MAPPING OUT
A CONSTRUCTION INVENTORY
WITH (LEXICAL) MAPPING THEORY

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Abstract

In this paper I propose how to model the relation between the meaning and the syntax of lexical items in a way which allows to account for all argument alternations in any language despite the absence of an adequate and complete representation of lexical knowledge for any language. The proposed model assumes an empirical, corpus-based collection of the patterns of participant-to-function mappings for classes of verbs in a given language (such as Levin 1993 and its follow-ups for English) and represents the alternative mappings without committing the grammar writer to represent the speakers' knowledge of the world. The proposed model can be interfaced with a representation of lexical knowledge when one becomes available. In the interim, the present proposal together with some earlier work on the representation of argument structure (in particular, Kibort 2007, 2008, 2013) can, for the first time, be considered a complete stand-alone tool to create an inventory of constructions involving argument alternations in a language. Since the available argument structure operations are represented in the same way across languages regardless of their realisation, the model should be useful for descriptive and typological studies. It may also be a helpful step forward for computational grammars grappling with how to capture the wide range of argument alternations systematically: although it is far from representing full lexical knowledge, it is sufficient to capture the fact that some alternations are determined by semantic factors, and formally to relate the alternating variants to one another.

1. Introduction

'The relation between the meaning and the syntax of lexical items is among the more frustrating issues in linguistics: on the one hand it seems clear that the meaning of a lexical item determines at least to some degree the syntactic behavior of its participant roles; on the other hand, attempts to characterize the relation explicitly tend not to be very successful' (Zaenen 1993: 129). Unfortunately, twenty years on this statement is still true and none of the major syntactic frameworks has made a breakthrough in this area.[1] Furthermore, within LFG, the issue in question has become an obstacle preventing LFG-based computational grammars from adequately representing semantic valency and from capturing the commonalities of valency-altering constructions across languages. The continuing prolific research in lexical semantics appears to suggest that the way to arrive at a satisfactory model of semantic valency is by modelling event structures. However, the disparate approaches demonstrate that there is no agreement as to which model of event structure to use – whether centered around 'location' and 'motion', 'causality', or 'aspectuality' (see Levin and Rappaport Hovav 2005: Ch. 4 for an overview of the major approaches), and no one has yet offered a comprehensive theory of event structure including a full inventory of the building blocks of event

[1] For the most recent overviev of this topic, see the collection edited by Kittilä and Zúñiga (2014a) devoted to the different conceptualisations of semantic roles and their status in theories of grammar. They add one more authoritative voice to the same conclusion, namely that 'semantic roles both vigorously resist being abandoned and persistently defy being defined in such a way that principled theories of linguistic meaning, linguistic form, and linguistic form-function correspondences can employ them without non-trivial provisos and/or significant gaps in the range of phenomena such theories successfully cover' (2014b: 458).

structures that could be used to model all classes of predicates cross-linguistically. The reason may be that this kind of knowledge representation corresponds to the linguistic component of artificial intelligence and it will not be adequate until we are able to create an artifical intelligence which mimicks a human one.

The present proposal does not deny that it would be immensely useful to have such a comprehensive representation of lexical knowledge. But I accept that, at least for now, this goal has turned out too ambitious: it appears that it is impossible to sort out all the event types and the mapping options. Therefore, I have instead focused on the question of how much semantic information the mapping mechanism needs to 'see' in order to manipulate participants and give them different syntactic status. I assume that the mapping mechanism does not need to have access to the full lexical knowledge, and I sketch out a proposal of how to represent the **minimum** of the semantic information required by the mapping mechanism.

In the present model, predicates are considered to be related to each other via simple semantic extensions (e.g. *eat*$_{\text{intr}}$ and *eat*$_{\text{tr}}$), lexical derivations (e.g. *open*$_{\text{tr}}$ and *open*$_{\text{intr}}$), 'voice' alternations (e.g. active and passive), and alternative basic mappings (e.g. *spray paint on the wall* vs *spray the wall with paint*). Argument structure as a level of representation of linguistic knowledge is conceived of as a repository of valency templates[2] which instantiate particular operations (e.g. anticausativisation, passivisation) and capture the alternative mapping options. Particular classes of verbs fit particular templates. The templates, which can be rendered in the 'attribute-value matrix' (AVM) format, provide the output which can – if one wishes to use such a model – be related to f-structure and c-structure via projections, as proposed by Butt, Dalrymple and Frank (1997) (with an important difference that the proposed model of a-structure does not involve atomic semantic roles, as these have long been considered inadequate, see e.g. Levin and Rappaport Hovav 2005).

Some alternations are morphologically marked and others unmarked. Importantly, the proposed model interfaces correctly with different types of morphological realisation as well as with morphological-and-syntactic realisation as found for example in the periphrastic passive. By allowing single- or multi-word realisations of valency templates, I concur with researchers who have argued that LMT is inadequately labelled as 'lexical' since monoclausal syntactic structures can be associated with constructions consisting of more than one potentially nonadjacent word (Butt 1996; Alsina 1996). For this reason, in the title of this paper the 'L' of the name '(L)MT' is shown in brackets, and I suggest it would be better to drop it altogether in favour of the more accurate though less familiar label 'Mapping Theory' (MT).

