Inferences between Aspectual Verbs and Events

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1 Introduction

In order to calculate the temporal structure of texts, one needs to (1) determine the temporal profile of the eventualities described in single sentences constituting texts, (2) provide a stock of world knowledge, (3) consider the rhetorical relations between single utterances of texts, (4) account for the pragmatic context of the situation in which the texts are uttered. The literature has known an extensive list of theoretical accounts about how to formalise and compute these components for various applications like text representation, interpretation, generation ([Kamp, 1979], [Kamp, 1981], [Kamp and Reyle, 1993], [Lascarides and Asher, 1993], [Lascarides and Oberlander, 1993], [Hobbs, 1985]). The most prominent approaches all assume the presence of logical semantic representations, derived from the syntactic structures of single sentences which are to be connected with their theories on pragmatics and discourse representation. While the approaches offer different ingenious theoretical solutions for these accounts, they do not discuss in detail the practical realisation of the connection between the language structures and the derived meaning representations. An area that has seen little attention is how syntactic structures and their semantic contents can disambiguate possible interpretational contexts. The present paper is an attempt to address exactly this problem, namely how linguistic knowledge can contribute to the reconstruction the temporal or rhetorical structure of texts. More precisely we are going to address in detail how the interrelation between aspect, temporal reference, and structure of discourse accounts for the lexical meaning of some predicates.

2 Views on Events

Singling out events in sequences of sentences is essential for the proper representation of the temporal structure of texts. The ways natural languages reflect the possible conceptualisations of entities which have a crucial temporal dimension (such as events, and the like) are referred to in the literature as *"states of affairs"* or as *"eventualities"* ([Bach, 1986], [Moens and Steedman, 1988], [Kamp and Reyle, 1993], etc.). States of affairs or eventualities are typically categorised according to different intrinsic temporal parameters characterising them. For example, states of affairs described by the verbs *to run* or *to work* convey temporal extendedness (usually called "processes"), whereas states of affairs described by the verbs *to die* or *to knock* convey temporal punctuality (usually called "achievements"). States of affairs described by the expression *write a letter* (usually called "accomplishments") are temporally limited, alias bounded or telic, as they describe a situation with a natural end - the moment where the letter is completed. States of affairs described by the expression *walk in the park* are temporally unlimited ("process"), alias unbounded or atelic, as they describe a situation without an explicit natural end. Thus, eventualities or states of affairs exhibit internal structure. Up to now the literature explores the evidence related to tense, aspect, and temporal reference in texts with two respects:

1. what is the interrelation between language predicates and the ontological underlying general structures.
2. what is the interrelation between the language means and the human perception of them such that in texts convey the temporal order, they actually do.

These two views are basically reflected in two interpretations of the notion of event in the literature. In both of them change is an important distinctive feature for singling out events.

In the first view change is associated with culmination or reaching of a termination point. It takes the notion of aspect as equal to the notion of event type. Aspectual type of the verbs is determined through the underlying ontological properties of the eventuality described, typically referred to as *event*. This approach regards events as mirroring the ontological properties of a conceptual entity with rigid edges (begin, continuation, termination), which can be conceptually decomposed ([Pustejovsky, 1991], [Grimshaw, 1990], [Bach, 1986], [Moens and Steedman, 1988]).

The second view associates change with the flowing time in terms of conditions that hold or do not hold at particular times ([Kamp, 1979], [Kamp and Reyle, 1993]). This approach regards events as mirroring the common understanding of the nature of time as a discrete sequence of points in each of which either something obtains or something occurs. It distinguishes between events and states on the basis of whether the eventuality described conveys a change or a condition. It also adopts the position that aspectual meaning of an expression gives rise to the distinction *event - state*, and suggests a method to cope with the temporal order of the states of affairs described in texts. *States* typically convey a temporal relation of inclusion with the previously introduced event in the discourse, whereas *events* convey a temporal relation of sequence with the previously introduced event in the discourse.

In most cases these two views are either intuitively seen as overlapping, or if their distinction is recognized the boundary between the two of them seems to be loose and unclear. For example, in Moens and Steedman's approach [Moens and Steedman, 1988], *event* and *state* are hyperconcepts, comprising subclasses of ontological constructs, according to certain criteria. Thus, *culminations*, *culminated processes*, *points*, and *processes* belong in their taxonomy of ontological classes into the group of *events*, and *lexical states*, *progressive states*, *consequent states*, *habitual states* belong into the group of *states* (cf. figure 1). In Partee [Partee, 1984] and Hinrichs [Hinrichs, 1986], ontological *processes* and *states* are uniformly classified as *states* on the basis of their lacking of termination point, whereas the ontological *culminated processes* and *culminations* are considered as *events* to name just two.

