Existential Disclosure*

Paul Dekker

ILLC/Department of Philosophy

University of Amsterdam

e-mail: dekker@illc.uva.nl

first version: 1 November 1990, revised version: 15 January 1992

The work of Kamp [1981] and Heim [1982] in the early eighties has started a new branch of semantic theorizing within the format of discourse representation theory (*DRT*). More recently, compositional, dynamic reformulations of the *DRT* framework have been given that enhance comparison of *DRT* with more classical semantic theories, in particular, Montague grammar, and that enable an integration of results (Barwise [1987], Rooth [1987], Asher and Wada [1988], Zeevat [1989], Groenendijk and Stokhof [1990], Muskens [1990]). Groenendijk and Stokhof [1990] in particular formulates a dynamic Montague grammar (*DMG*), in which the paradigmatic Montague grammar of the seventies is adapted in order to incorporate *DRT*-results.

In this paper I want to show how existing treatments of relational nouns, adverbial modification and tense in discourse can be formulated within such dynamic frameworks. Although there are vaste differences between the three kinds of phenomena, they have one feature in common. In existing treatments they all involve the specification of an implicit argument. Relational nouns appear to have implicit object arguments which can be specified by complement phrases. Many adverbs have been interpreted as predicates that range over events implicitly introduced by verb phrases. And in temporal discourse reference times implicitly referred to in one sentence are related to reference times involved in subsequent discourse. In all

*I would like to thank the organizers of the Third Symposium on Logic and Language, (Révfülöp, Hungary, August 26–31, 1990), where this paper was presented first. László Kálmán deserves special mention here. Furthermore, I would like to thank David Beaver, Gennaro Chierchia, Jeroen Groenendijk, Herman Hendriks and Martin Stokhof, and two anonymous referees, for their helpful comments. The research for this paper was supported by the Netherlands Organization for Scientific Research (NWO). The paper has been revised while the author was working on the ESPRIT Basic Research Project 6852, Dynamic Interpretation of Natural Language.

three cases we find expressions with implicit arguments referred back to by other expressions.

A dynamic semantics provides a natural framework for the treatment of these phenomena. In a dynamic semantics nouns and verbs with implicit arguments can be interpreted as functions from individuals to sentence denotations, that is, to context change potentials. Thus, they may be interpreted in precisely the same way as nouns and verbs without implicit arguments. However, the expressions which carry implicit arguments can be taken to introduce objects into the context which are available for optional adnominal, adverbial or temporal specification.

The proposals made in this paper are programmatic, compositional reformulations of existing treatments of relational nouns, adverbs and tense. The point is to show that a compositional system of dynamic interpretation provides a natural framework for the description of the phenomena involved. Although the reformulations are cast within the framework of *DMG*, such reformulations are not restricted to this particular framework. As I hope the following sections show, a completely parallel treatment of the phenomena at issue is possible in any compositional reformulation of *DRT*. I have chosen to use *DMG* because it is relatively simple, at least to those who are used to Montagovian semantics.

The paper is organized as follows. In section 1, I review very shortly the rudimentary but compositional dynamic reformulation of *DRT* into *DMG* proposed by Groenendijk and Stokhof. In this section I show that dynamic interpretation comes along with the possibility of what I will call 'existential disclosure', the possibility of addressing (dynamic) existentially closed (implicit) arguments as if they were free variables. The subsequent sections 2–4 show how existential disclosure can be employed to model the specification of implicit arguments of nouns and verbs by means of adnominal modification, adverbial modification and temporal operators.

1 Implicit arguments in dynamic semantics

Certain nouns and nominalized constructions come with implicit arguments which can, but need not, be specified by complement phrases. For instance, the relational noun *sister* may be used to denote a set of sisters without indicating the individuals of which they are a sister. Still, these individuals may be specified by a complement phrase as in *sister of John*. Similarly, we can talk about the destruction of the city without explicitly mentioning the destructive agents, but the agents can be specified, as in *the destruction of the city by the extra-terrestrials*.