The present proposal builds on my earlier work on argument structure, and adds the results of new research that complements it. I will demonstrate that together these

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[2] A 'valency template' is understood here as a generalisation over a set of argument structures of particular predicates. A valency template captures a specific way of mapping from semantic participants to syntactic functions which is the same for all predicates in the set. This concept of valency template can be formalised with the use of LFG's 'templates' (Asudeh, Dalrymple and Toivonen 2008) and implemented in XLE, as shown by Findlay (2014) and Asudeh, Giorgolo and Toivonen (2014). However, the novel proposal presented in this paper has not yet had an opportunity to be implemented in this way.

results can, for the first time, be considered a complete stand-alone tool to map out an inventory of constructions involving argument alternations in a language. Due to the lack of space, I give only an abbreviated example of a morphosyntactic alternation (for more of these see the previous publications), and I demonstrate a simple application of the proposed concept to a couple of common morphosemantic alternations. The fact that the model enables a straightforward creation of a construction inventory for a language, with the available a-structure operations being represented in the same way across languages regardless of their realisation, is very satisfying from the point of view of language description. Additionally, the model may constitute a helpful step forward for computational grammars grappling with how to capture the wide range of argument alternations systematically: although it is far from representing full lexical knowledge, it is sufficient to capture the fact that some alternations are determined by semantic factors, and to relate the alternating variants to one another.

2. Argument structure in the present proposal

In the literature on valency and valency alternations one may find reference to any of the following types of information:

referents	<ref$_1$	ref$_2$	ref$_3$>	
instantiated roles	*<giver*	*given*	*givee>*	SEMANTIC/THEMATIC
generic roles	*<ag*	*pat/th*	*goal/rec>*	STRUCTURE
	|	|	|	
dependents of the predicate	**<arg$_1$**	**arg$_2$**	**arg$_3$>**	LEXICAL VALENCY
	|	|	|	
grammatical relations	[SUBJ	OBJ	IOBJ]	SYNTACTIC/FUNCTIONAL
syntactic categories	[NP	NP	NP]	SUBCATEGORISATION

Fig. 1. Semantic and syntactic valency

The problem outlined in the introduction concerns the representation of the semantic information in the two lines in Fig. 1 which are rendered in italics. I argue that semantic roles such as those exemplified by the 'generic roles' in Fig. 1 are not adequate units of analysis at this level of representation, despite the fact that they do capture some descriptive generalisations and are useful for human as opposed to machine readability of argument structure examples. Before discussing this in more detail in section 2.3, I will summarise the component parts of the Mapping Theory (MT) which are assumed here, based in particular on Kibort (2007, 2008 and 2013).

2.1. The core: subcategorisation frame and partial descriptions of grammatical functions

The core of argument structure is a universally available subcategorisation frame which represents the relative syntactic prominence of the arguments of the predicate. This valency template is fixed and the argument positions are characterised by intrinsic

features:

(1) < arg_1 arg_2 arg_3 ... arg_4 ... arg_n>
[–o/–r] [–r] [+o] [–o] [–o]

Basic argument functions are not atomic but decomposable into features (Bresnan and Kanerva 1989; Bresnan and Zaenen 1990; see also Bresnan 2001: 308):[3]

(2)

	[– r]	[+ r]
[– o]	SUBJ	OBL_θ
[+ o]	OBJ	OBJ_θ

The diagram in (2) can be read as a **markedness hierarchy** of syntactic functions and has also been referred to as a partial ordering of basic argument functions (though see (5) below for a relational hierarchy of syntactic functions):

(3) [–o]/[–r] **SUBJ** > [–r]/[+o] **OBJ ,** [–o]/[+r] **OBL_θ** > [+o]/[+r] **OBJ_θ**

The original LFG interpretation of the features is: [+/–r] thematically (i.e. semantically) restricted; [+/–o] (non)objective. However, I have argued that the following re-interpretation of the features derives from a long tradition of linguistic description and correctly preserves a syntactic characterisation of grammatical functions (Kibort 2013):

(4) [+o] complements ('internal arguments' of the predicate)
[–o] non-complements (the 'external' argument and oblique arguments)
[–r] core arguments (subject and object only)
[+r] non-core arguments (all arguments except subject and object)

Note that at least two other linguists have proposed MT feature sets without referring to the semantic/thematic restriction: Alsina (1996), and Hemmings (2012).

The ordering of arguments in (1) corresponds to LFG's **relational hierarchy** of syntactic functions, with adjunct being a non-argument function (Bresnan 2001:96):

(5) SUBJ > OBJ > OBJ_θ > OBL_θ > COMPL[4] > ADJUNCT

The relational hierarchy is proposed after Keenan and Comrie's (1977) Noun Phrase Accessibility Hierachy, presumed to be universal (at least in nominative-accusative systems):

(6) SUBJ > OBJ > OBJ_θ > OBL > possessor NP > object of comparison

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[3] Many accounts, and computational implementations of LFG grammars, additionally use COMP and XCOMP for clausal arguments, though other linguists analyse them as specialised types of the basic grammatical functions (e.g. Zaenen and Engdahl 1994; Alsina, Mohanan and Mohanan 1996; Alsina, Mohanan and Mohanan 2005).