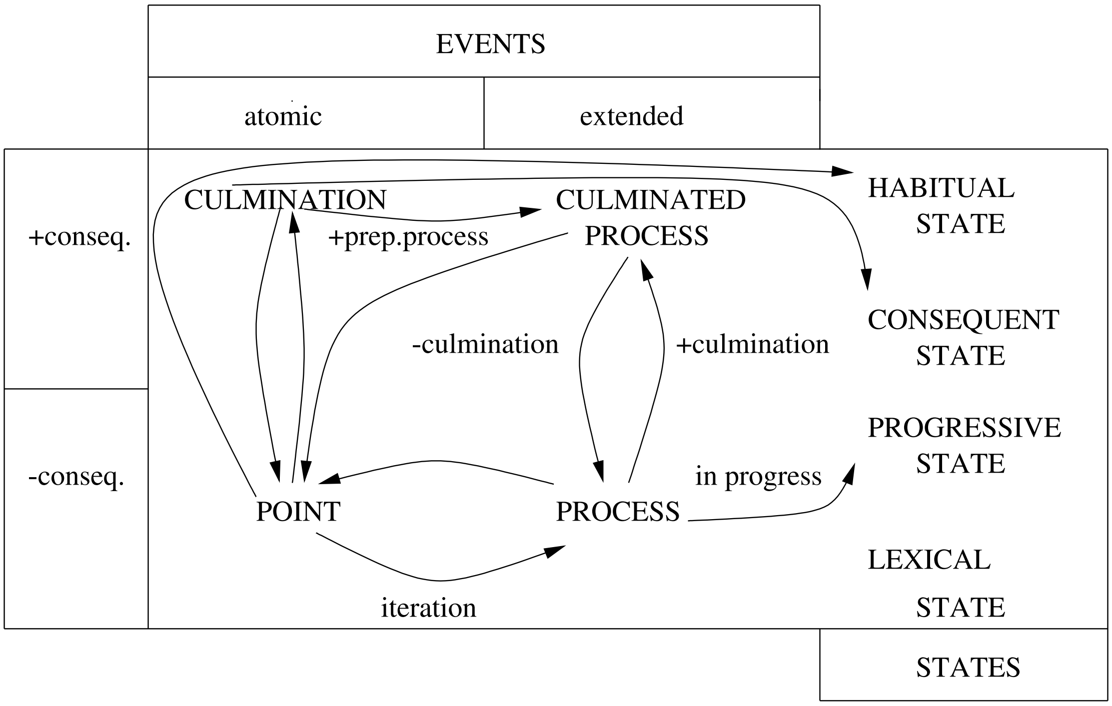

Figure 1: Moens's aspectual taxonomy and network.

3 Events as a Lexical Category

Pustejovsky's [Pustejovsky, 1991] account for the syntax of event structure is based on the idea of creating a method for a structured representation of lexical and compositional information. His theory of lexical decomposition is based on the central idea that word meaning is highly structured, and not simply a set of semantic features. He argues that one level of semantic description involves an event-based interpretation of a word or phrase - its *event structure*, where *event structure* is just one level of the semantic specification for a lexical item, along with subcategorization, argument structure, and qualia structure. *Event* in Pustejovsky's view is used to describe the properties of certain lexical items with respect to their internal ontological temporal structure. Because in English an event structure is recursively defined in the syntax, "event-type" is also a property of phrases and sentences. Event structure is described by three components:

1. the primitive *event type* of the lexical item
2. the rules of *event composition*
3. the mapping rules to lexical structure.

Pustejovky accounts for three basic event types (E, where E is a variable for any event type):

(i) *states* (S), single events which are evaluated relative to no other event, with structural representation:

$$\begin{array}{c} S \\ | \\ e \end{array}$$

(ii) *processes* (P), sequences of events identifying the same semantic expression with structural representation:

$$\begin{array}{c} P \\ | \\ e_1 \ . \ . \ . \ e_n \end{array}$$

and (iii) *transitions* (T), events identifying a semantic expression, which is evaluated relative to its opposition with structural representation:

$$\begin{array}{c} T \\ E_1 \quad \neg E_2 \end{array}$$

He gives a unified decomposition of all eventualities into smaller *"subevents"*. Pustejovsky's notion of temporal aspect, referring to different event types, is defined as

> "the behaviour of sets of periods involving the concepts of *initial*, *internal*, and *final* temporal subperiods, as they relate to the semantic roles associated with the arguments of predicates."

So, he generalizes ontological types of activities, accomplishments, achievements, states to one notion of *event*, expresses them with a unified structural description, and explores syntactic patterns of constructing differently structured event descriptions.

4 Aspectual Verbs in English

English verbs like *begin*, *start*, *cease*, *resume*, *end*, *stop* are called *aspectual* ([Dowty, 1981]) because of their lexical meaning. They describe predicates which refer to temporal parameters of states of affairs talked about in texts. This direct relation between the specific lexical verb meaning, temporal structure of the eventualities, and aspect, mirrors the common understanding of aspect as associated with the ontological configurations. This class of verbs is referred to as *aspectual*, because of their lexical meaning, which is very closely associated with the ontological constructs describing the internal temporal structure of states of affairs. On the other hand, as independent lexical items these verbs generally behave in sentences as any other lexical class of verbs. This includes their compatibility with other means of conveying aspectual meaning. For example, they have aktionsart, select for progressive in English, etc. Semantically, *begin* refers to the temporal structure of the eventuality described by its complement verb. The complement verb is the main eventuality described and *begin* functions as an aspectual marker (with respect to the definition of aspect in [Dowty, 1986]) of this main eventuality. For example, the sentence in (1) describes the situation of John's beginning a process of writing.

(1) John began to write a letter last night.

This sentence has in fact two predicates that exhibit aspectual properties. One is described by the expression *write a letter*, which is an *accomplishment*, and the other one is described by the verb *begin*, which lexically is an *achievement*. But semantically, *begin* relates to the internal temporal structure of the eventuality described by its complement verb *write*. It refers to the initial point, the time of the start of a temporally extended telic eventuality of *John's writing a letter*. We claim that the functional role of aspectual verbs is to modify the eventuality described by their complement, and in consequence require particular interpretation.

4.1 Aspectual verbs - *achievements*

Achievements have a well defined and straightforwardly determined meaning in terms of the abstract temporal schema they evoke. They are defined as punctual states of affairs with climax, which trigger resultative state (cf. [Vendler, 1967]). The paradigmatic examples for achievements are the verbs *to reach*, *to arrive*, *to die*. They all describe instantaneous changes in situations. This can be illustrated and justified through the linguistic tests for selection of achievements. Examples 2-4 show the parallel evidence of the tests in question used with the verb *reach*, and with the verb - *begin*.

In the context of *"it took + temporal amount expression"* achievements trigger the intuition that the time period denoted by the temporal amount expression entirely precedes the time of the eventuality described by the verb. Examples 2(a) and 2(b) describe situations which correspond to this intuition. The three hour period referred to in these to examples is conceived as totally preceding the *reaching of the top*, and the *beginning of the letter writing*.

(2) a. It took John three hours to reach the top.

b. It took John three hours to begin to write a letter.

