3.1 About Project A02

3.1.1 Title: Argument linking and extended locality: A frame-based implementation

3.1.2 Research areas:

104-01 Allgemeine und Angewandte Sprachwissenschaften, computational linguistics, syntax-semantics interface

3.1.3 Principal investigator(s)

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Do the above mentioned persons hold fixed-term positions? no

3.1.4 Legal issues

This project includes

1.	research on human subjects or human material.	no
2.	clinical studies	no
3.	experiments involving vertebrates	no
4.	experiments involving recombining DNA	no
5.	research involving human embryonic stem cells.	no
6.	research concerning the Convention on Biological Diversity.	no

3.2 Summary

The project addresses the composition of frames at the sentential level, where syntactic composition is performed by a Lexicalized Tree Adjoining Grammar (LTAG), or, more generally, a grammar formalism that allows for an extended domain of locality (EDL). By EDL we understand the immediate access to arbitrarily distant parts of syntactic structure within one lexical entry or syntactic rule, which considerably facilitates the argument linking in the syntax-semantics interface. We therefore claim that EDL constitutes a crucial ingredient of a syntactic counterpart of a frame-based semantics. Moreover, the project seeks to implement and evaluate the developed analyses by using (and adapting) existing grammar engineering tools: XMG for implementation and TuLiPA for parsing.

During the first funding period, the project mainly concentrated on (i) a detailed decomposition of the meaning of verbal constructions in English into constructional and lexical meaning, and (ii) the morpho-semantic decomposition of the meaning of prefixed verbs in Russian. Furthermore we managed to extend the XMG framework to cope with frame descriptions, and to gain a better understanding of other grammar formalisms that implement an EDL, namely variants of LTAG, Role and Reference Grammar (RRG) and certain flavors of Construction Grammar (CxG).

In the second funding period, we will continue to pursue our methodological approach, but extend it from elementary pairs of syntactic building blocks and corresponding frames to more intricate cases of tree and frame composition. More concretely, we will apply our approach to different empirical domains, namely cross modification, modification of complex predicates, and idiomaticity in multi-word expressions. The reason for choosing these domains is that they provide insights into the locality and accessibility of information within the syntax-semantics interface. Our underlying hypothesis is that the required locality matches the one provided by the combination of EDL and frames. In other words, we assume that the combination of EDL and frames comes with adequate empirical predictions concerning the scope possibilities of modifiers.

Besides these empirical investigations, the project will also focus on issues of complexity and implementation. Here, our assumption is that the extended locality we obtain from our EDL syntax enables us to use

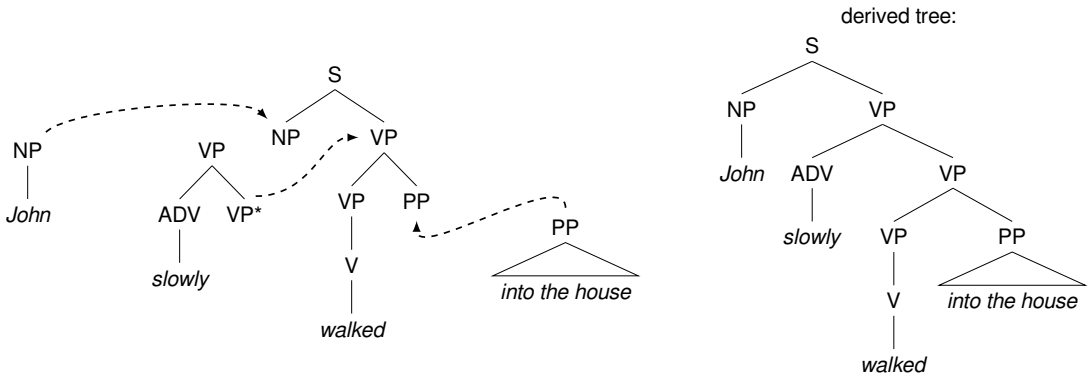

Figure 1: Sample LTAG derivation

a rather simple feature structure unification on frames as a composition operation, which allows for efficient parsing. In the second funding period, we plan to extend the TuLiPA parsing environment to process frames.

3.3 Project Progress to Date

3.3.1 Report and state of understanding

Members of the project in the first funding period were Timm Lichte (postdoc), Yulia Zinova (doctoral student), Alexander Diez (student assistant) and, as core support, Kata Balogh. Furthermore, Pierre Bourreau and Simon Petitjean joined us as long-term visitors with MGK grants, and Sylvain Pogodalla joined us as senior visiting researcher with an INRIA grant.

During the first funding period, we aimed at pairing a *Lexicalized Tree Adjoining Grammar* (LTAG, Joshi & Schabes, 1997; Abeillé & Rambow, 2000) with a frame-based semantics. LTAG is a tree-rewriting formalism where the grammar consists of a finite set of *elementary trees*, each of them having a lexical element. Starting from the elementary trees, larger trees are derived by *substitution* (replacing a leaf with another elementary tree) and *adjunction* (replacing an internal node with another elementary tree). Sample elementary trees and a derivation are shown in Fig. 1. In this derivation, the elementary trees for *John* and *into the house* substitute into the subject slot and the directional object slot of the elementary tree for *walked*, and the modifier tree for *slowly* adjoins to the VP node.

From our analyses of various constructions in English and Russian, certain requirements for the underlying notion of frames emerged. In particular, we a) needed to be able to mark different nodes in a frame as accessible for composition, b) needed a notion of unification that does not require the identification of roots of frames, c) wanted to allow for multi-rooted frames, and d) wanted to allow for relations between nodes that are not necessarily functional. These considerations have led to the formal definition of frames

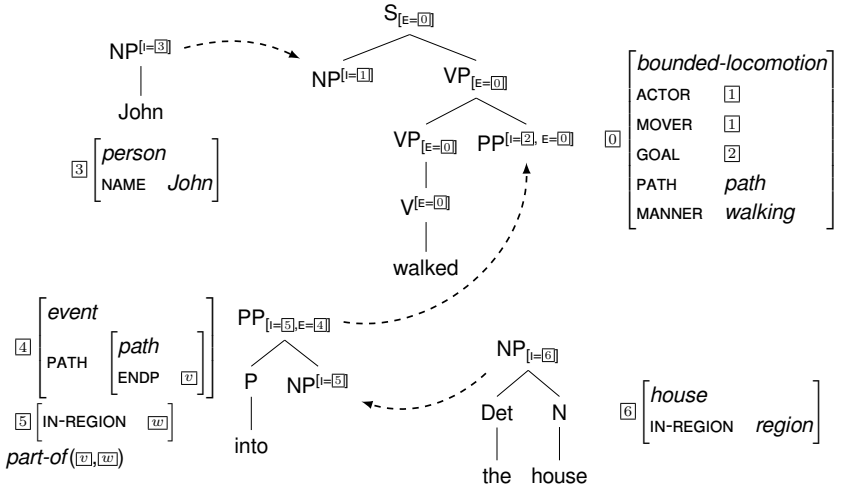

Figure 2: Sample LTAG derivation with semantic frame unification

as base-labeled feature structures (Kallmeyer & Osswald, 2013), a work in collaboration with B01.