[4] Here, the label COMPL stands for the whole class of various predicate complements (Bresnan 2001: 96).

Thus, the ordering of argument positions in (1) also parallels Keenan and Comrie's accessibility hierarchy, however, while LFG's relational hierarchy in (5) is based on final grammatical functions, the ordering in (1) is based on MT's atomic values [+/–r/o].

In the realisation of a particular predicate, the angled brackets contain all and only the selected valency slots for the arguments associated with that predicate, both core and non-core. In other words: predicates do not have to select a contiguous series of arguments. (This can be understood in the sense of the 'derived arguments' of Needham and Toivonen 2011, and is a useful generalisation bearing in mind that the distinction between arguments and adjuncts is notoriously difficult to justify, see e.g. Przepiórkowski 1999: Ch. 6-10). For example, in *Both parents cooked supper for the children*, the lexical and syntactic valency of the predicate can be illustrated as follows:[5]

(7) *cook* < arg_1 arg_2 arg_4 >
[–o] [–r] [–o]

2.2. Argument-to-function mapping

The default mapping of arguments to grammatical functions follows the Mapping Principle in (8):

(8) MAPPING PRINCIPLE
The ordered arguments are mapped onto the highest (i.e. *least* marked) compatible function on the markedness hierarchy.

Morphosyntactic operations interfere with the 'default' argument-to-function mapping, but do not affect the lexical or semantic tiers of representation of the predicate – that is, they are meaning-preserving (see e.g. Sadler and Spencer 1998). Such results are achieved by the mechanism of increasing markedness which preserves monotonicity (Kibort 2007): a morphosyntactic operation can only restrict an argument by adding a 'marked' specification [+r] or [+o] to its syntactic pre-specification. Hence, the available morphosyntactic (i.e. restricting) operations are:

(9) a. adding the [+r] specification to a [–o] argument;
b. adding the [+o] specification to a [–r] argument; and
c. adding the [+r] specification to a [+o] argument.

Each of these operations does not only change the mapping of the grammatical function onto the affected argument, but may also have a knock-on effect on the mapping of grammatical function(s) onto other argument(s).

For example, passivisation is a morphosyntactic operation which restricts the first, unergative, argument pre-specified as [–o] by adding to it the [+r] specification (Kibort 2001: 170). As a result, the argument in the second position (arg_2), if there is one, may

[5] There is no scope here to discuss the argument/adjunct distinction, but in all examples that follow it is assumed that a non-core semantic participant such as a recipient, instrument, or location, is an argument if it can alternate between an oblique and a core grammatical function.

become a subject as in (10). In the absence of an argument in the second position (arg_2), the passive predicate is subjectless, as in (11):[6]

(10) $\text{PREDICATE}_{\text{passive}}$ ⟨ arg_1 arg_2 ⟩

[–o]	[–r]
[+r]	
OBL_θ	SUBJ

(11) $\text{PREDICATE}_{\text{passive}}$ ⟨ arg_1 ⟩

[–o]
[+r]
OBL_θ

Sentences (12a-b) illstrate a personal and an impersonal (subjectless) passive, respectively, in Polish.

(12) a. *Firma codziennie sprzątała w pokojach.*
company(F).NOM every-day tidied.3SG.F in rooms
'The (professional) company did the cleaning in the rooms every day.'

b. *W pokojach było codziennie sprzątane (przez firmę).*
in rooms was.3SG.N every-day tidy.PART.SG.N (by company)
'[It] was cleaned every day in the rooms (by the company). /
There was cleaning in the rooms every day (by the company).'

2.3. Participant-to-argument mapping

2.3.1. The state of the field

LFG researchers agree that argument structure contains some amount of semantic information, but no agreement has yet been reached as to how much. Dalrymple (2001: Ch. 8) summarises both the development of the representation of argument structure itself within LFG, and the different proposals concerning the amount and type of semantic information argument structure contains. Looking at all LFG output until now, it appears that all proposals so far, including the most recent ones (such as Asudeh, Dalrymple and Toivonen 2008, Asudeh and Giorgolo 2012, and Asudeh, Giorgolo and Toivonen 2014), have chosen to represent the semantic component of argument structure via the concept of semantic roles, although the definitions and the content of the roles have varied between the proposals.

Levin and Rappaport Hovav (2005) give an overview of the approaches to semantic roles as used across major syntactic frameworks. The most basic approach uses atomic/unanalyzable semantic roles, usually arranged in hierarchies. Even though it is easy to demonstrate – as has been done by Levin and Rappaport Hovav and others – that this approach is highly unsatisfactory, it remains the textbook LFG approach and is used by LFG linguists who need an 'off the shelf' version of LMT to illustrate an example of argument structure. In mainstream LFG, there are two variants of a fixed hierarchy of thematic (θ) roles which determines the ordering of argument positions:

(13) agent > beneficiary > experiencer/goal > instrument > patient/theme > location
(Bresnan 2001: 307)

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[6] For LFG approaches to the pseudopassive, see e.g. Lødrup (1991), Alsina (2009), and Findlay (2013).