Punctual temporal adverbials, uttered in combination with achievements, temporally locate the instantaneous eventuality described by the verbs. Thus, the adverbial *at five* in examples 3(a), 3(b), and 3(c) denotes the time at which the *reaching*, the *beginning*, and the *starting* took place.

(3) a. John reached the top at five.

b. John began to run at five.

c. John started to swim at five.

Further, the interpretation of sentences with adverbials like *almost* and achievements implies that the eventuality described by the verb did not take place at all. Thus, the *reaching*, the *beginning*, and the *starting* of sentences 4(a), 4(b), and 4(c) are said to not having taken place at all.

(4) a. John almost reached the top.
b. John almost began to run.
c. John almost started to swim.

So, the verb *begin*, the one we chose to exemplify the aspectual behaviour of the group of aspectual verbs, exhibits the typical semantic properties of *achievements*.

We showed that in the Vendler's terms [Vendler, 1967] *begin* is an achievements. But, not all tests for achievements successfully apply to *begin*. Achievements do not combine felicitously with volitional adverbs. While it is possible to *write a letter*$_{(accomplishment)}$ *carefully* or *deliberately*, or to *push a cart*$_{(activity)}$ *carefully*, it is not possible to *spot*$_{(achievement)}$ or *recognise*$_{(achievement)}$ something *carefully* or *deliberately*, as it is not possible to *know*$_{(state)}$, *believe*$_{(state)}$, *love deliberately* or *carefully*, but the same adverbs sound acceptable in sentences with *begin* (cf. 5(b)-(c)). This is because they actually modify the process described by the complement verb, and not to the verb *begin* itself.

(5) a. John began running carefully.
b. John began to whistle carefully.
c. John started to run carefully.

Thus, on the one hand the verb *begin* conveys an instantaneous change of state, on the other hand the lexical meaning of this verb opens a particular ontological context, which affects the surrounding discourse, and must be accounted for.

4.2 Aspectual verbs - driving inferencing context

Note that all complement verbs of *begin* in the examples above denote processes. The following newspaper and literary examples justify this observation.

(6) Meanwhile, Northrop's own board *began* inquiring$_{(process)}$ about what happened to the hotel – the Seoul Palace, it was to be called – and the $6,250,000. It was

at that point, the filing alleges, that a cover-up$_{(process)}$ *began.*
WSJ 891027-0051

(7) There had been times, lately, when he had *begun* to wonder$_{(state)}$ whether he was entirely suited to the career in which he had been launched some fifteen years earlier, not so much by personal choice as by the mere impetus of his remarkable First.
David Lodge, *Changing Places*

It appears that the complement of *begin* can be only describing an ontologically protracted eventuality - a process, or a state. The language predicates which describe punctual eventualities - points or achievements - typically have two possible interpretations. They either describe the single occurrence of the punctual eventuality, referred to by the verb, or the process of repeated occurrences of the punctual eventuality, referred to by the verb. Thus, sentence in (8) can describe either the situation of a single *"kick"*, or the situation of repeated *"kicking"*.

(8) John kicked the ball.
two interpretations - episodic, iterative

The extension of sentence 8 with a *punctual*, and a *temporal amount adverbial* in 9(a)-(b) illustrate this evidence.

(9) a. John kicked the ball at five.
(episodic)

b. John kicked the ball the whole afternoon.
(iterative)

Thus, when *begin* occurs in a sentence with a verb describing an instantaneous situation like *kick*, *sneeze*, *win*, *see*, *spot*, it enforces the process interpretation of these predicates, excluding their punctual episodic reading. Example 10(a) describes the beginning of a process of repeated kicking. 10(b) describes the beginning of the state of being aware, as *see* is her intuitively grasped in its metaphorical meaning of *understand.*

(10) a. John began to kick the ball.

b. John began to see the point of that argument.

This paper explores the evidence that the aspectual predicate *begin* introduces particular inferential context, and claims that this context constrains the interpretation of sentences and texts.

4.3 Aspectual verbs - in discourse

Generally, the syntactic role of *begin* as a main verb implies its role of carrier of the tense marking and of the information which establishes the temporal cohesive links with the surrounding discourse.

But, examples 11(a)-(c), representing little discourses, show that the eventualities described by each second sentence in fact anaphorically refer to the process described by the complement verb, and not to its beginning, referred to by the main verb *begin* of the first sentences.

(11) a. John began to write a letter last night. He gave up after a while.

b. John began to write a letter last night. It took him a while before he could concentrate.

c. John began to write a letter last night. He finished it by 2:00 am.

The pronoun *it* of the second sentences of examples 12(a)-(b) could be interpreted as referring back either to the beginning, referred to by the verb *begin* or th the initiated processes described by the complement verbs *walk* and *kick*.

(12) a. John began to walk. I saw it.

b. John began to kick the ball. I saw it.

The first sentences in 11(a)-(c) and 12(a)-(b) can be regarded as containing two eventualities each: (i) the one of the start, which is described by the syntactically governing, and semantically auxiliary verb *begin*, and (ii) the one of the process, which is described by the syntactically subordinated, and semantically topical eventuality. The two of them can be referred to anaphorically by subsequent sentences. This is due to the meaning of the aspectual verb *begin*. If we try to interpret a similarly shaped discourse, but containing instead an aspectual verb like *finish* or *stop* (cf. 13(a)-(b)) pointing to the ontological final edge of the topical eventuality described, then the pronoun *it* of the second sentence can only be interpreted as referring to the stopping or the finishing point of the eventuality described.

(13) a. John stopped walking. I saw it.

b. John finished to build a house. I saw it.

Furthermore, the inferential context triggered by the lexical meaning of the aspectual verb *begin* allows the construction of a well-formed embedded discourse, where pronoun and anaphoric antecedent are separated by several sentences, and provides relevant information for correctly resolving the established anaphoric links. For example, the last sentence of the following discourse (cf. 14) refers back to its first sentence. The pronoun *it* refers back to the process of singing, described in the complement of *begin*.