Verbs, too, have been argued to come with implicit arguments which license optional specification. For instance, the sentence *The pigeon flew* has been taken to describe a certain event or change of location the source and goal of which can be specified by (optional) adverbial phrases like *from Sevilla* and *to Amsterdam*. Similarly, the time of such an event can be specified by a phrase like *last month*, or referred to anaphorically, as in the continuation *And it flew back to Sevilla afterwards*.

Implicit arguments are indefinite objects, that is, they are assumed to be, eventually, existentially closed arguments. So, a sister is supposed to be a sister of *someone*, a destruction is conceived to be a destruction of *something* by *someone* (or *something*), and the statement that the pigeon flew appears to assert the 'existence' of *some* event of flying with *some* source and goal location at *some* time. However, we just saw that complement phrases, adverbial phrases or temporal anaphors may give a further specification of these indefinite, implicit arguments or impose further conditions on them. There is no straightforward way of accounting for this in static theories.

In static theories of interpretation, an existentially closed argument is not available for further specification. So, if it is stated that Mary is a sister of someone, or if we consider the set of individuals which are a child of somebody, then, in classical theories, there is hardly any non-ad hoc means of referring back to the individual(s) of which Mary is a sister, or to the parents of the previously mentioned set of children. This is where dynamic semantics comes in. In a dynamic semantics, indefinite objects, that is, objects which are existentially quantified over, *are* available for further specification.

In a dynamic semantics, a sentence like *There is a thief in the house* is assigned an interpretation which allows the indefinite thief to be further specified in subsequent discourse. For instance, if this sentence were followed by the sentence *He came in through the window*, the resulting interpretation would be equivalent with that of *There is a thief in the house who came in through the window*. Similarly, if a *noun* or *verb* comes with an implicit argument which is existentially quantified over, then, in a dynamic semantics, the argument remains available for further specification or restriction.

Before I show how a dynamic treatment can be given of the specification of implicit arguments, I will give a sketch of the basic properties of a dynamic semantics which are required for a proper understanding of what follows. I use a formulation of *DMG* which differs slightly, but not significantly, from the one presented by Groenendijk and Stokhof (cf., Dekker [1993], Ch. 1).

Dynamic Montague grammar

Dynamic Montague grammar (*DMG*) is a version of Montague grammar (*MG*, Montague [1973]) which employs the formal apparatus of dynamic intensional logic (*DIL*, cf., Janssen [1986]), a variant of Montague's intensional logic *IL*. In *DMG* intensionality in the ordinary sense of the word is ignored. The apparatus of (dynamic) intensional logic merely serves the purpose of giving a compositional formulation of the dynamics of interpretation.

In *DMG* a proper subset of the types of *DIL* is used, the basic types $\varepsilon = \langle s, e \rangle$ and $\tau = \langle s, \langle\langle s, t\rangle, t\rangle\rangle$, and functional types derived from these two types. Sentences are assigned denotations in the type τ, which are functions from states (assignments) and propositions (sets of assignments) to truth values. Such functions can be conceived of as context change potentials. Typically, the denotation of a sentence S is a function that holds of a state s and a proposition p if, in the terminology of *DRT*, p contains a state (assignment) that verifies S with respect to state (assignment) s.

Like in *MG*, expressions of a fragment of natural language are translated into expressions of some logical language which has a well-defined interpretation. This language is built up from variables and from lifts $\uparrow c$ of extensional *DIL* constants c. (The lift $\uparrow c$ of such a constant c is of a type obtained from the type of c by replacing all occurrences of e and t in that type by ε and τ, respectively.) Among the lifted constants of type e a set of discourse markers $d, d', \ldots$ is distinguished, whose lift has type ε. The language employs λ-abstraction, application and dynamic counterparts of identity ($\tilde{=}$), negation ($\sim$), existential quantification ($\mathcal{E}d$, where d is a discourse marker) and conjunction (;). I will also use lifted extensional variables and existential quantification over the values of these variables.