(14) agent > patient/beneficiary > instrument > theme > path/location/reference object
(Falk 2001: 104)

In addition to the approaches developed in theoretical frameworks, there have also been several significant engineering attempts to come up with an inventory of semantic roles for English, each with its own set of problems: PropBank[7] (a small inventory of roles not conveying a clear semantics), VerbNet[8] and Sowa's Knowledge Representation[9] (medium size inventories which pose problems for assignment and mapping), and FrameNet[10] (an enormous inventory with hundreds of specific roles which are very difficult to assign). VerbNet is probably the largest online verb lexicon currently available for English which has been widely used in a multitude of NLP tasks; what is noteworthy from the theoretical point of view discussed here is that semantic role names in VerbNet may not carry the same content in their uses across different predicates.

The theoretical approaches which reject atomic roles fall into one of the following categories:

(15) a. semantic roles are decomposed into features (e.g. Reinhart 2000, 2002);

b. a single argument can be assigned more than one role, or arguments are assigned different roles at different tiers (e.g. 'thematic tier' and 'action tier'; Jackendoff 1983, 1990);

c. roles are generalized into proto-roles (Dowty 1991) or macro-roles (Role and Reference Grammar, e.g. Van Valin 1990, 1993; Van Valin and LaPolla 1997);

d. no traditional roles are proposed, but predicates are decomposed into more primitive predicates; event structures are modelled according to 'location' and 'motion', 'causality', or 'aspectuality' (CAUSE, BE, STAY, CHANGE, etc.; see Levin and Rappaport Hovav 2005: Ch. 4 for references); participants in these events fulfil the roles of arguments of the predicates.

The best known LFG models of argument structure have all used either one, or a combination of the above approaches, often with some modifications or additions. Alsina (1993, 1996) identifies the arguments via their proto-role status and orders them according to the thematic hierarchy. Similarly, Ackerman (1990, 1992), Ackerman and Moore (1999, 2001, 2013), Joshi (1993), and Markantonatou (1995) use Dowty's proto-role classification. By contrast, Butt (1996, 1998), Broadwell (1998), and others have adapted Jackendoff's (1990) two-tiered Lexical Conceptual Structures to represent argument structure.

Butt, Dalrymple and Frank (1997) revert to using atomic roles; they are also the first ones to demonstrate explicitly how argument structure is related to functional structure and constituent structure within LFG's projection architecture. Asudeh, Dalrymple and Toivonen (2008) and Asudeh and Giorgolo (2012) propose that semantic

[7] http://verbs.colorado.edu/~mpalmer/projects/ace.html
[8] http://verbs.colorado.edu/~mpalmer/projects/verbnet.html
[9] http://www.jfsowa.com/ontology/thematic.htm
[10] https://framenet.icsi.berkeley.edu/

valency is composed flexibly in Glue Semantics, and the latter further propose to do away with argument structure as a separate level of representation by incorporating it into a 'connected' semantic structure; finally, in very recent work Findlay (2014) shows that the theory of argument-to-function mappings as captured in the MT model offered here is compatible with Asudeh and Giorgolo's (2012) proposal. This development means that LFG appears finally to have arrived at an adequate model of argument-to-function mappings backed up by proper formal semantics.

Nevertheless, the challenge of accounting for participant-to-argument mappings still remains: following Butt, Dalrymple and Frank (1997), Asudeh et al.'s lexical entries and templates still contain atomic semantic roles representing semantic participants, while my own model of MT, developed in successive papers since (2001), has so far focused on argument-to-function mappings. Despite flagging atomic roles as inadequate, distinguishing between morphosyntactic and morphosemantic operations on argument structure, and restoring the level of representation of lexical valency as distinct from semantic valency, I have so far assumed that the semantic makeup of the participants in the event could be captured with some semantic concepts akin to Dowty's proto-roles or, alternatively, via semantic features of the type proposed by Reinhart. However, I know now that proto-roles and feature decomposition are not adequate an approach to the semantic representation of arguments. The present proposal is my first attempt to tackle the challenge of accounting for participant-to-argument mappings in a different way.

2.3.2. The essence of the problem

In the absence of a universal thematic hierarchy governing participant-to-argument mapping, the following may represent the most general mapping principles which capture instead the relations the participants of the predication bear to one another and to the predication (Kibort 2013):

(16) RULES FOR MAPPING PARTICIPANTS TO THE ARGUMENT POSITIONS (general, informal)

a. The first argument position (arg_1) is associated with the participant of whom the event or state is predicated.
b. If the predicator has any other dependents, the most prominent of the remaining semantic dependents of the predicator maps on the second argument position (arg_2).
c. This rule is applicable only to languages with structural datives (as some languages may not use this argument position): if the predicator has another semantic dependent, it maps on the third argument position (arg_3).
d. If the predicator has further semantic dependents which it selects, they map onto further argument positions ($arg_{4, \ldots,} arg_n$).