(14) John *began* singing$_{(process)}$. He was in a good mood. He had spent a marvelous week end. He went to that famous island. The weather was nice, his company bearable, the atmosphere relaxing. Unfortunately, the melody was false. He had never had an ear for music. "Stop it$_{(referring_back_to_''singing'')}$!" someone shouted.

Thus, the aspectual verb *begin* creates such an inferential context, which has effects on sentence and on discourse level. It restricts the ontological type of the eventuality described by its complement verb, and it allows for certain patterns of anaphoric binding of texts.

4.4 Aspectual verbs - in progressive

The fact, that *begin* is a full verb makes it possible for it to combine with progressive - the grammatical device in English to convey aspectual meaning. Roughly, progressive is interpreted in formal semantics accounts (for example, [Landman, 1992], [Asher, 1992]) as conveying incompleteness of the eventuality described by the verb it applies to. This effect is especially relevant for ontological types of eventualities which have an inherent termination point, like accomplishments. The sentences in 15(a)-(c) with the verb *begin* in progressive convey situations in which the beginning of the process at stake is described as coming about.

(15) a. He was beginning to play soccer.

b. He was beginning to realize the absurdity of the situation.

c. He was beginning to learn Spanish.

Further, the progressive of the verb *begin* conveys temporal relation of overlap with the eventuality described by an adjacent clause. For example, the *when* clauses of sentences 16(a)-(b) describe eventualities which overlap with the beginning of the process, coming about.

(16) a. John was beginning to run, when the rain started.

b. He was beginning to paint the walls in his kitchen, when a stone flew through the window and almost killed him.

Thus, in the case of aspectual verbs in progressive we observe a twofold application of aspectual information to the eventuality described by the complement verb. On the one hand the full verb *begin* signals the starting point of the process, on the other hand the progressive modifies the situation referred to with *begin* as not completed, or intended. So, the verb *begin*, governing syntactically, has semantically an auxiliary role. It denotes the initial moment of this other main eventuality. As a full verb it can be interpreted as describing an eventuality itself. Tense and progressive affect its meaning the way they affect eventualities described by other full verbs, for example *reach*, *win*, *read*, *work*, etc. Here we need to decide how are we going to make explicit the fact that the aspectual verb itself gets aspectually modified.

We argue that aspectual lexical predicates prove that we are in need of two notions of events - lets call them *ontological eventuality type*, and *textual event* - if we wish to be able to account properly for the temporal structure of texts in a formal way.

5 Other Language Means to describe *begin*

The language means to derive aspectual meaning are numerous: lexical predicates, combination between predicates, tense, aspectual markers, argument types. Moreover, very often one and the same semantic effect within one language can be achieved by different devices. For example, the sentence in 17(a) triggers such inchoative context. Their interpretation is semantically identical to the interpretation of the *begin + complement verb* construction.

(17) a. Suddenly he knew the answer.

Whether it is lexicalized or conveyed by the context the inchoative meaning have one and the same semantic effect with this respect. It describes an event which is the start of something extended in time, which can be inferred in consequence. We claim that these two syntactic patterns convey identical semantic content, so they are to be accounted for in a uniform way. To do this we are going to adopt two well known theoretical approaches: Discourse Representation Theory ([Kamp, 1981], [Kamp and Reyle, 1993]) and The Generative Lexicon ([Pustejovsky, 1995]).

6 Discourse Representation Theory

Discourse Representation Theory ([Kamp, 1979]; [Kamp and Reyle, 1993]) originates in model-theoretic semantics and provides a theoretical framework to account for the semantic representation of linguistic phenomena which cannot be accounted for by the standard truth conditional approaches. Model-theoretic semantics considers the representation of the truth-conditions of single propositions (cf. 18(a)-(c)).

(18) a. John opened his eyes.

b. $\exists$ j $\exists$ e $\exists$ y $\exists$ t0 (e $<$ t0 $\wedge$ open (e,j,y) $\wedge$ eyes(y) $\wedge$ belong(y,j))

c. His wife smiled at him.

d. $\exists$ e$'$ $\exists$ y $\exists$ t0 (e$'$ $<$ t0 $\wedge$ smile_at (e$'$,y,j) $\wedge$ wife(y) $\wedge$ belong(y,j))

But it failed to provide tools to represent the truth conditions of whole discourses. Discourse Representation Theory considers the fact that it is in general not possible to represent the truth conditions of a text as a simple conjunction of the truth conditions of the sentences of which it consists. Many sentences contain anaphoric elements which connect them semantically to earlier sentences in the text. So, the meaning of the whole is at the end more than the conjunction of its parts. A simple conjunction of sentence meanings does not account correctly for the anaphoric links which appear in a sequence of sentences. For example, the two sentences of (19) would be assigned the same truth conditions, as the single sentences in (18a) and (18c), but the conjunction of them both in 19 fails to capture the intuition that in $(19)_{(1)\text{-}(2)}$ the smiling is temporally related to the eye opening. It also fails to capture in a salient way how the pronouns in the two sentences are connected with each other.

(19) a. $_{(1)}$ John opened his eyes. $_{(2)}$ His wife smiled at him.

b. $\exists$ j $\exists$ e $\exists$ y $\exists$ t0 $\exists$ e$'$ $\exists$ y$'$ (e $<$ t0 $\wedge$ open (e,j,y) $\wedge$ eyes(y) $\wedge$ belong(y,j) $\wedge$ e$'$ $<$ t0 $\wedge$ smile_at (e$'$,y$'$,j) $\wedge$ wife(y$'$) $\wedge$ belong(y$'$,j))

The idea which lies at the heart of DRT is that such phenomena in discourse can only be properly analysed within a model-theoretic semantics by using a model of the discourse, in which the cohesive links between the elements of the consequent sentences are made explicit. Thus, DRT combines a definition of truth with a systematic account of semantic representations. The analysis of a sequence of clauses proceeds in two steps:

1. after a syntactic analysis of language input, discourse representation rules are applied which map the sequence onto a discourse representation structure,

2. the discourse representation is given a truth-conditional interpretation relative to a model of the world (whereas the individual sentences are not truth-conditionally interpreted directly).