Building on this frame formalization, we then developed an LTAG syntax-semantics interface, pairing LTAG elementary trees with semantic frames in such a way that substitutions and adjunctions trigger unifications on the attached semantic frames (Kallmeyer & Osswald, 2013). In the sample derivation in Fig. 2, we have three substitutions, which cause unifications of the interface feature structures on the two indentified nodes. This then triggers frame unifications. The substitution at the subject NP node for instance leads to the unification of $[\text{I} = \boxed{3}]$ (NP node of the *John* tree) and $[\text{I} = \boxed{1}]$ (subject node), which means that, in the semantics, the two frames labeled $\boxed{3}$ and $\boxed{1}$ unify. Similarly, $\boxed{2}$, $\boxed{5}$ and $\boxed{6}$ get identified and so do $\boxed{4}$ and $\boxed{0}$. These unifications lead to the semantic frame in Fig. 3.

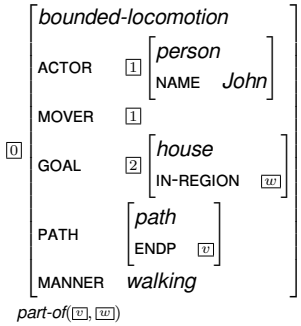

Figure 3: Frame resulting from the derivation in Fig. 2

As such, a grammar of this sort is a loose set of elementary tree-frame pairs. Linguistic generalizations across and within these pairs are expressed at the level of the metagrammar, which allows for the decomposition or factorization of trees and frames into recurring fragments. Taking the elementary pair for *walked* as an example, Fig. 4 sketches the composition of the underlying unanchored *tree template*, based on a metagrammar of named fragment classes (IntransDir, Intrans, and DirPrepObj). Note that classes basically consist of sets of descriptions (of trees or frames) that get unified when being combined. Furthermore note that there can be global constraints that encode, for example, a frame-semantic type hierarchy.[1] Finally, as indicated in Fig. 4, the resolved tree template is combined with the lexical anchor (*lexical insertion*) to yield a plain elementary tree. For the implementation of the metagrammatical layer, we have chosen XMG (eXtensible MetaGrammar, Crabbé et al. 2013).

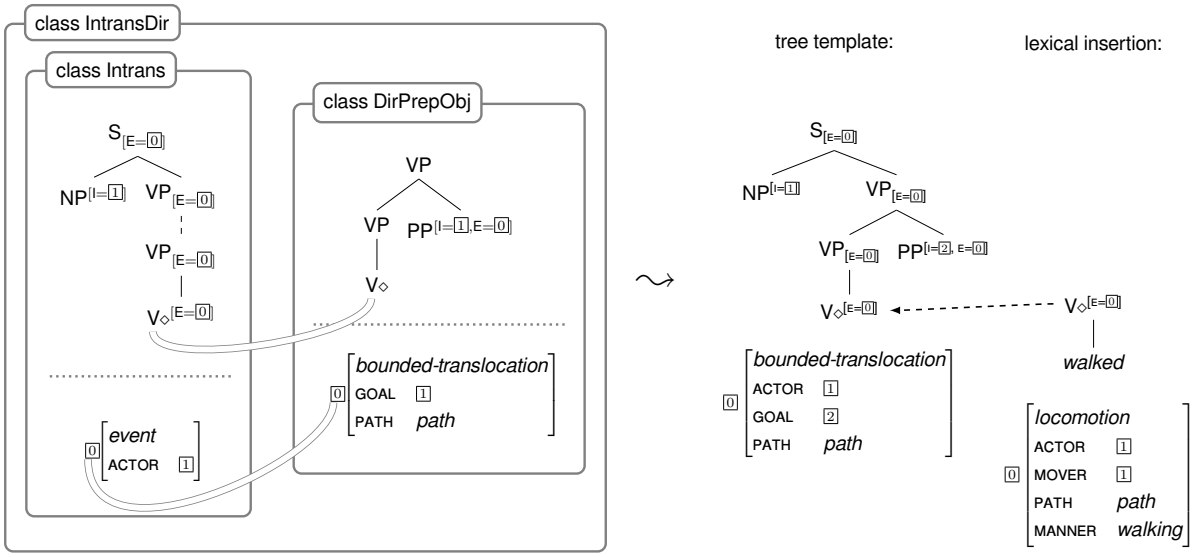

Figure 4: Metagrammatical factorization of the elementary tree and the frame representation for *walked*. Taking back the lexical insertion of the lexical anchor yields a tree template, which is further factorized into so-called classes.

Within this framework, in the first funding period, the project mainly concentrated on (i) a detailed decomposition of the meaning of verbal constructions in English into constructional and lexical meaning, and (ii) the morpho-semantic decomposition of the meaning of prefixed verbs in Russian. Furthermore we extended the XMG framework to frame descriptions, and we achieved a better understanding of other EDL formalisms, namely some variants of LTAG, RRG and certain flavours of CxG. Originally, we planned to concentrate only on English but the fact that Yulia Zinova became the doctoral student in the project made us extend the scope to Russian as well. Russian is particularly challenging for frame semantics because of its rich system of aspectual prefixation. Kata Balogh, who is associated with the project, applied our framework to

[1] The type hierarchy determines the result of type unification. For example, the unifier of *bounded-translocation* and *locomotion* is *bounded-locomotion*, as can be seen from Fig. 4. The underlying type hierarchy was developed in Kallmeyer & Osswald (2013) and is not shown here.

focus and information structure (Balogh, 2012, 2014). Her work will feed into the new project D04.

Besides the specification of the overall framework, the following results have been obtained:

Directed motion expressions in English and Russian The LTAG-frame interface of directed motion expressions in English has been developed together with B01 (Kallmeyer & Osswald, 2012a, 2013). Telic directional PPs receive a constructional analysis which amounts to a frame-semantic decomposition in the metagrammar, whereas atelic directional PPs are treated in terms of adjunction and path modification. Path modification implies the use of relations within frame representations (i. e., the part-of relation, see Fig. 1, Section 1.2.2.1 in the general part of the CRC proposal). This is also the approach chosen for the analysis of motion verbs in Russian, while concentrating on the distinction between determinate and indeterminate motion verbs. Furthermore, the effects of prefixation are taken into account (presented by Yulia Zinova and Rainer Osswald at the *Conference on Actionality, Tense, Aspect, Modality/Evidentiality*, CHRONOS 11). The analysis aims to predict the aspect and semantics of a given (prefixed) verb and whether or not it can be combined with certain time- and path-related expressions.

Alternation constructions in English and Russian Moreover the LTAG-frame interface has also been applied to the characterization of alternation constructions such as the dative alternation in English and the locative alternation in English and Russian (Kallmeyer & Osswald, 2012b; Zinova & Kallmeyer, 2012; Zinova, 2014; Kallmeyer & Osswald, 2013). Again the primary focus was on the distinction between lexical and constructional meaning components. Despite some differences in the locative alternation construction in English and Russian, a considerable level of uniformness was achieved in the representation. The Russian part also includes a morphology-frame interface. This additional decompositional step allows us to predict the ability of prefixed Russian verbs to participate in the locative alternation and thus to greatly decrease the size of the lexicon by factorization in the domain of derivational morphology.

