associated with an action concept will show these differences. The theme may be incorporated as well: the theme *colore* ('paint') from sentence (13) is lexicalized into the verb in (14), thus resulting in different TSs for those captions of the same action concept.

(13)   Maria mette il colore sul foglio.
       (AG-V-TH-DEST)
       'Maria puts paint on the paper.'

(14)   Maria colora il foglio.
       (AG-V-TH)
       'Maria paints the paper.'

The same can be observed for various verbs. The verb *salare* ('to salt') encodes the theme expressed by *mettere* ('to put') in sentence (15), and the verbs *tappare* ('to plug', ex. (18)) the theme expressed in (17). *Chiudere* ('to close', ex. (19)) can refer to the same scene, but it does not encode the argument *tappo* (which could be expressed as Instrument, e.g. ex. (20).

(15)   Maria mette il sale sulle acciughe.
       (AG-V-TH-DEST)
       'Maria puts salt on the anchovies.'

(16)   Maria sala le acciughe.
       (AG-V-TH)
       'Maria salts the anchovies.'

(17)   Maria mette il tappo nel buco.
       (AG-V-TH-DEST)
       'Maria puts a cap in the hole.'

(18)   Maria tappa il buco.
       (AG-V-TH)
       'Maria plugs the hole.'

(19)   Maria chiude il buco.
       (AG-V-TH)
       'Maria seals the hole.'

(20)   Maria chiude il buco con un tappo.
       (AG-V-TH-INSTR)
       'Maria seals the hole with a cap.'

Similarly, the destination may be not necessarily expressed: *mettere* requires it in its minimal TS, whereas *piantare* ('to plant') already expresses it:

Figure 6: Frame from the scene "Maria puts the plastic on the book".

(21)   Maria mette il palo nel terreno.
       (AG-V-TH-DEST)
       'Maria puts the pole into the ground.'

(22)   Maria pianta il palo.
       (AG-V-TH)
       'Maria plants the pole in the ground.'

Note that it is possible to express an additional destination with *piantare* (ex. (23), even if in this case it is not the minimal TS that is considered), but the same is not possible with *mettere* ((24)): in this case, the sentence would not refer unambiguously to the same action concept as in (23), but it could be interpreted as denoting another action, such as those of putting the pole horizontally on the ground.

(23)   Maria pianta il palo nel suo giardino.
       (AG-V-TH-DEST)
       'Maria plants the pole in her garden.'

(24)   ≠ Maria mette il palo nel suo giardino.
       (AG-V-TH-DEST)
       ≠ 'Maria puts the pole in her garden.'

All these differences considered may be attributed to a more general distinction among general verbs and more specific ones, but also to the different focus the verbs bring. *Mettere* focuses on the process of the event ((24)), whereas *piantare* on the goal/result of the action.

Let's consider now some examples from the second case, i.e. action concepts that can be described by verbs that encode the same arguments but with different roles. Consider the scene represented in fig.6 and by the next two sentences:

(25)   Maria mette la copertina al libro.
       (AG-V-TH-DEST)
       'Maria puts the plastic on the book'.'

(26)   Maria riveste il libro con la copertina.
       (AG-V-TH-INSTR)
       'Maria covers the book with plastic.'

The noun *libro*, which is encoded as destination in the sentence (25), becomes the theme in sentence (26) where the predicate is *rivestire* ('to cover'). On the contrary, the noun *copertina* is encoded as theme in (25), and as instrument in (26).

A similar case is given by the verb *mettere* ('to put') in contrast with the verb *caricare* ('to load'). The latter is well-

known for its possibility to show the locative alternation (Levin, 1993), as for its English translation:

(27) Maria carica le assi con i pacchi.
      (AG-V-TH-INSTR)
      'Maria loads the shelfs with boxes.'

(28) Maria carica i pacchi sulle assi.
      (AG-V-TH-DEST)
      'Maria loads the boxes on the shelfs.

The verb *mettere*, instead, can refer to this scene only with one argument configuration:

(29) Maria mette i pacchi sulle assi.
      (AG-V-TH-DEST)
      'Maria puts the boxes on the shelfs.'

(30) *Maria mette le assi con i pacchi.
      (AG-V-TH-INSTR)
      '*Maria puts the shelfs with boxes.'

Again, the different TSs bring a different focus on the action. If we represent the noun *pacchi* as theme ((28) and (29)) we are focusing on the processual part of the event in which the boxes are been moved. If we represent the noun *shelves* as theme, instead, the result of the action is in focus, i.e. the shelves becoming loaded. The different TSs differ for the informative focus they realize.

In this section, we have shown that if TS is not a property of the verb, it is not even a necessary property of an AT. Indeed, verbs that can be equivalently applied to one type may record different alternative structures.

The cognitive representation of an action scene consists of multiple elements (a theme, a recipient, a destination, an instrument), but the linguistic expression (by means of one verb or the other) frequently forces us to focus on some of these elements. The construal of the scene by the linguistic expression can vary in reason of which aspect we want to put in focus.

4. Conclusion

In this paper, we have seen what analyses are enabled by the annotation of Thematic Structure in the IMAGACT ontology. By looking at the TS variation across verbs and action concepts, it has been shown that TS is not a property of the verb, but neither a property of the action concept. It is a lexical property of the verb with reference to its action concept.