6.1 Discourse Representation Structures

Discourse Representation Theory suggests a mechanism to handle the problem of increasing the information conveyed by each successive sentence in discourse and to represent this dynamically in a formal way. The dynamic representation of discourse consists in using a complex formal tool for semantic representations, referred to as Discourse Representation Structures (DRS-s), which, constructed according to particular principles, provides a bridge between the linguistic expressions and the truth model of discourse. DRSs are not mere representations of just single sentences. They are designed to describe the informational content of multi sentential units, paragraphs, or texts. DRSs consist of two components:

1. a set of discourse referents, called the universe of the DRS.

2. a set of DRS-conditions or formulas in which predicates are combined with chosen discourse referents to encode which individuals satisfy which predicates in the DRS-conditions.

Thus, the two components of the DRS form a logically connected pair <U,C> of discourse referents <U> for abstract entities (individuals or events), and discourse conditions <C>, describing in logical conjunctions the ways in which the discourse referents relate to each other. Graphically, the DRSs are displayed as boxes. The upper part of the box is reserved for the elements constituting the universe of discourse. The part below the universe contains the outline of the DRS-conditions. In example 20 the universe of the DRS representing the sentence *Jones loves Birgit* consists of the discourse referents x and y, the set of conditions Jones(x), Birgit(y) and the predicate [x loves y]. This DRS mirrors the interpretation of the sentence as describing a relation of love between two individuals, the one who loves, and the one who is loved.

(20) a. Jones loves Birgit.

b. $$\begin{array}{|c|}\hline \text{x y} \\ \hline \text{Jones(x)} \\ \text{Birgit(y)} \\ \text{x loves y} \\ \hline \end{array}$$

DRSs provide mechanisms to make the temporal relations in texts explicit. The temporal abstract entities that can be part of the universe of the DRSs are: *events*, *states*, *times* and n - a temporal referent standing for *now*, e.g. referring to the speech time. The DRS conditions which represent the interrelations between those entities comprise two theoretically justified and formally determined temporal relations: temporal inclusion ($\subseteq$) and temporal precedence ($<$). Starting point of DRT theory of temporal reference is the observation that the contrasts in the natural language devices for temporal reference cannot be captured within a theory of truth conditions. The ways humans interpret the temporal order of states of affairs talked about in sequences of sentences relies sometimes on pragmatic and rhetorical evidence, not merely on semantics. The conveyed order of events in discourse can be regarded as depending on the status of the mechanism for conveying it. For example, the English expression *be ill*, bearing the ontological properties of a state, in simple past can have different impact on the temporal order of the story told, as shown in examples 21(a)-(b):

(21) a. I only corrected the paper last night. First I had to finish the grant proposal. Then I *was ill*. Then we had the project review which took three days and more than a week of preparation.

b. I arrived at the Olivers' cottage on Friday night. It was not a propitious beginning to my visit. She *was ill* and he in a foul mood.

In the context of 21(a) the illness reported in the second sentence is understood as temporally located after the time of finishing of the grant proposal and before the time of the project review. On the contrary, the illness in the context of 21(b) seems to describe a state of affairs obtaining at the time of the speaker's arrival. The comparison between 21(a) and 21(b) brings out clear evidence to what extent it is a matter of pragmatic salience or of conceptualisation of the described situation to convey different temporal order with one and the same device. In the first case *be ill* is conceived in one way, as it updates the time of reference in pushing it forward, whereas in the second case it is conceived in another way, as it overlaps with the already introduced temporal referent and does not move the narrative time forward.

The sequence of sentences in 22(a) describes a situation of two subsequent events. The first sentence describes an event of *eye opening by John* which took place before the speech time. The second sentence describes an event of *smiling at John by his wife* which took place before the speech time, and after the event described by the first sentence. The DRS in 22(b) has two events, e1 : $\boxed{\text{open(x,y)}}$ and e2 : $\boxed{\text{smile\_at(z,l)}}$. Their times (e1 $\subseteq$ t$'$ and e2 $\subseteq$ t$''$) are both located before the *now* time (t$'$ < n and t$''$ < n), and e1 temporally precedes e2 (cf. e1 < e2).

(22) a. (1) John opened his eyes. (2) His wife smiled at him.

b.
$$\begin{array}{|c|}\hline \text{n e1 e2 x y z l t}'\text{ t}'' \\ \\ \text{e1} \subseteq \text{t}' \\ \text{t}' < \text{n} \\ \text{John(x)} \\ \text{his\_eyes(y)} \\ \text{e1 : } \boxed{\text{open(x,y)}} \\ \text{e2} \subseteq \text{t}'' \\ \text{t}'' < \text{n} \\ \text{e1} < \text{e2} \\ \text{his\_wife(z)} \\ \text{l} = \text{x} \\ \text{e2 : } \boxed{\text{smile\_at(z,l)}} \\ \hline \end{array}$$

The sequence of sentences in 23(a) describes another situation. While in 22(a) the *smiling* of the second sentence is intuitively understood as occurring after the *eye opening*, whereas the *smiling* of the second sentence in 23(a) is rather conveyed as obtaining before the event of *eye opening*. This distinction is made explicit in the DRS 23(b). It has one event (e1), and one state (s2), whose times are located before the *now* time (t$'$ < n), and the state temporally overlaps the event, e.g. the event is temporally included into the state (e1 $\subseteq$ s2).