The morphology-frame interface of aspectual prefixation in Russian In Russian, prefixation plays a prominent role in the verbal domain and is largely productive. We provided analyses for several cases of aspectual prefixation in Russian. The interaction of constructional meaning and prefix-specific meaning was studied in Zinova & Kallmeyer (2012) and Zinova (2014), investigating the locative alternation. Furthermore, in joint work with B01, Yulia Zinova and Ranier Osswald investigated Russian motion verbs and their prefixation (presentations at CHRONOS 11 and at the *Concept Types and Frames* conference, CTF, in 2014). For more details on this, see the report of B01. Exceptions from the general assumption that verbal prefixes in Russian contribute perfectivity were discussed in work by Yulia Zinova and Hana Filip (project C09) (Zinova & Filip, 2014, and presentation at the *Conference on Formal Description of Slavic Languages*, FDSL-10).

Scope and quantification in frames One of the questions we started with concerns the relation between frames and more classical approaches to semantics such as predicate logic and truth conditions. In particular, the representation of scope and quantification in frames needed to be clarified in order to allow us to link our current frame-based research to previous work on quantifiers and scope in LTAG (Gardent & Kallmeyer, 2003; Kallmeyer & Romero, 2008). In Kallmeyer & Richter (2014), we proposed to capture the relation between the two arguments of binary quantifiers in their frame type. This leads to types *every*, *most*, *two*, etc. We further proposed that the concept of a quantifier must minimally delimit the candidate concepts of its arguments, i.e. the concepts that occupy the restrictor and nuclear scope of the logical counterpart of a given quantifier concept. For this purpose, a quantifier frame contains the attribute RESTR for the maximal type of objects that the natural language quantifier in question lives on (in terms of logic: the restricting predicate), and the attributes MAXS and MINS that, in logical terms, characterize the scope window of the quantifier: The logical counterpart of the quantifier frame will scope at least over everything below the MINS value and at most over everything below the MAXS value.

We assume in Kallmeyer & Richter (2014) that frames do not immediately encode truth conditions that come with a model-theoretic interpretation. However, we can extract a predicate-logical formula from these frames that tells us what properties the world must have in a situation where the concepts represented by the frames get instantiated. We propose a way to extract such a formula that includes standard underspecification techniques for quantifiers like those that have been used previously in LTAG. This analysis is extended to the scope of adverbs such as *again* that are also underspecified with respect to scope.

Extending XMG to frame representations Together with Simon Petitjean and Denys Duchier (University of Orléans) we have integrated frame-based representations into XMG, which is used in A02 to decompose tree templates and their constructional meaning component. Originally, XMG allowed for the description of tree-based syntactic structures and predicate-logical formulae, but the representation of frames as typed feature structures, particularly type unification, was not supported. Therefore, we have developed an extension that is capable of handling frame representations directly within a novel frame dimension. This not

only enables a straightforward specification of frame descriptions, but also offers various ways to state constraints on types, either as a contiguous type hierarchy or a loose set of frame constraints (Lichte et al., 2013; Lichte & Petitjean, to appear).

A web-based version of XMG is under implementation in collaboration with INF. This can become a useful tool for the entire CRC since the XMG frame component can be used on its own as a frame implementation tool. We presented the frame component with applications taken from various projects of the CRC at the CTF 2014.

Formalization of Role and Reference Grammar (RRG) In joint work with B01, we have gained a more precise understanding of RRG as an EDL formalism, resulting in a formalization of its syntactic inventory by means of Tree Wrapping Grammar (TWG, Kallmeyer et al. 2013). The formal properties of TWG have been further investigated in Kallmeyer (2014). Furthermore, the relation of TWG to mildly context-sensitive formalisms is further examined in collaboration with Marco Kuhlmann (Linköping University). The broader picture of formalizing RRG as an EDL formalism, including in particular aspects of syntax and semantics and their interplay, can be found in Osswald & Kallmeyer (2014).

Valency and EDL We have also investigated EDL-based approaches from a more general perspective, namely as a specific way of integrating valency, i. e. the lexical information on argument linking, into the syntactic theory, and for this we have taken further phenomena into consideration (Lichte, 2012, 2013). In the light of discontinuity effects and flexible word order in German we designed a variant of TAG, called TT-MCTAG (Multi-component TAG with Tree Tuples, Lichte & Kallmeyer 2008), which was shown to be expressive enough to cope with critical data in a linguistically sound fashion, but still remain computationally tractable. A more radical conception of the relation between valency and syntax was chosen for the modeling of ellipsis. Instead of the standard amalgamation of syntax and valency, we developed a grammar formalisms, STUG, which allows for a clean separation of the two. While syntax is solely concerned with linear order and the generation of the surface string, the valency domain collects and combines information that deals with valency, agreement or determination. One of the many consequences of this approach is that valency information can be distributed over the syntagmatic context and left largely underspecified in the governor proper, thereby considerably facilitating incremental derivations.

Constructions in LTAG LTAG shares central ideas with (some versions of) Construction Grammar (CxG, Goldberg, 2013) since (i) its unanchored elementary trees represent grammatical constructions, (ii) it assumes only a surface structure, i.e., no transformational or derivational component operating on complete syntax trees, and (iii) it allows for the specification of a network of constructions whose nodes are related by inheritance links within the metagrammar. In spite of these rather obvious connections, CxG has not really been in the focus of the LTAG community so far (and vice versa). In order to approach the CxG community, we have presented the way in which LTAG allows modeling argument structure constructions, transitive motion constructions and the DO and PO constructions of the dative alternation (Kallmeyer & Osswald, 2013) at the *International Conference on Construction Grammar 2014* (ICCG 8).

Next steps: Depictive secondary predicates and multi-word expressions In order to prepare our next steps, we presented first preliminary ideas concerning EDL and the analyses of depictives and multi-word expressions in LTAG at the CTF 2014 (in collaboration with B01). Furthermore, we are part of the European COST Action IC1207 *PARSEME: PARSing and Multi-word Expressions*, and at its most recent meeting we presented and discussed first ideas towards a frame-based analysis of multi-word expressions in LTAG. This has also led to a collaboration with Manfred Sailer (University of Frankfurt) on this topic.

General aspects of the project Important aspects of our approach are:

- An architecture that decomposes frames and elementary syntactic structures in the metagrammar. This is coupled with a frame composition that consists of unifications triggered by substitution and adjunction.
- The division between lexical and constructional contributions to meaning; constructions can be characterized via unanchored elementary trees.
- An architecture with an extended domain of locality. This allows for an order-independent syntactic predicate-argument composition, which combines well with the unspecified order of semantic arguments in frames.
- The specification of argument linking either takes place in the lexicon (where unpredictable), or in a principled way by morphological features (active-passive diathesis), and via general compatibility with event types.

Dissertations Timm Lichte defended his dissertation, submitted in September 2012, at the Eberhard-Karls-Universität Tübingen. Yulia Zinova plans to submit her thesis by June 2015.

3.3.2 Project-related publications of the principal investigator(s)

Kallmeyer, L., T. Lichte, W. Maier, Y. Parmentier & J. Dellert. 2008. Developing a TT-MCTAG for German with an RCG-based Parser. In E. L. R. A. (ELRA) (ed.), *Proceedings of the Sixth International Language Resources and Evaluation (LREC'08)*, Marrakech, Morocco.