Moreover, it has been highlighted how in some cases the same TS can mirror cognitive similarities among concepts and, on the other side, how different TSs referring to the same concept can vary for the informative focus they realize.

5. Bibliographical References

Boas, H. C. (2002). Bilingual framenet dictionaries for machine translation. In *Proceedings of LREC*.

Brown, S. W., Gagliardi, G., and Moneglia, M. (2014). Imagact4all. mapping spanish varieties onto a corpus-based ontology of action. *CHIMERA: Journal of Romance Corpora and Linguistic Studies*, (1):91–135.

Dowty, D. (1979). *Word Meaning and Montague Grammar.* Reidel Publishing Co, Dordrecht.

Fillmore, C. J., Ruppenhofer, J., and Baker, C. F. (2004). Framenet and representing the link between semantic and syntactic relations. *Frontiers in linguistics*, 1:19–59.

Frontini, F., De Felice, I., Khan, F., Russo, I., Monachini, M., Gagliardi, G., and Panunzi, A. (2012). Verb interpretation for basic action types: annotation, ontology induction and creation of prototypical scenes. In *Proceedings of the 3rd Workshop on Cognitive Aspects of the Lexicon*, pages 69–80.

Gagliardi, G. (2013). *Validazione dell'ontologia dell'azione IMAGACT per lo studio e la diagnosi del mild cognitive impairment (MCI).* Ph.D. thesis, University of Florence.

Gagliardi, G. (2014). Rappresentazione dei concetti azionali attraverso prototipi e accordo nella categorizzazione dei verbi generali: una validazione statistica. *Proceedings of the First Italian Conference on Computational Linguistics CLiC-it 2014 and the Fourth International Workshop EVALITA 2014*, pages 180–185.

Gildea, D. and Jurafsky, D. (2002). Automatic labeling of semantic roles. *Computational linguistics*, 28(3):245–288.

Kipper-Schuler, K. (2005). *VerbNet: A broad-coverage, comprehensive verb lexicon*. Ph.D. thesis, University of Pennsylvania.

Levin, B. (1993). *English verb classes and alternations: A preliminary investigation*. University of Chicago press.

Melli, G., Wang, Y., Liu, Y., Kashani, M. M., Shi, Z., Gu, B., Sarkar, A., and Popowich, F. (2006). Description of squash, the sfu question answering summary handler for the duc-2005 summarization task. *Proceedings of the HLT/EMNLP Document Understanding Workshop (DUC)*.

Moneglia, M., Gagliardi, G., Panunzi, A., Frontini, F., Russo, I., and Monachini, M. (2012a). Imagact: Deriving an action ontology from spoken corpora. In *Proceedings of the Eight Joint ACL - ISO Workshop on Interoperable Semantic Annotation (ISA-8). Pisa, October 3-5, 2012*, pages 42–47.

Moneglia, M., Monachini, M., Calabrese, O., Panunzi, A., Frontini, F., Gagliardi, G., and Russo, I. (2012b). The imagact cross-linguistic ontology of action. a new infrastructure for natural language disambiguation. In Nicoletta Calzolari, editor, *Proceedings of the Eight International Conference on Language Resources and Evaluation*, pages 948–955. European Language Resources Association (ELRA).

Moneglia, M., Panunzi, A., and Gregori, L. (2018). Taking events in hindi. a case study from the annotation of indian languages in imagact. In *Proceedings of the LREC 2018 Workshop WILDRE4– 4th Workshop on Indian Language Data: Resources and Evaluation*, pages 46–51. LREC.

Palmer, M., Gildea, D., and Kingsbury, P. (2005). The proposition bank: An annotated corpus of semantic roles. *Computational linguistics*, 31(1):71–106.

Pan, Y., Moneglia, M., Panunzi, A., and Gregori, L. (2018).

Imagact4all. una ontologia per immagini dell'azione per l'apprendimento del lessico verbale di base delle lingue seconde. In Anna De Meo et al., editors, *Usare le lingue seconde*, pages 120–150. Officinaventuno.

Panunzi, A., De Felice, I., Gregori, L., Jacoviello, S., Monachini, M., Moneglia, M., and Quochi, V. (2014). Translating action verbs using a dictionary of images: the imagact ontology. In *Proceedings of the XVI EURALEX International Congress: The User in Focus. Bolzano: EURAC research*, pages 1163–1170.

Rappaport Hovav, M. and Levin, B. (2012). Building verb meanings. In Miriam Butt et al., editors, *The projection of arguments: Lexical and compositional factors*, pages 97–134. CSLI Publications, Stanford, CA.

Rosch, E. (1983). Prototype classification and logical classification: The two systems. *New trends in conceptual representation: Challenges to Piaget's theory*, pages 73–86.

Surdeanu, M., Harabagiu, S., Williams, J., and Aarseth, P. (2003). Using predicate-argument structures for information extraction. In *Proceedings of the 41st Annual Meeting of the Association for Computational Linguistics*.

Talmy, L. (2000). *Toward a cognitive semantics*, volume 1-2. MIT press.

Uresova, Z., Fucíková, E., Hajicová, E., and Hajic, J. (2018). Creating a Verb Synonym Lexicon Based on a Parallel Corpus. In *Proceedings of the Eleventh International Conference on Language Resources and Evaluation (LREC 2018)*.