(23) a. (1) John opened his eyes. (2) His wife was smiling at him.

b.
$$\begin{array}{|c|}\hline \text{n e1 s2 x y z l t}' \\ \\ \text{e1} \subseteq \text{t}' \\ \text{t}' < \text{n} \\ \text{John(x)} \\ \text{his\_eyes(y)} \\ \text{e1 : } \boxed{\text{open(x,y)}} \\ \text{t}' \subseteq \text{s2} \\ \text{e1} \subseteq \text{s2} \\ \text{his\_wife(z)} \\ \text{x} = \text{l} \\ \text{s2 : } \boxed{\text{PROG : } \boxed{\text{smile\_at(z,l)}}} \\ \hline \end{array}$$

Furthermore, the operator PROG which appears between the discourse referent s2, and the predicate $\boxed{\text{smile\_at(z,l)}}$ indicates the semantic nature of the states described. Such DRS operators are one additional extension of the language of DRT intended to make explicit some parameterized meaning divergences, which apply to DRS universe individuals. The operators are connected to corresponding meaning postulates. Our proposal pretains to the determination of new parameterized ways of modifying DRS temporal referents, which trigger the definition of new aspectual operators with new meaning postulates.

6.2 The DRT Model of Time

In order to be able to account for the temporal relations described by language expressions, according to formal semantics, it is necessary to provide a model of time. DRT introduces into this idea an important subjective element. The distinctive feature of the concept of time which underlies the formal account of DRT is the thesis that the structure of time depends on the conceptual framework that is used in the determination of the eventualities talked about in texts. The structural properties of time are determined by presenting time as a linear ordering of points, derived from an underlying structure of events. Instants are postulated to be times that are atomic and intervals are postulated to be non-atomic times, which can trigger pluralities. Unlike the more common approach of defining events in terms of times, DRT advances the idea that instants may be constructed from events, structured in accordance to some mathematical principles. Central role in Hans Kamp's theory of temporal reference [Kamp, 1979] is the transformation of event structure into instant structures. He argues that this allows more adequate representation and flexible modelling, namely:

1. to discover additional postulates for event structures which allow the derivation of additional structural conditions on the derived ordering;
2. to find independent justification for these additional postulates.

Mathematically such a construction can proceed in the use of two binary temporal relations: the one of complete precedence, and the one of temporal overlap that can hold between events. While it is possible to indicate how to define the earlier-later relation, it does not seem to be so evident to show how to construct instants themselves. This representation involves some sort of contraction of what are in physical terms protracted happenings to indivisible temporal units. For example, something may emerge as an instant in the instant structure induced by the discourse representations, but from a common sense physical or ontological point of view it may be temporally extended. It is thus determined through the particular ways of talking about it. Formally this should mean that in a model which represents the "real world" as it develops through time the sequence of sentences taken in its entirety is true at the time they were uttered. The interpretation of such an example leads to temporally ordered structures in which they do play the role of instants. Thus, the model provides a structure of instants such that for each of the events there is a certain set of instants at each of which the event is "going on". In contradiction with the conception of the linearity of time the instant structures are represented in Kamp's model as partially ordered, corresponding to the way humans seem to process linguistically conveyed information.

While the temporal connections between the introduced entities are objective, the concept of event itself is not. What can count as an individual separate event in the framework of DRT depends on the means for singling it out. Events are considered as irreducible entities but not taken to be instantaneous absolutely. And this is the basis for the distinction between events and states. Events involve some kind of change, whereas states do not. States involve the continuation of some condition whereas events involve its abrogation. It means for a state to obtain over some interval that some condition remains in force for the duration of that interval. The occurrence of an event, in contrast, implies that some condition, which obtains before the event begins, is terminated by the1' event and gets replaced by another, "opposite" condition.

6.3 From Language Structures to DRS

Whether a language expression conveys a state or an event, argues DRT, depends on its aspectual characteristics. A closer look at the kind of eventualities that are described by different verbs, or by different verb-argument combinations reveals, however, that many finer distinctions do exist. These finer distinctions that are relevant for English, claim Kamp and Reyle ([Kamp and Reyle, 1993]), can be drawn on the basis of a pair of simple structural schemata which play crucial role in the view of humans' conceptualisation of events and states. The relevant for English distinctions of aspectual properties can be described in a nuclear schema consisting of three parts: (I) preparatory phase, (II) culmination point (CP), (III) result state, as shown in figure 2. The paradigmatic differences of aspect for given linguistic expressions are determined as a function of their referring to different parts of this general nuclear schema. This incorporates Kamp's view [Kamp, 1979] of the difference between the perfective and imperfective constructions. One and the same predicate *write a letter* can be described as referring to different parts of the general schema, and thus qualified as exhibiting different aspectual forms (cf. 24(a)-(c).

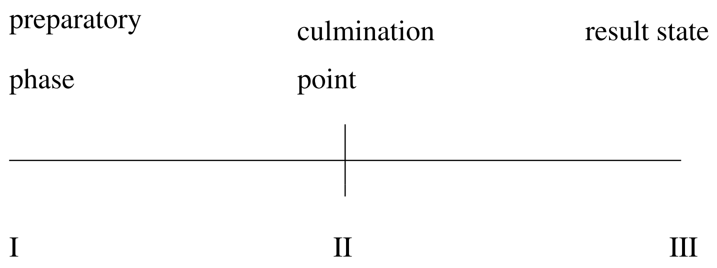

Figure 2: Abstract Schema.

(24) a. John wrote$_{(simple_past)}$ the letter.
→ referring to part (I)+(II) of the general schema

b. John was writing$_{(past_progressive)}$ the letter.
→ referring to part (I) of the general schema

c. John has written$_{(present_perfect)}$ the letter.
→ referring to part (III) of the general schema

DRT has elaborated a mechanism to keep a trace in the DRS-es which indicates the type of the input state. Special DRS operators basically apply to the eventuality describing predicates, and are separately assigned appropriate meaning in meaning postulates. The meaning of such DRS operators, being also related to aspectual in nature, is defined with the components of the postulated general schema. Thus, the DRS operator **PROG**[1], covering the meaning of the English progressive is described in the following meaning postulate:

Semantic Effect of the Progressive:

> The eventuality described by progressive forms of a verb **v** are of the type which is represented by that part of the schema corresponding to the Aktionsart of **v** which terminates in, but does not include, the culmination point.

Thus, the notion of the general schema which has been used to describe the meaning of English progressive. These examples show that several grammatical phenomena can refer to identical conceptual entities. We saw however that *begin* and generally the class of aspectual verbs pertains to the ontological type of the eventuality described by their complement.