Kallmeyer, L., W. Maier, Y. Parmentier & J. Dellert. 2010. TuLiPA: Parsing Extensions of TAG with Range Concatenation Grammars. *Bulletin of the Polish Academy of Sciences* 58(3). 377–392.

Kallmeyer, L. & M. Kuhlmann. 2012. A Formal Model for Plausible Dependencies in Lexicalized Tree Adjoining Grammar. In *Proceedings of the 11th International Workshop on Tree Adjoining Grammar and Related Formalisms (TAG+11)*, 108–116. Paris.

Kallmeyer, L. & R. Osswald. 2012a. An Analysis of Directed Motion Expressions with Lexicalized Tree Adjoining Grammars and Frame Semantics. In L. Ong & R. de Queiroz (eds.), *Proceedings of WoLLIC* (Lecture Notes in Computer Science LNCS 7456), 34–55. Springer.

Kallmeyer, L. & R. Osswald. 2012b. A Frame-based Semantics of the Dative Alternation in Lexicalized Tree Adjoining Grammars. In C. Piñón (ed.), *Empirical Issues in Syntax and Semantics 9*, 167–184.

Kallmeyer, L. & R. Osswald. 2013. Syntax-Driven Semantic Frame Composition in Lexicalized Tree Adjoining Grammar. *Journal of Language Modelling* 1. 267–330.

Kallmeyer, L. & F. Richter. 2014. Quantifiers in Frame Semantics. In G. Morrill, R. Muskens, R. Osswald & F. Richter (eds.), *Formal Grammar. 19th International Conference, FG 2014*, vol. 8612 LNCS, 69–85. Springer.

Kallmeyer, L., R. Osswald & R. D. Van Valin, Jr. 2013. Tree Wrapping for Role and Reference Grammar. In G. Morrill & M.-J. Nederhof (eds.), *Formal Grammar 2012/2013*, vol. 8036 LNCS, 175–190. Springer.

Lichte, T. 2012. Synchronous Tree Unification Grammar. In *Proceedings of the 11th International Workshop on Tree Adjoining Grammars and Related Formalisms (TAG+11)*, 46–54. Paris, France.

Zinova, Y. & L. Kallmeyer. 2012. A Frame-Based Semantics of Locative Alternation in LTAG. In *Proceedings of the 11th International Workshop on Tree Adjoining Grammars and Related Formalisms (TAG+11)*, 28–36. Paris, France.

3.4 Research Plan

3.4.1 Research questions, aims and hypotheses

This project investigates the methods and consequences of coupling an EDL-based syntax with frame-based representations. On the syntactic side, we mainly focus on variants of LTAG. But we want to also take a more general perspective across grammar frameworks, in order to understand the nature of EDL and the range of syntax models that it applies to. Ultimately, an EDL results from a set-like representation of valency that avoids a predetermined total order on the arguments. This implies that the head, in principle, can be combined with each of its arguments immediately, without having to wait until other derivation steps have been carried out. For the same reason, complementation and modification turn out to be derivationally independent as well. Note that EDL can appear in quite heterogeneous grammar architectures, LTAG and STUG being a notable case in point: while TAG generally amalgamates syntactic structure and valency, effecting larger syntactic units in the lexicon, STUG assigns syntax and valency to two distinct, yet linked representations. This latter representational division is moreover reminiscent of Lexical-functional Grammar (LFG) with its c-structure and f-structure, and indeed LFG's f-structure incorporates a set-like valency representation as well. But at the same time, the surface syntax in the c-structure is driven by a regular Context-free Grammar (CFG), which is known to oppose an EDL-approach in general.

The opposite paradigm can be characterized as spanning over a Limited Domain of Locality (LDL), for example two adjacent constituents, which is the case in binarized CFG and related formalisms such as Combinatorial Categorial Grammar (CCG), Head-driven Phrase Structure Grammar (HPSG) or Minimalist Grammar (MG). This property basically follows from the use and step-wise processing of list-like valency representations that imply a total order on the arguments of a head. As a consequence, and in contrast to EDL-approaches, heads can only be directly combined with one of their adjacent arguments. In order to account for linear discontinuity such as with long-distance dependencies, LDL-approaches must invoke powerful mechanisms such as movement, slash storing, type raising or valency merge. Furthermore, the lexically fixed order of arguments on the valency list needs to be theoretically substantiated. Despite these severe requirements, however, it is still an open question which of the two paradigms, EDL and LDL, is to be preferred in general. And it remains to be seen which one LFG is closer to.

The major technical benefit of using EDL with frame representations is that argument linking can be done

in a straightforward manner. This can be seen in Fig. 2 above, where the nodes of the elementary syntactic structure are directly linked with parts of the semantic frame (in AVM notation). While the syntactic arguments, generally represented as nonterminal leaf nodes, are linked with specific semantic roles, the linking at the modifiers, which adjoin to the S- or VP-node, is less specific. It is basically left to the semantics of the modifier what frame component is affected when the modifier and the head are composed. In other words, the syntax-semantics couple of *walked* in Fig. 2 seems to impose that the locality of modification stretches over every component of the frame. This, of course, comes with substantial empirical ramifications that we plan to investigate in the second funding period.

Before going into more detail, let us explicate the assumptions underlying the perspective of this project. Our basic assumption is that EDL is not just an arbitrary choice, but suits the frame objective well:

(1) **EDL-assumption:**
EDL-approaches constitute a "natural" syntactic counterpart to frame-semantic composition.

By "natural" counterpart, two sorts of correlations are intended: (i) a certain degree of structural and compositional similarity, and (ii) the sparseness and transparency of the interface.

Given that frames are formalized as extended typed feature structures (Petersen, 2007; Kallmeyer & Osswald, 2013), oneof their crucial structural property is that the immediate attributes form an unordered set. They are therefore composed by means of unification rather than functional application. In other words, the frame does not provide any reason to believe that first the THEME is fed in by the syntax, and only after that the ACTOR. Similarly, EDL-approaches do not impose any inherent ordering on the arguments due to the set-like valency representation. The argument leaves of *walked* in Fig. 2 can be substituted in any order, and the performed substitutions are by no means derivationally dependent on the adjunction of some modifier at S or VP. By contrast, a fixed derivational ordering of this kind is assumed in virtually all LDL-approaches that make use of valency lists (e. g. HPSG, CCG, MG) or base configurations (GB).

A further cornerstone of the definition of frames is that there is no explicit distinction between arguments and modifiers. So, following the EDL-assumption, there should be no such distinction on the syntactic side, either. In fact there is a long history of complaints about the ill-foundedness of the argument/modifier dichotomy (e. g., Vater 1978; Jacobs 1994; Storrer 1992; Przepiórkowski 1999). At close inspection, popular criteria for the A/M-distinction (such as obligatoriness, argumenthood, iterability, morphological governedness, "Subklassenspezifik", etc.) turn out to be either inconsistent or hard to determine, or both. But the recognized ill-foundedness has had almost no impact on the mechanics of mainstream syntactic models, as they generally impose a clear-cut A/M-distinction. LTAG is no different in this respect when it comes to the shape of elementary trees. While argument slots are usually represented as non-terminal leaf nodes of the governors's elementary tree, modifiers must adjoin at inner nodes, as *slowly* does in Fig. 1.