Even the most general way of referring to the participants by their meaning, independently of the relation they bear to one another or to the predication, would need to take account of the following observations and be made specific for particular languages:

(17) a. Many languages restrict the semantics of the participant which is allowed to map onto (arg_1), the default argument position of the subject – this restriction would have to be specified, but it has been proven very difficult to capture (see e.g. Alexiadou and Schäfer 2006, Bruening 2010).

b. For most languages, rule (16b) regarding (arg_2) would probably remain as it is, stating no restrictions whatsoever, since objects are known to be the least semantically restricted (see e.g. Börjars and Vincent 2008).

c. For all nominative-accusative languages with canonical datives, rule (16c) would need to specify that the participant that maps onto (arg_3) has to be a beneficiary/recipient; with this specification, we achieve correct mappings for monotransitive verbs which subcategorise only for a dative (e.g. 'help', 'serve', etc.). However, languages with dative shift or applied arguments may allow a much wider range of semantic participants to map onto this position.[11]

d. Rule (16d) is for all other arguments contributing to the specification of the predication, i.e. arguments fulfilling various oblique roles selected by the predicate. However, the large number of alternations involving arguments within the verb phrase (such as those examined for English by Levin 1993: Ch. 2) demonstrates that semantic restrictions here are again too difficult to specify.

The more semantics we try to identify, the more inadequate the rules become. The reason for this is that any such rules are systematically disrupted by the fact that the same semantic participants of the event may map onto the argument positions in more than one way – e.g. in the locative alternation, swarm alternation, instrument-causer alternation, etc. When the same semantic participants have more than one option of mapping onto the argument positions, the alternative mappings are associated with (more, or less) different interpretations of the event and the roles of its participants.[12] For this reason, this type of alternation is correctly referred to as morphosemantic, or meaning-altering (e.g. Sadler and Spencer 1998). Therefore, attempts to find a consistent line-up of participant meanings and argument positions, where a particular participant meaning would always map on a particular argument position, cannot be successful.

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[11] For example, in (some varieties of) English the argument position of the non-passivisable secondary object (arg_3) can be filled by either a theme (*Give him that book*) or a beneficiary (*Give it him*); in Kichaga, a so-called 'alternating' language with a morphological applicative, the arg_3 position can be filled by any of the applied participants, i.e. a theme, beneficiary, instrument, or locative. See Kibort (2008) for a detailed account.

[12] This is a principled reason why it is impossible to annotate the predicates in any one language for traditionally assumed semantic roles with consistency. It is not surprising that this problem does not disappear when we compare predicates cross-linguistically. Bickel et al. (2014) apply fuzzy cluster and NeighborNet algorithms to a sample of 141 languages with predicates annotated for cross-linguistically recurrent semantic roles such as 'the one who feels cold', 'the one who eats something', 'the thing that is being eaten', to determine whether and to what extent these roles are treated alike across languages. Non-default case assignment and alternations with a non-default case marker reveal evidence for role clusters around experiencers, undergoers of body processes, and cognizers/perceivers in one- and two-place predicates; and around sources and transmitted speech in three-place predicates. But no support is found for any other role clusters that are traditionally assumed.

If the participant-to-argument mapping rules are made inadequate when they are invested with semantic concepts, how else can they be formulated?

2.3.3. Insights from Zaenen (1993)

Among the earlier LFG models of argument structure, Zaenen's (1993) proposal, though also using Dowty's proto-properties – stands out for two reasons. First, Zaenen does not believe that lexical meanings of verbs should be characterised in terms of entailments, understood as in: 'an agent has the property of being volitional if the meaning of the verb entails that the activity of the agent was volitional'. Instead: '[t]he fact that the combination of a verb with an adverb expressing volition is felicitous shows that the activity is such that it makes sense to talk about it in terms of volition but not that it is in each particular instance volitional' (1993: 147). She suggests that semantically definable characteristics such as volition (or, 'controllability' in Zaenen's terms) are lexically specified semantic *dimensions* of verbs. 'The existence of a volitional dimension in the argument structure of a verb does not entail that every use of the verb denotes a volitional act; rather, the verb denotes an act that *can* be volitional' (this phrasing has been taken from Dalrymple's 2001: 199 summary of Zaenen's proposal). Furthermore, Zaenen emphasises that 'whether an activity described by a particular verb has a volitional dimension or not is not a fact about the outside world as such but is linked to conventionalized meanings of words' (1993: 147).

This part of Zaenen's approach already yields two important insights that I adopt in the present proposal: [1] lexical meanings of verbs do not model our knowledge of the world, but represent conventionalised meanings of words; [2] the lexical meaning of a verb encodes the availability of the verb to be interpreted in a certain range of ways, according to some semantically definable characteristics (which Zaenen terms *dimensions* and the present proposal terms *semantic markers*, but which are not equivalent to semantic roles).

The second reason Zaenen's proposal stands out is her explicit rejection of a fixed hierarchy of thematic roles. She argues that 'the influence of thematic roles is calculated in from the beginning in the partial assignment of intrinsic classifications' (1993: 151). Although she distinguishes between classes of Dutch verbs on the basis of semantic characteristics which she terms controllability and telicity (boundedness), and despite the fact that 'among the stative verbs there are more semantic distinctions to be made than Dowty's list of properties allows for' (1993: 150), she chooses to exemplify her mapping proposal using semantic characteristics derived from Dowty's proto-agent and proto-patient roles, as they are close enough to the semantic properties which she had identified (1993: 148). The following steps illustrate the method used by Zaenen to deduce the mapping of arguments from semantic characteristics to syntactic functions for a small set of Dutch verbs (1993: 149-151):

(18) a. identify the verb's **syntactic valency** e.g.:

- *irriteren* 'irritate' <SUBJ OBJ>
- *vrezen* 'fear' <SUBJ OBJ>
- *telefoneren* 'phone' <SUBJ>
- *aankomen* 'arrive' <SUBJ>

b. identify the semantic characteristics of the participants of the verb:

- in *irriteren* 'irritate' the SUBJ participant has 2 agentive properties and 0 patientive properties, while the OBJ participant has 1 agentive property and 2 patientive properties
- in *vrezen* 'fear' the SUBJ participant has 1 agentive property and 0 patientive properties, while the OBJ participant has 0 agentive properties and 0 patientive properties
- in *telefoneren* 'phone' the SUBJ participant has 2 agentive properties and 0 patientive properties
- in *aankomen* 'arrive' the SUBJ participant has 1 agentive property and 1 patientive property

c. on the basis of the semantic characteristics, identify the intrinsic classification of the participants of the verb (according to the features assumed in LMT), i.e. the verb's **semantic valency**; no need to assume any particular ordering of the participants:

- *irriteren* 'irritate' < -o -r >
- *vrezen* 'fear' < -o -r >
- *telefoneren* 'phone' < -o >
- *aankomen* 'arrive' < -r >

Note that we know that the verbs *telefoneren* 'phone' and *aankomen* 'arrive' differ in their syntactic behaviour (auxiliary selection). We assume that this is due to a semantic difference, and therefore need to say that the two verbs differ in some semantic characteristic. According to Dowty's list, *aankomen* 'arrive' has 1 agentive property and 1 patientive property – this combination of characteristics does not unequivocally point to its participant being a 'patient', but is sufficient for us to claim that there is a semantic difference between the verbs, regardless of how exactly it is labelled.

d. the mapping from participants to functions is assumed to involve the following default (1993: ex. 86), which gives us the correct mapping from the semantic characteristics to syntactic functions:

(i) order the participants according to their intrinsic markings:
-o < -r < + o < +r

(ii) order the grammatical functions as follows:
SUBJ < OBJ < OBJ_θ (< OBL)

(iii) starting from the left, associate the leftmost participant with the left-most grammatical function it is compatible with

Although we now know that the version of the mapping scheme proposed by Zaenen is not sufficient to model a wider range of morphosyntactic and morphosemantic argument-changing operations in a language, this part of Zaenen's proposal yields two more crucial insights: [3] the only type of information that is relevant to the system of rules which maps semantic participants to functions is the participant's ability to map onto particular syntactic functions (this ability is captured here via LMT's intrinsic features, and in Zaenen's model it is these features that actually represent the verb's semantic valency); [4] since we are not modelling our knowledge of the world, but

instead modelling the observed patterns of participant-to-function mappings for classes of verbs, the method used by Zaenen to identify the syntactically relevant semantic characteristics seems appropriate and sufficient: we need to identify classes of verbs that differ in their mapping patterns and attribute the distinctions to some semantic characteristics, but it is not necessary for the mapping theory to 'understand' the semantics in order to achieve correct mappings; the mapping system needs to 'see' only the appropriate labels in the lexical entries of verbs in order to allow the verb to appear with a particular syntactic configuration of its participants.[13]

2.3.4. The present proposal

How do we find the semantic factors which determine what mapping options are available for the participants of a particular predicate?

- Look at a particular alternation, find verbs which participate in it (as in Levin 1993, complemented by Korhonen and Briscoe 2004, for English; Hajnicz 2011, Przepiórkowski et al. 2014, for Polish; etc.).
- The semantic factors that allow the verb to map its arguments in two different ways are often hard to identify.
- The solution proposed here is that we do not need to try to name the semantic factors. We just need to identify the pattern and the verbs that participate in it.
- We should expect some uncertainty about our classification – after all, it is semantics, so boundaries will not be as clear cut as with some syntactic phenomena (**They walks* but ?*A song sings*; however: *If you can fit it in a song, it sings well; It is as good as it is, and it sings well with the melody, but this version is too detached;* etc.). There may be uncertainty whether a particular variant is felicitous; or different speakers may allow different verbs to alternate or not; and – last but not least – we should expect the most extraordinary creative uses of alternations.
- For these reasons, our grammar should allow a wide range of options. In a computational application the options could be appropriately weighted as more or less likely and therefore more or less preferred for parsing (and generation).
- For our grammar, we need only as many semantic distinctions as are necessary to capture the alternative mappings, even though the verb meanings might be further subdivided into smaller classes.

The proposed MT model distinguishes the level of semantic participants from the level of argument positions and therefore in principle allows alternative participant-to-argument mappings: in morphosemantic (meaning-altering) alternations the same semantic participants may align with the available argument positions in two (or more) different ways, or the semantic participants may 'change order' and re-associate with different argument positions for derived (morphosemantically altered) predicates.

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[13] A very similar argument to the one made here in [4] was made by van Hout (1998), even though the mapping system proposed by her had different components (in order to be compatible with a transformational syntactic framework) and was not fully comprehensive. However, she additionally undertook a study of first language acquisition of verbs and their syntactic and semantic valency frames to test and prove her hypothesis.