[1]Example (23) shows DRS representation of sentence in past progressive, containing **PROG**.

7 Representation and Construction

As the lexical meaning of the aspectual predicates evokes particular predictable ontological event/eventuality types, we suggest a solution of this problem in expoiting the notions of *textual event* and of *ontological eventuality type* and showing that in combination they represent a powerful expressive tool. We propose a method to treat aspectual predicates as "eventuality" modifiers. We focus on the observation that the aspectual predicates only combine with particular ontological types of states of affairs, namely the ones which conceptually allow for phases like states, and processes, whereas they cannot co-occur with predicates, which denote single and punctual occurrences like achievements, culminations or points (in the sense of [Vendler, 1967] or [Moens and Steedman, 1988]). We keep the notions of e and s in the sense of DRT, and use the DRT mechanisms to construct and interpret temporal information in discourse. We add into the language of the DRS the notion of ontological eventuality type σ, which describes the temporal profile of the eventulity described by the expression - process, point, accomplishment, achievement, state[2]. In fact the notion of σ corresponds to the notion of *event* in Pustejovsky's account about the syntax of events. The interpretation and the structure of σ is derived from the lexical meaning of the predicate, and is structured according to the principles of the generative lexicon ([Pustejovsky, 1995]). Also, we adopt Bergler's idea (cf. [Bergler, 1995]) of the matrix clauses, as semantic carriers of textual meta-information, and consider the aspectual verbs as constituing a similar phenomenon, but in different lexical semantic domain. Because of their auxiliary role aspectual verbs will not be directly referred to as σ-s, but as DRS operators. Like the progressive they will introduce aspectual operators, which describe their lexical meaning in the operator's meaning postulate, but will not appear in the DRS of the processed discourse. They are represented as DRS operators with a meaning explicited in the form of meaning postulates. The aspectual operators transform a predicate of certain ontological type into another. Their meaning enforces particular interpretation of the eventuality they are applied to, and thus play the role of disambiguation factors.

For example, the meaning postulate of *begin* will describe its meaning contribution. **BEG** describes an event e, which points out the start of an eventuality σ. The meaning postulate makes this explicit by stating the temporal relation of immediate precedence between a state s representing the negation of σ, and the event e, which provides the transition from $\neg \boxed{\sigma}$ to σ - s $\supset\subset$ e. Thus, while the culmination is intuitively a transition from an eventuality σ to its abrogation, the inchoatives can be considered as transitions from the abrogation of σ to its manifestation. Further, we already mentioned that the meaning of the verb *begin* infers that the eventuality

[2]For further details and motivation regarding the plausibility of such a propsal see [Damova, forthcoming].

described by its complement is of a particular type. To make this explicit, we incorporate into the meaning postulate of *begin* the description of the ontological eventuality type of σ - σ: $\boxed{\begin{array}{c} \mathrm{T} \\ \mathrm{P}^{*} \quad \mathrm{S} \end{array}}$ [3] which follows the generative lexicon definitions of event types, extensively discussed in [Pustejovsky, 1995].

(25) Meaning Postulate for **BEG**:

$$\mathrm{BEG}(\mathrm{e}(\sigma)) \Rightarrow \boxed{\begin{array}{c} \mathrm{s} \\ \\ \mathrm{s}\text{: } \neg \boxed{\sigma} \\ \mathrm{s} \supset\subset \mathrm{e} \\ \sigma\text{: } \boxed{\begin{array}{c} \mathrm{T} \\ \mathrm{P}^{*} \quad \mathrm{S} \end{array}} \end{array}}$$

Thus, the DRS 26(a) of the sentence in 26(a) contain only the description of σ - $READ(\sigma$,m,c), and the event - e - derived from the application of the **BEG** operator to σ. This represents correctly and in a concise way the intuition conveyed by the sentence.

(26) a. Maria began$_{(simple_past)}$ reading the$_{dir.obj,det.}$ book$_{(dir.obj.sg.)}$.

a′. $$\boxed{\begin{array}{c} \mathrm{e\ n\ m\ c}\ \sigma \\ \\ \mathrm{e} < \mathrm{n} \\ READ(\sigma,\mathrm{m},\mathrm{c}) \\ \mathrm{e}\text{: } \boxed{\mathrm{BEG}\boxed{READ(\sigma,\mathrm{m},\mathrm{c})}} \\ \mathrm{book(c)} \\ \mathrm{Maria(m)} \end{array}}$$

The combination between the meaning postulate, and the actual DRS captures and makes explicit the entire scale of semantic evidence, relevant for the processing of temporal information, which is contained in this sentence. We claim, that this way of approaching the representation and the interpretation of aspectual predicates correctly mirrors the semantic role of aspectual predicates, and the syntactic function of aspectual verbs in discourse.

Following this method of representation we can achieve a uniform account for the

[3] The * in Pustejovsky's event structure representation denotes which part of the event structure of the represented event is at stake, and is to be considered as the head of the event structure.

entire range of linguistic means describing the beginning of an eventuality. For example, the same DRS mechanism can be utterred to represent the sentence in a which describes the beginning of the state of knowing. Syntactically, this information is conveyed by the cooccurence of the punctual adverbual *suddenly* and the stative verb *to know* in simple past[4]. Thus, the DRS 27(a) representing the sentence 27(a) contains the σ referring to the predicate *KNOW*, and the event e, which is derived from the application fo teh **BEG** operator to the σ. The meaning postulate of **BEG** provides the inferred semantic information[5].