Note, however, that the A/M-distinction is blurred with respect to derivations, since the adjunction operation is not restricted to modifiers. Certain heads also combine with their arguments via adjunction (e. g. raising verbs). In other words, the choice between adjunction and substitution is made on largely combinatorial grounds in LTAG. Still, other EDL-approaches such as STUG (Lichte, 2012, 2013) are even more "natural" contenders in that they avoid the A/M-distinction even on the level of elementary structures.

The other correlation suggested by the EDL-assumption is concerned with the transparency of the syntax-semantics interface. Transparency is understood here as a rather direct access to the frame component from the point of view of the syntax, with no extra intervening level that acts as a filter. A simple example illustrating this is again the tree frame pair of *walked* in Fig. 2. Arguments filling the NP and PP slots want to access the ACTOR and GOAL nodes in the frame while modifiers such as *slowly* have to access the event node labeled $\boxed{0}$. All these frame elements are accessible via interface features on the syntactic tree and via the shared boxed frame labels. Our hypothesis is that this way of accessing frame nodes via interface features is sufficient to deal with more complex cases of modifications as well. Note that accessibility of frame components can be flexibly adjusted via frame labels, and in principle it is possible to access any frame component around the labeled frame node, as long as they are connected through a path of fixed length. An example is shown in Fig. 5 below. Thus the frame is fully transparent in the corresponding elementary tree, and it remains so throughout the derivation. This persistence is missing from many LDL approaches, most prominently HPSG, where syntactic accessibility is highly dependent on the derivation step and the remaining entries on the valency list.

Against the background of the EDL-assumption, several empirical and theoretical consequences emerge that we will investigate in the second funding period. In this respect, cases of (non-local) modification are particularly interesting since modification, regarding the syntax-semantics interface, seems more flexible in nature than canonical valency relations.

The consequences of transparency The bold conjecture following from the EDL-assumption is that everything in the frame is accessible from every part of an elementary tree that it is linked with. The syntax-semantics interface is basically non-local. For example, nothing prevents *slowly* in Fig. 1 from taking scope somewhere outside the proper domain of *walked* by means of explicit paths of finite length. But is this really needed? Or does a less extended locality suffice in most cases? Or worse, does this make the wrong empirical predictions, thus requiring the additional implementation of not so natural restrictions? This has been conjectured by Müller (2010) regarding depictive secondary predicates in German:

(2) a. dass er$_i$ den Apfel$_j$ ungewaschen$_{i/j}$ isst
that he the apple unwashed eats
'that he eats the apple unwashed'
b. dass sie$_i$ ihn$_j$ nackt$_{i/j}$ beobachtet
that she him naked watches
'that she watches him naked'

In (2) the antecedent of the depictives *ungewaschen*/*nackt* can either be the subject (*er*/*sie*) or the direct object (*den Apfel*/*ihn*). A preliminary LTAG analysis of (2b) is shown in Fig. 5. Note that we will be using TT-MCTAG rather than LTAG to account for the flexible word order in German. Nevertheless we have chosen LTAG here for expository reasons. A crucial property of this analysis is the disjunction (ACTOR|THEME|...) in

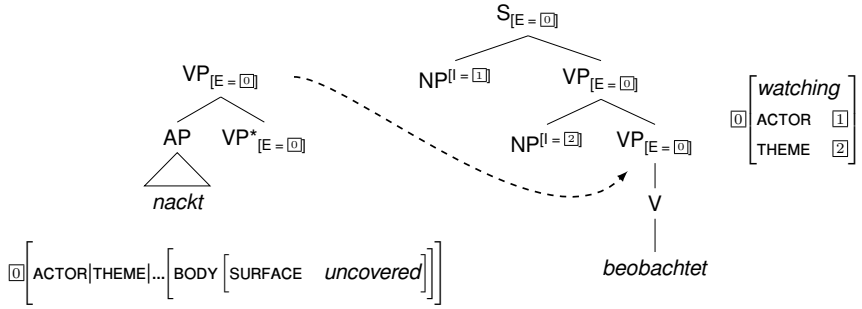

Figure 5: Preliminary analysis of the depictive predication in (2b).

the frame description that comes with *nackt*. It guarantees that *nackt* can scope over different participants of the *watching* event. In principle, the frame description of the depictive need not be limited to frame participants contributed by arguments – and it is difficult to see how it could be, since valency information is simply not part of the frame. This is a major difference from LDL-approaches where the target of modification is determined based on the valency of the governing head or its projection. One empirical question therefore is whether the A/M-distinction does indeed constrain the target of depictives.

According to Müller (2002) and others, modifiers (or the complement of modifying PPs) are excluded from being the subject of depictives:

(3) weil Karl$_i$ [neben Maria$_j$] nackt$_{i/*j}$ schlief
because Karl next.to Maria naked slept
'because Karl slept naked next to Maria'

Yet we are not convinced that this sort of extrapolation from (3) is really conclusive, at least for German. It is widely acknowledged that depictives are quite flexible at choosing their subject, allowing it to be unrealized as in (4a), or to be part of a PP-argument as in (4b):[2]

(4) a. Hier wird ungewaschen gegessen.
here is unwashed eaten
'Here one eats everything unwashed.'
b. [Noch am Boden liegend]$_i$, sei [auf ihn$_i$] eingetreten worden.
still on.the floor lying be on him PART.kicked got
'While he was still on the floor he was kicked.'
(Cf. (422) in Müller 2002)

What is more, the following constructed examples show that some modifiers (or complements thereof) may be able to act as the subject of the depictive:

[2] It could be argued that in (4b) the depictive actually scopes over the unexpressed subject of the reported speech, triggered by the subjunctive verb *sei*, which then could be coreferential with the PP-argument *auf ihn*. While this reading indeed seems to be be available, it is not obligatory and the verb can be replaced by an indicative.

(5) a. Deiner Oma$_i$ bis du [ohne Gehhilfe]$_i$ zu schnell.
your.DAT grandma are you without walker too fast
'You are too fast for your grandma as she has no walker.'
b. In der Wohnung$_i$ hält man es nur gut gelüftet$_i$ aus.
in the apartment bear one it only well aired PART
'The apartment is bearable only when being well aired.'

The modifier *deiner Oma* in (5a) is a so-called free dative (Wegener, 1985), whereas *in der Wohnung* in (5b) is a regular locative modifier. Given the examples in (5), we have reason to believe that the limitation to arguments is too narrow, and that in this particular case the predictions that follow from assuming an EDL are in fact correct. On this reading the choice is not determined by the A/M-distinction, but is rather subject to information-structural factors, namely perspective and salience. As modifiers tend to be less salient than arguments, it is also harder for them to fall under the scope of a depictive. However, the salience of modifiers is a function of many factors (lexical, syntactic, discourse-structural) and can be increased by, e. g., topicalization. Therefore the integration of information-structural aspects into the syntax-frame interface is one of the interests of this project – an interest that it shares with project D04.

Modeling intransparency and idiomaticity While the phenomena mentioned so far suggest a high degree of regularity in the syntax-semantics interface, there are, as is well known, less regular, more idiomatic cases of composition, like argument structure constructions (ASC), light verb constructions (LVC), and figurative idioms. Another line of research will therefore be the handling of intransparency and idiomaticity of those so-called multi-word expressions (MWEs).