Any operations on argument structure that alter the meaning of the predicate – and thereby change the predicate's entailments and the interpretation of the roles of its participants – occur in the lexical semantics (Ackerman and Moore 2013: 10ff). In this way, the (L)MT algorithm that determines grammatical functions can remain monotonic and be entirely dependent on the classificatory features (Ackerman and Moore 2013: 18).

A simple implementation of the present proposal would be to identify the semantic participants of the event by their **semantic markers** instead of thematic role labels. For the purpose of this presentation, I have chosen numerals as easy labels for the semantic markers. In reading the following examples it is important to bear in mind that the proposed semantic markers do not correspond to thematic roles; there is no individual marker that corresponds to any traditionally assumed thematic role uniquely; a particular traditionally assumed thematic role is usually identified with more than one semantic marker (reflecting the ability of the different participants bearing these markers to map to the same argument position):

(19) **1** a semantic participant which can map on the (arg_1) position

2 a semantic participant which can map on the (arg_2) position

3 a semantic participant which can map on the (arg_3) position

4 a semantic participant which can map on the (arg_4-arg_n) position

41 a semantic participant which can map either on the (arg_4-arg_n) or the (arg_1) position

42 a semantic participant which can map either on the (arg_4-arg_n) or the (arg_2) position

23 a semantic participant which can map either on the (arg_2) or the (arg_3) position

and so on.[14]

The semantic participants which map on the oblique argument positions (arg_4-arg_n) can be distinguished by their indices, e.g. 4_{INST}, 41_{INST}, 4_{LOC}, 41_{LOC}, etc.

The mapping of semantic participants on the argument positions results from the following algorithm:

(20) RULES FOR MAPPING PARTICIPANTS TO THE ARGUMENT POSITIONS (general, formal)

a. The first argument position (arg_1) is associated with the participant of whom the event or state is predicated.
b. If the predicator has any dependents, the most prominent semantic complement of the predicator maps on the second argument position (arg_2).
c. This rule is applicable only to languages with structural datives (as

[14] This proposal bears some similarity to Pāṇini's account of the one-to-many correspondences between semantic roles and case marking in his grammar of Sanskrit, discussed by Butt (2006: 15-18).

some languages may not use this argument position): if the predicator has another semantic complement, it maps on the third argument position (arg_3).

d. If the predicator has further semantic dependents which it selects, they map onto further argument positions ($arg_{4, ..., } arg_n$).

In the next two sections I illustrate an application of this concept to a couple of common morphosemantic alternations in Polish.[15]

3. Example 1: The instrument-causer alternation in Polish

The verb *jeść* 'eat' (causative; the anticausative is marked morphologically in Polish and would be listed as a separate lexical item) is found with the following syntactic arguments:[16]

(21) syntactic valency frames for *jeść* 'eat':

<SUBJ>	*Piotr jadł.*	'Peter ate.'
<SUBJ OBJ>	*Piotr jadł ciastko.*	'Peter ate a cake.'
<SUBJ OBJ OBL-INST>	*Piotr jadł ciastko łyżką.*	'Peter ate a cake with a spoon.'
<SUBJ OBL-INST>	*Piotr jadł łyżką.*	'Peter ate with a spoon.'

The verb *otworzyć* 'open' (again, the basic causative) is found with the following syntactic arguments:

(22) syntactic valency frames for *otworzyć* 'open':

<SUBJ>		*Piotr otworzył.*	'Peter opened.'
	or:	*Klucz otworzył.*	'Key opened.'
<SUBJ OBJ>		*Piotr otworzył bramę.*	'Peter opened the gate.'
	or:	*Klucz otworzył bramę.*	'Key opened the gate.'
<SUBJ OBJ OBL-INST>		*Piotr otworzył bramę kluczem.*	'Peter opened the gate with a key.'
<SUBJ OBL-INST>		*Piotr otworzył kluczem.*	'Peter opened with a key.'

[15] The following two examples illustrate alternations which are not marked morphologically. With morphologically marked operations on argument structure, the morphologically marked predicate is associated with its own set of valency frames. However, as it is still a form of the base verb, the interpretation of the roles of the arguments which may appear in its syntactic valency frames is achieved via the relevant valency template which captures the argument structure operation which has applied. There is no scope to discuss this further here, but see Spencer (2013) for an overview of lexical relatedness.

[16] Other arguments that could be found with this verb are spatial oblique arguments (source, path, goal) and the beneficiary. I have omitted these from this presentation for the sake of greater clarity.

It has been observed that facilitating instruments cannot be subjects, while intermediary instruments can (Levin 1993: 80 and references therein). Verbs which take one or the other instrument fall into two classes.

It is possible to investigate further the semantics of the events denoted by the verbs in these two classes and their arguments, and try to find out what kind of involvement in the event the instrument needs to have in order to qualify for an 'intermediary' one. The intermediary instruments include: tools, means, locatum/contents, and even form. Note, however, that pinning down this semantic distinction has not yet been successful (see e.g. Alexiadou and Schäfer 2006, and Bruening 2010).

However, for the purpose of constructing a successful mapping rule, it is sufficient to code the fact that the instruments with the two verbs are different. The coding does not have to be understood as a semantic role, it is sufficient that it is interpreted by the grammar as a **semantic marker**.