(27) a. Suddenly Maria knew$_{(simple_past)}$ the$_{(dir.obj,det.)}$ answer$_{(dir.obj.sg.)}$.

a′.
$$\boxed{\begin{array}{c} \mathrm{e\ n\ m\ a}\ \sigma \\ \\ \mathrm{e} < \mathrm{n} \\ KNOW(\sigma,\mathrm{m},\mathrm{a}) \\ \mathrm{e}\text{: } \boxed{\mathrm{BEG}\boxed{KNOW(\sigma,\mathrm{m})}} \\ \mathrm{Maria(m)} \\ \mathrm{answer(a)} \end{array}}$$

Meaning Postulate for **BEG**:

$$\mathrm{BEG}(\mathrm{e},KNOW(\sigma,\mathrm{x},\mathrm{y})) \Rightarrow \boxed{\begin{array}{c} \mathrm{s} \\ \mathrm{s}\text{: } \neg \boxed{\begin{array}{c} \sigma\ \mathrm{x\ y} \\ \sigma\text{: } \boxed{\mathrm{x},KNOW,\mathrm{y}} \end{array}} \\ \mathrm{s} \supset\subset \mathrm{e} \\ \sigma : \boxed{\begin{array}{c} S \\ | \\ e \end{array}} \end{array}}$$

Thus, we argue, that the advantages of this approach are that it allows to derive a concise representation for evidence which can be conveyed by various language means, e.g. different syntactic structures, morphological derivations, or compositional contextual constraints, that it allows to make explicit and keep apart the

[4]Note that *suddenly* derives different interpretations when it modifies an accomplishment utterred in simple past. In this case the point it refers to coincides with the moment of the culmination, and not of the start of the eventuality described. This evidence addresses another issue of the interraction between temporal adverbials, eventuality types, and aspectual information, and of its semantic effects. For the sake of the clearness of our argument in the present paper we are not going to consider a discussion of this issue in depth.

[5]The meaning postulate of this example contains the concrete names of the predicates at stake in order to show in a more specific way its role and its function.

semantic and the textual relevance of the meaning of the aspectual operators. Further, the proposed approach allows through the mechanism of multiple application of DRS operators to regulate the accessibility relations between the embedded DRSes. For example, this method can correctly represent the intuitions derived by a sentence with *begin* in progressive and its complement by applying the **PROG** operator to the event derived by the **BEG** operator.

8 Conclusion

We showed the connection between the lexical meaning of aspectual predicates and the interpretation of the temproal structure of discourse. We argued for several effects derived through lexically driven inferences from the meaning of aspectual predicates: that the presence of aspectual verbs in texts, because of their lexical meaning, indicates particular temporal and aspectual discourse context, which evokes precise interpretation; that thus, they can play the role of disambiguation factors. We also claimed that because of their lexical meaning aspectual verbs have an auxiliary functional role for the interpretation of the eventualities descibed in sentences and texts, so that they are not registered as separate eventualities in the process of interpretation. Having discussed their semantic properties as full verbs, we recognized the mismatch between the syntactically governing role of aspectual verbs, and their semantically functional role. We offered a formal solution of the analyzed evidence by combining the insights of two prominent semantic approaches - Discourse Representation Theory and the Generative Lexicon, focussing on different sides of the problem of representing temporal information of texts. We demonstrated their compatibility.

References

[Asher, 1992] Nickolas Asher. A default, truth conditional semantics for the progressive. *Linguistics and Philosophy*, 15(5):462–509, October 1992.

[Bach, 1986] Emmon Bach. The algebra of events. *Linguistics and Philosophy*, 1986.

[Bergler, 1995] Sabine Bergler. From lexical semantics to text analysis. In P.Saint-Dizier and E.Viegas, editors, *Computational Lexical Semantics*. Combridge University Press, 1995.

[Damova, forthcoming] Mariana Damova. *Tense and Aspect in Discourse: A Study of the interaction between aspect, discourse relations and temporal reference within DRT with special attention to Bulgarian.* PhD thesis, University of Stuttgart, forthcoming.

[Dowty, 1981] David R. Dowty. *Word Meaning and Montague Grammar.* Kluwer Academic Publishers, 1981.

[Dowty, 1986] David R. Dowty. The effects of aspectual class on the temporal structure of discourse: Semantics or pragmatics. *Linguistics and Philosophy*, 1986.

[Grimshaw, 1990] Jane Grimshaw. *Argument Structure.* MIT Pres, 1990.

[Hinrichs, 1986] Erhard Hinrichs. Temporal anaphora in discourses of english. *Linguistics and Philosophy*, 9(1):63–82, 1986.

[Hobbs, 1985] Jerry Hobbs. On the coherence and structure of discourse. Technical report, CSLI, 1985.

[Kamp and Reyle, 1993] Hans Kamp and Uwe Reyle. *From Discourse to Logic.* Kluwer Academic Publishers, 1993.

[Kamp, 1979] Hans Kamp. *Events, Instants and Temporal Reference.* Springer-Verlag, 1979.

[Kamp, 1981] Hans Kamp. A theory of truth and semantic representation. In Gronendijk/Janssen/Stokhof (eds), editor, *Formal Methods in the Study of Language, Part 1.* Mathematisch Centrum, 1981.

[Landman, 1992] Fred Landman. The progressive. *Natural Language Semantics*, 1992.

[Lascarides and Asher, 1993] Alex Lascarides and Nick Asher. Temporal interpretation, discourse relations and commonsense entailment. *Linguistics and Philosophy*, 16(5):1–37, October 1993.

[Lascarides and Oberlander, 1993] Alex Lascarides and John Oberlander. Temporal coherence and defeasable knowledge. *Theoretical Linguistics*, 19:1–37, 1993.

[Moens and Steedman, 1988] Marc Moens and Mark Steedman. Temporal ontology and temporal reference. *Computational Linguistics*, 1988.

[Partee, 1984] Barbara Partee. Nominal and temporal anaphora. *Linguistics and Philosophy*, 1984.

[Pustejovsky, 1991] James Pustejovsky. The syntax of event structure. *Cognition*, 41:47–81, 1991.

[Pustejovsky, 1995] James Pustejovsky. *The Generative Lexicon.* Massachusetts Institute of Technology, 1995.

[Vendler, 1967] Zeno Vendler. Verbs and times. In *Linguistics and Philosophy.* Cornell University Press, Ithaca, New York, 1967.