EDL-approaches such as LTAG are known to provide elegant accounts for MWEs with non-compositional meaning (Abeillé & Schabes, 1989; Abeillé & Schabes, 1996; Abeillé, 1995). The reason is that elementary trees can be made as large as is necessary to span any multi-word expression, even discontinuous or clausal ones. An example based on the idiom *kick the bucket* is shown in Fig. 6a. In the first funding

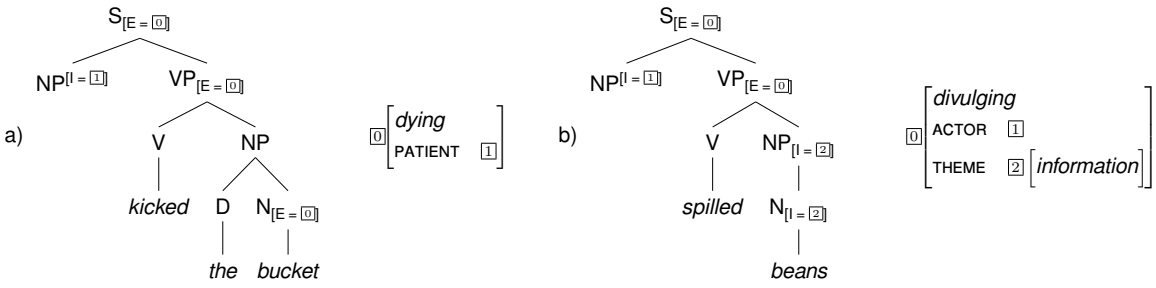

Figure 6: Elementary tree and frame semantics of multi-word expressions

period, we contributed to this picture by providing in-depth analyses of ASCs which make extensive use of metagrammars. Furthermore the close relationship of LTAG and (some versions of) CxG in terms of their basic assumptions became striking.

Despite their success in this domain, EDL-approaches have not gone uncontested. One important challenge arises from the flexibility of idiomatic multi-word expressions with respect to internal modification (Ernst, 1981), i. e. modification at the NP-component of the idiom:

(6) a. John kicked the proverbial/social/#rusty bucket. (cf. McClure 2011)
Proverbially/socially/#rustily John kicked the bucket.
b. John immediately spilled the hot/juicy/political beans about the meeting.

Following Müller (2010), the classic LTAG-approach of Abeillé & Schabes (1989) is inappropriate, because it predicts that the internal modifier only takes wide scope as in (6a). This is captured in Fig. 6 by means of a link between the N-node (where adjectives are adjoined) and the frame of the dying event. Narrow scope readings such as in (6b) are supposed to be absent, however, as the idiom and its meaning are inserted en bloc, at least in Abeillé & Schabes (1989). On the other hand, this does not seem to hold for the syntax-semantics interface presented later in Abeillé & Schabes (1996), and it does not seem to apply to the one developed here either. An example showing how to model a more flexible MWE in LTAG is the elementary tree-frame pair for *spill the beans* given in Fig. 6b. The NP and N nodes of *beans* carry interface features that allow modifiers to access the INFORMATION part of the frame. In the second phase of the CRC we plan to look into these cases of modification in more detail. On this, as well as other issues of MWEs, we will collaborate with Manfred Sailer (University of Frankfurt).

Another maybe more severe challenge affects the efficiency of EDL-analyses of MWEs. EDL-approaches such as LTAG tend to enumerate non-compositional expressions by assigning a separate elementary tree to each of them (abstracting away from morphological flexibility). Taken as such, this approach becomes inefficient both in terms of implementation and processing. As shown in the first funding period when analysing ASCs, the burden on implementation can be considerably eased with the help of metagrammars, which make it possible to factorize the shape and semantics of yet unanchored tree templates. But it is still unclear how that carries over to other types of MWEs, and eventually to parsing. Regarding LVCs, an alternative would be to assume a compositional process in which a semantically bleached verb is combined with an event-denoting noun, as for example in *take a walk*. However, since not every such combination receives an analogous interpretation, for example *take a kiss*, it first needs to be examined what the restricting factors are, and how they can be taken into account within a compositional model. As for figurative idioms such as *spill the beans* or *pull strings*, the occasional availability of pronominalization or isolation of parts of the MWE, such as in (7), pose serious challenges for accounts of factorization:

(7) a. Eventually she spilled all the beans. But it took her a few days to spill them all.
(Riehemann, 2001, (229))
b. Pat pulled some strings for Chris. But Alex didn't have access to any strings.
(Manfred Sailer, p.c.)

In order to lower the burden caused by syntactic ambiguity, we will consider also a theory-oriented strategy, namely a non-syntactic treatment of compositional idiomaticity that operates directly at the level of frame representations. This strategy has been pursued in very few works within DRT (Fischer & Keil, 1996), at least to our knowledge. It also seems worthwhile because it would be in line with psycholinguistic results (e. g. Wittenberg et al. to appear), which indicate that MWEs cause an increased semantic rather than syntactic processing load and are therefore brought forward against "phrasal" EDL-based approaches, particularly against CxG (Müller & Wechsler, 2014).

Modeling locality constraints So far, we have been concerned with the technical and empirical consequences of the syntax-frame interface being fully transparent. Another way to look at it is to ask what part of the available locality is actually needed and how we can implement the locality constraints we find. For this we want to investigate further instances of cross modification besides depicitve secondary predicates, namely iterated modification and modification of complex event descriptions.

To start with depictive secondary predicates, there seems to be a strict constraint on the relative position of the depictive and its subject: the latter may not be embedded into co-constituents of the depictive:

(8) daß Jan [den Freund von Maria$_i$] nackt$_{*i}$ traf (Müller, 2002, (433a))
that Jan the friend of Maria naked met
'that Jan met the (male) friend of Maria naked'

This locality constraint is nicely captured by the analysis sketched in Fig. 5, where the disjunction of attributes denotes paths of length 1. But there are apparent counterexamples such as (9), where it is not the doctor who is supposed to be sober, but the treated patient should not eat beforehand:

(9) [Die Untersuchung an dem Patienten$_i$] wird nur nüchtern$_i$ durchgeführt.
the examination of the patient is only sober performed
'The patient will only be examined on an empty stomach.'

The crucial property of (9) is that it involves a light verb construction, in which the event semantics of *Untersuchung* is raised to the matrix level. We therefore believe that the same locality constraint holds for both (8) and (9), yet it operates at the level of semantics, not syntax. Similarly, cases such as (10) do not count as counterexamples, since the syntactic domain of the embedded non-finite verb is systematically extended since it is in a so-called coherent construction:

(10) Betrunken$_i$ versuchte sie [ihn$_i$ vom Auto fernzuhalten].
drunken tried she him from.the car keep.away
'She tried to keep him away from the car whenever he was drunken.'

Note that certain secondary predicates have the property of accessing both the dependents and the verbal governor. An example of this is shown in (11):

(11) Peter$_i$ öffnet$_j$ widerwillig$_{i,j}$ die Tür.
Peter opens reluctantly the door
'Peter reluctantly opens the door.'

While *Peter* surely constitutes the POSSESSOR of reluctance, the THEME of reluctance is rather the opening event. We will discuss this in detail with project B09. B09 is dedicated to the study of lexical manner specification, and will contribute the lexical frames. To keep the project focused, however, we will put aside cases of NP-PP-splitting and quantifier floating, even though they appear to bear resemblance to cross modification.