Recall that I have chosen numerals as labels for the semantic markers:

(23) semantic valency frame for JEŚĆ 'eat': < 1 2 3 4_{INST} >

(24) semantic valency frame for OTWORZYĆ 'open': < 1 2 3 41_{INST} >

Note that participant 4 has an index INST (instrument) because there may be more oblique participants which are not instruments that can map on the oblique argument positions arg_4 - arg_n.

(25) RULES FOR MAPPING PARTICIPANTS TO THE ARGUMENT POSITIONS (specific, formal):

a. Arg_1 position is associated with the participant bearing the semantic marker **1**. [If participant **1** is not expressed, participant **41** maps on the first argument position.[17]]

b. Arg_2 position is associated with the participant bearing the semantic marker **2**.

c. Arg_3 position is associated with the participant bearing the semantic marker **3**.[18]

d. Arg_4 position is associated with the participant bearing the semantic marker **4**. [This means either **4** or **41**.]

4. Example 2: The 'swarm' alternation in Polish

The verb classes involved in this alternation include verbs of emission of smell, sound,

[17] This entails that for unergative predicates participant 41, the so-called intermediary instrument, may also be capable of being expressed in the passive as an oblique in a way analogous to an oblique agent.

[18] Note that participant 3, the beneficiary/dative, was not illustrated in the sentences above.

or light, verbs expressing expansion of an aggregate or a mass/abstract entity (corresponding roughly to the English SWARM verbs), and verbs expressing physical or psychological states due to a stimulus which can be interpreted as an intermediary agent. Examples include: *pachnieć* 'emit fragrance', and *roić się* 'swarm, teem' (an inherently reflexive verb).

(26) syntactic valency frames for *pachnieć* 'emit fragrance':

<SUBJ>		*Kawa pachnie.*	'The coffee emits fragrance.'
	or:	*Dom pachnie.*	'The house emits fragrance.'
<SUBJ OBL-LOC>		*Kawa pachnie w domu.*	'The coffee smells in the house.'
<SUBJ OBL-INST>		*Dom pachnie kawą.*	'The house smells of coffee.'
<SUBJ OBL-INST OBL-LOC >		*Pachnie kawą w domu.*	'[pro_{INDEF}] smells of coffee in the house.'

In other words, there are three possibilities for the mapping of the emitter and the location:

(27) a. $SUBJ_{location}$ $OBL_{emitter}$

b. $SUBJ_{emitter}$ $OBL_{location}$

c. $OBL_{emitter}$ $OBL_{location}$

The participants seem to 'swap' functions and, like in the locative alternation, it is difficult to say whether any of these variants is more basic than others. The two participants can map in two different ways (becoming a SUBJ or an OBL) because they can each fulfil two different semantic roles entailed by the predicate. Therefore, I assign to them the following semantic markers:

(28) semantic valency frame for PACHNIEĆ 'emit fragrance' and ROIĆ SIĘ 'swarm':

< 1 3 41_{INST} 41_{LOC} >

Note that here the instrument is more specifically a means/aggregate.

(29) RULES FOR MAPPING PARTICIPANTS TO THE ARGUMENT POSITIONS (specific, formal):

a. Arg_1 position is associated with the participant bearing the semantic marker **1**. [If participant **1** is not expressed, either participant **41** maps on the first argument position.]

b. Arg_3 position is associated with the participant bearing the semantic marker **3**.[19]

[19] Note that participant 3, the beneficiary/dative, was not illustrated in the sentences above.

c. Arg_4 position is associated with the participant bearing the semantic marker **4**. [This means either of the **41** participants.]

d. If there is a remaining **41** participant, it maps on position arg_5.

If both the emitter and the location map onto oblique arguments, the causer participant which maps on the first argument position is filled with a 'dummy' subject, the indefinite pronoun *pro*$_{\text{INDEF}}$ (usually not expressed overtly; see Kibort 2009).

The *pro*$_{\text{INDEF}}$ is an independent participant, but not an independent referent, therefore it may co-refer with either of the remaining participants. At the level of referents (see Fig. 1 above), it is represented as coindexed with another participant.

Since with many predicates, such as the ones exemplified here, OBL arguments are optional, the single-argument frame can also have the following realisation:

(30) <SUBJ> *Pachnie.* "[*pro*$_{\text{INDEF}}$] emits fragrance."

5. Conclusions

The model presented here builds on my earlier work in which I tackled various aspects of the representation of argument structure (e.g. Kibort 2001, 2004, 2007, 2009, 2013) and adds the results of new research that complements it.

In this paper I have argued for and demonstrated a new way of modelling argument structure alternations which has two important features. First, it offers a stable and interpretation-independent handle on (the minimum of) the semantic information required by a mapping mechanism, and therefore all its building blocks and algorithms are trivially implementable in a formal grammar which can provide a basis for a computational application. And second, since the model has a comprehensive coverage of argument alternations, distinguishes between different types of alternations, and can be visualised with easy-to-read templates, it can be considered a complete stand-alone tool to map out an inventory of constructions involving argument alternations in any language. The available argument structure operations are represented in the same way across languages regardless of their realisation, and therefore provide a sound basis for typological comparisons. Although the proposed solution of handling the semantic component of argument structure is far from representing full lexical knowledge, it is sufficient to capture the fact that some alternations are determined by semantic factors, and to relate the alternating variants to one another.

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