Besides depictives we also take iterative modification of the kind in (12) into consideration:

(12) a. In Berlin wohnt er in der Donaustraße in einer Dreizimmerwohnung.
in Berlin lives he in the Donaustraße in a three-room.flat
'In Berlin, he lives in Donaustraße in a three-room flat.'
b. Der Ball flog durchs Tor über die Hecke ins Nachbarhaus.
the ball flew through.DET goal across the hedge into.DET neighboring.house
'The ball flew through the goal across the hedge into the neighboring house.'

In (12a) the locational meaning component is gradually specified. Does this also gradually increase the locality of the syntax-semantics interface? A similar question arises for the path specification in (12b), but here the linear position plays a role as well. Note that, despite the central status of iterability in the traditional notion of modifiers, iterative modification is highly constrained and by no means applicable to every kind of modifier:

(13) *Wegen Berlin hat er wegen einer Dreizimmerwohnung nicht umziehen wollen.
due.to Berlin has he due.to a three-room.flat not move want

The grammatical examples in (12) suggest that iterative modification is restricted to the specification of locational or directional meaning components.

Finally, we will investigate and try to model the locality of adverbial modification in cases of verbal complexes, particularly with regard to scope contrasts such as in (14):

(14) a. Morgen versprach er die Tür zu öffnen.
tomorrow promised he the door to open
'Tomorrow he promised to open the door.' / 'He promised to open the door tomorrow.'
b. Wieder versprach er die Tür zu öffnen.
again promised he the door to open
'He again promised to open the door.'

While the fronted temporal modifier *morgen* in (14a) allows for both wide and narrow scope readings (just over the embedded verb *zu öffnen*), the fronting of the modifier *wieder* only yields a wide scope reading over the matrix verb *versprach*. Note that modifiers such as *again* and *wieder*, which need to access the result state of the event frame, have already been modelled in terms of LTAG and frames in Kallmeyer & Richter (2014).

Complexity and implementation of processing an EDL-based syntax-semantics interface with frames Bangalore & Joshi (2010) subsume the principal properties of EDL approaches such as LTAG under the slogan "complicate locally, simplify globally". The idea is that basically all linguistic constraints are specified over the local domains represented by elementary trees and, as a consequence, the composition of elementary trees can be expressed by general operations such as substitution and adjunction. This view of the architecture of grammar, which underlies LTAG, has direct consequences for semantic representation and computation. Since elementary trees are the basic syntactic building blocks, it is possible to assign complex semantic representations to them without necessarily deriving these representations compositionally from smaller parts of the tree. Hence, there is no need to reproduce the internal structure of an elementary syntactic tree within its associated semantic representation (Kallmeyer & Joshi, 2003). In the case of frames, there is no one-to-one correspondence between the nodes of the tree and the nodes of the frame. As a consequence, we do not need complex operations that account for mismatches between surface syntax and semantic composition. Our hypothesis is that the flexible and transparent EDL approach allows us to use a rather simple monotonic unification operation as our frame composition.

In the second CRC period, we plan to implement a parser for LTAG and other TAG variants such as TT-MCTAG that integrates the use of frames and frame unification as semantic composition. The goal is to obtain, in combination with the metagrammar compiler XMG that we have extended for frames during the first funding period, a complete tool chain for EDL-based grammar development with frame semantics. For this we will extend the Tübingen Linguistic Parsing Architecture (TuLiPA, Parmentier et al. 2008) environment, which already parses LTAG and TT-MCTAG, but does not yet process frames.

3.4.2 Work packages

The project's work packages fall into two groups: WP 1 and WP 2 are concerned with the modeling of two aspects of non-canonical composition, namely cross modification and idiomaticity in multi-word expressions. This branch can be seen as a continuation of work done in the preceding funding period in the area of constructional meaning contributions. The other group, WP 3 and WP 4, deals with implementational and theoretic aspects.

WP 1: Cross modification subsumes cases of frame composition, where the contributing syntactic entities do not stand in a syntactic dominance relation, at least not in a traditional sense. They should rather be seen as syntactic siblings and therefore provide suitable research objects for surveys about locality and accessibility. We will be considering three subtypes of cross composition: depictive secondary predicates, iterative modification, and modification into verbal complexes. For each of these subtypes, the general research plan consists of three steps:

1. understanding (based on the literature, the expertise of other projects and external collaborators, and corpus studies, while restricting ourselves to English and German)
2. analyzing with LTAG/TT-MCTAG, possibly developing novel instruments (underspecified paths, obliqueness hierarchy, information structural elements)
3. implementation with XMG/TuLiPA

WP 1.1: Depictive secondary predicates This subpackage probably makes up the largest part of WP1. We will have to consider the full range of NP modification in semantic terms, test the prediction that modifiers can be the subject of depictives, and take into account conditions on scope preferences, most prominently information structural salience, as well as linear order.
WP 1.2: Iterative modification seems to be closely related to depictive secondary predication. We will restrict ourselves to iterative modification of location and path, where again the impact of word order comes into play. Moreover we will be concerned with the demarcation from non-iterable modifiers and parenthesis/apposition.
WP 1.3: Modification of the verbal complex Focusing on the locality of verbal complexes in German, we will largely restrict ourselves to event modifiers such as *wieder*/*again* and try to carry over results from preceding work (Kallmeyer & Richter, 2014).

WP 2: Multi-word expressions will also be approached from an empirical and an implementational side. On the empirical side, we will concentrate on internal modification of multi-word expressions that are subject to varying degrees of semantic flexibility. In Section 3.4.1 above we mentioned the classic pair *kick the bucket* and *spill the beans*, but we will also consider more transparent light verb constructions such as *take a walk*. As for WP1 this research is pursued in three steps:

1. understanding (based on the literature, the expertise of other projects and external collaborators, and corpus studies, while restricting ourselves to English and German)
2. analyzing with LTAG/TT-MCTAG,
3. implementation with XMG/TuLiPA

On the implementational (and analytical) side we will aim at keeping syntactic ambiguity as low as possible, for example, by developing a non-syntactic mechanism which operates at the level of frame representations.

WP 3: Grammar engineering is concerned with the development of software tools for implementation and parsing. It therefore strongly intertwines with the implementational parts of WP1 and WP2.
WP 3.1: Metagrammar compiler For the implementation of elaborated analyses we use XMG, which is currently being reimplemented and enhanced by Simon Petitjean and Denys Duchier (University of Orléans) in active collaboration with A02. So far, we have extended XMG to handle frame constraints and frame unification (Lichte et al., 2013; Lichte & Petitjean, to appear). In the second period we will further develop the XMG frame component and possibly also add other representational layers such as information structure and morphology.
WP 3.2: Parser The grammar resource resulting from the implementation is the main input for the parser. Here we make use of TuLiPA, which is a parsing environment for tree-based mildly context-sensitive grammars. In the second phase we will integrate frame composition into the parser. For this work package, we will collaborate with Yannick Parmentier (University of Orléans), is one of the developers of TuLiPA.

WP 4: Formalization and examination of other EDL approaches One of the main purposes of this project is to better understand the nature of EDL and the grammar-theoretical consequences that follow from the EDL-hypothesis. For this we will broaden the view by examining other frameworks that include some notion of an EDL. In the first phase we initiated this line of work with formalizing RRG (Kallmeyer et al., 2013) and CxG (Kallmeyer & Osswald, 2013). In the second phase we will turn our attention to STUG and LFG, in addition, and we will try to clarify the theoretical status of metagrammars for TAG, i. e., whether

this engineering tool could be seen as a first class grammar formalism or a component thereof. In doing so we will pay particular attention to aspects of computational complexity, the interaction of linking rules and meaning, and the distinction between arguments and modifiers.

Timeline

	2015/2	2016/1	2016/2	2017/1	2017/2	2018/1	2018/2	2019/1
WP1.1	x	x	x	x	x	x	x	x
WP1.2	x	x	x	x	x	x		
WP1.3	x	x	x					
WP2				x	x	x	x	x
WP3.1	x	x	x	x				
WP3.2				x	x	x	x	x
WP4	x	x	x	x	x	x	x	x

3.5 Role within the Collaborative Research Centre

Overall role in the CRC A02 pursues the general assumption that EDL approaches are natural syntactic counterparts for frame semantics. We thereby contribute crucially to research on the degree of locality and transparency of the syntax-frame interface. Besides theoretical and empirical investigations, we also develop a grammar engineering framework that allows the actual implementation of our analyses. On the one hand, our analyses are inspired by the work of other CRC projects concerned with event semantics. We will continue to collaborate with these projects on the form of event frames, i. e., their formal nature and the specific types and attributes to be chosen. On the other hand, our insights about the formal architecture of a frame-based syntax-semantics can feed into other projects, in particular those that are concerned with the syntax-semantics interface as well. Finally, the XMG frame component developed in A02 will be a highly useful tool for frame implementation in the CRC.

Collaborations in the current funding period In the first funding period, the following cooperations were particularly fruitful: With B01 (Van Valin), we cooperated very closely on the formal definition of the frame-based syntax-semantics interface for LTAG and also for RRG, on specific analyses of certain constructions and their event semantics and on the formalization of RRG in the spirit of LTAG. This has resulted in a series of common publications (Kallmeyer & Osswald, 2012a,b, 2013; Kallmeyer et al., 2013; Osswald & Kallmeyer, 2014) and conference talks where A02 has contributed knowledge on grammar formalisms and formal frameworks for a syntax-semantics interface and on Russian aspectual prefixation while B01 has contributed insights in feature logics, knowledge on event semantics and the RRG background. With the predecessor project of C09 (Filip), we have close collaboration on the semantics of Russian prefixation, which has also lead to common publications (Zinova & Filip, 2014) and conference talks. Finally, the work on focus and information structure conducted in A02 (Balogh, 2012, 2014) has directly fed into the preparation of D04 (Latrouite, Van Valin) where Kata Balogh (currently A02) is the designated postdoctoral researcher.

Areas of collaboration in the second funding period In the second funding period, we plan to collaborate with other projects within the CRC on the following topics:

EDL, syntax-semantics-information structure interface and frames The fact that we explore the use of EDL formalisms for syntax in combination with frame semantics links us strongly to B01 (Van Valin) and D04 (Latrouite, Van Valin), both using RRG, another EDL formalism. With both projects, collaboration has already been established and will be continued. We will pursue the comparison of LTAG and RRG and the formalization of the latter. A further point of contact in the second period is the interest in coherent constructions and verbal complexes, which B01 will treat as an instance of so-called macro events. Information structure, the domain of investigation in D04, is also relevant for A02 when accounting for scope preferences of depictives, i. e., for the distinction of arguments and modifiers in terms information structural salience. But information structure also comes into play when formalizing other notions of valency and argument linking, such as the obligatoriness of certain arguments, or the choice of perspective (“Perspektivierung”) reflected by a specific verb and grammatical voice. It is on these topics that A02 will to collaborate with D04.

Event semantics The collaboration with B01 on event semantics will of course be continued. Furthermore, our insights about event frames will inform the frame assumptions underlying the probabilistic models in B08 (Kallmeyer) while B08 will be able to provide empirical evidence for specific verb frames that we are interested in. Concerning the semantics of mass and count nouns, which is the subject of investigation in C09 (Filip), this has its parallel in the verbal domain. We will continue the existing collaboration on aspectual properties of verbs with C09.

Modification Modification is one of the new topics emerging in the second funding period. Both B09 (Löbner,

Petersen) and A02 are concerned with adverbial modification, yet under complementary aims and perspectives. B09 seeks to determine the frame architecture based on the interplay of event frames and adverbial modifiers. Therefore its perspective is largely bound to frame semantics, leaving aside the details of the syntax-semantics interface, whereas A02 is focusing on the latter. Consequently, B09 will provide A02 with valuable test cases and lexical frames, while A02 will inform B09 about ramifications for the modeling of the syntax-semantics interface. Project C10 (Löbner, Petersen) addresses the issue of noun modification, however within contiguous NPs. A02, by contrast, addresses cross modification, notably depictives, where the modifier is outside the target NP. Nevertheless, A02 will benefit enormously from C10 in exchanging views on lexical noun frames and adnominal adjectives and their interaction.

Frame formalization and frame composition With A01 (Petersen) we share the interest in the formal properties of frames and the mechanisms that are used to combine them and, furthermore, the specific form of event and sentential frames. Unlike A01, however, A02 takes the viewpoint of an EDL-based syntax-semantics interface and lays its focus on complexity properties and implementation. Project C08 (Arndt-Lappe, Plag) addresses frame composition at the morphological level, in particular in connection with deverbal nominalization. Therefore, event frames play a role for them as well. Their insights will feed into formal assumptions made in A02 and into the implementation of the frame component in XMG, which can then be used to implement analyses from C08.

Frame logic and scientific theory Project A06 (Schurz) investigates the possibility of using so-called classificatory frames (frame descriptions) in order to model scientific theories and theory change. The frame logic developed in A02 and B01 is a possible choice in this context. Moreover, the XMG frame dimension even makes it possible to implement and test the frame descriptions that A06 develops as logical characterizations of scientific theories. We started discussing examples and, as a first test case, the bird taxonomy mentioned in Section 1.2.2 of this CRC proposal has already been implemented.

3.6 Delineation from other Funded Projects of the Principal Investigator(s)

Laura Kallmeyer's project *Grammar Formalisms beyond Context-Free Grammars and their use for Machine Learning Tasks* (DFG, KA 1665/4-2) is concerned with syntax-based statistical natural language processing (parsing and machine translation) and does not have any relation to frame semantics.

3.7 Project Funds

3.7.1 Previous funding

The project has been funded within the CRC since July 2011.

3.7.2 Funds requested

Funding for	2015/2		2016		2017		2018		2019/1	
Staff	Qty	Sum	Qty	Sum	Qty	Sum	Qty	Sum	Qty	Sum
Postdoc, 100 %	1	32.700	1	65.400	1	65.400	1	65.400	1	32.700
PhD-student, 65 %	-	-	1	39.390	1	39.390	1	39.390	1	19.695
Total		32.700		104.790		104.790		104.79		52.395
Total		**32.700**		**104.790**		**104.790**		**104.790**		**52.395**

(All figures in Euro)