Sentences in *DMG* are assigned dynamic translations with dynamic interpretations. The *static* contents of the sentences are given by the closure operation $\downarrow$. In many cases the *static* contents of a *dynamic* translation can be determined by turning the dynamic translation into an ordinary *DIL* expression using the following equivalences ($[\alpha/x]\beta$ is obtained from β by substituting all free occurrences of x in β by α):

DMG reduction

1. (λ-conversion)

   $(\lambda x\ \beta)(\alpha) \Leftrightarrow [\alpha/x]\beta$ (provided all free variables in α are free for x in β)

2. ($\uparrow$-export)

   $(\uparrow\beta)(\alpha) \Leftrightarrow \uparrow(\beta(\downarrow\alpha))$

   $\alpha \tilde{=} \beta \Leftrightarrow \uparrow(\downarrow\alpha = \downarrow\beta)$

   $\sim\Phi \Leftrightarrow \uparrow\neg\downarrow\Phi$

3. ($\downarrow$-import)

   $\downarrow\uparrow\phi \Leftrightarrow \phi$

   $\downarrow\mathcal{E}d\Phi \Leftrightarrow \exists d\downarrow\Phi$

   $\downarrow[\uparrow\phi\,;\Psi] \Leftrightarrow (\downarrow\uparrow\phi \wedge \downarrow\Psi)$

4. (associativity)

   $[\mathcal{E}d\Phi\,;\Psi] \Leftrightarrow \mathcal{E}d[\Phi\,;\Psi]$

   $[[\Phi\,;\Psi]\,;\Upsilon] \Leftrightarrow [\Phi\,;[\Psi\,;\Upsilon]]$

By means of λ-conversion an expression can be meaning-preservingly reduced under the ordinary conditions of an extensional type theory. The application of the lift of an expression β to a dynamic argument α involves the lift of the application of β to the static content of α. The dynamic equation of α and β involves the equation of the static content of α and β and the dynamic negation of Φ involves the negation of Φ's static content, i.e., of Φ's truth conditions. The import equivalences allow us to replace the other *DMG* operators by their static counterparts. The first associativity equivalence is characteristic for the system of interpretation. The equivalence holds without proviso. So $[\mathcal{E}d\Phi\,;\Psi] \Leftrightarrow \mathcal{E}d[\Phi\,;\Psi]$ also if d occurs free in Ψ. Of course, if t is a variable (not a discourse marker) the equivalence between $[\mathcal{E}t\Phi\,;\Psi]$ and $\mathcal{E}t[\Phi\,;\Psi]$ only holds if t does not occur free in Ψ.

An example

Some basic aspects of *DMG* are illustrated by a treatment of the following example, for which complications like tense will be ignored:

(1) A man is walking in the park. He is whistling.

The common noun *man* and the intransitive verbs *walk* and *whistle* translate into the lift of the constants `man`, `walk`, and `whistle`, respectively. These constants are of type $\langle e, t\rangle$, and their lifts are of type $\langle \varepsilon, \tau\rangle$, which is also the type of the variables

P and Q. The pronoun he_i is a noun phrase with an interpretation of type $\langle\langle\varepsilon,\tau\rangle,\tau\rangle$. The indefinite article a_i belongs to the category of determiners which is associated with the type $\langle\langle\varepsilon,\tau\rangle,\langle\langle\varepsilon,\tau\rangle,\tau\rangle\rangle$, the category of expressions that make up a noun phrase when combined with a common noun to their right. The combination of a noun phrase with an intransitive verb makes up a sentence. The noun phrases *a man* and *he* are coindexed in order to indicate their anaphoric relationship.

Basic fragment

- $\mathrm{a}_i \rightsquigarrow \lambda P \lambda Q\ \mathcal{E} d_i[P(\uparrow d_i)\,;Q(\uparrow d_i)]$
- *man* $\rightsquigarrow \uparrow\mathtt{man}$
- *walks* $\rightsquigarrow \uparrow\mathtt{walk}$
- $he_i \rightsquigarrow \lambda P\ P(\uparrow d_i)$
- *whistles* $\rightsquigarrow \uparrow\mathtt{whistle}$

Three standard applications yield the following translations of the two sentences in example 1:

$$(\lambda P \lambda Q\ \mathcal{E} d_i[P(\uparrow d_i)\,;Q(\uparrow d_i)])(\uparrow\mathtt{man})(\uparrow\mathtt{walk})$$
$$(\lambda P\ P(\uparrow d_i))(\uparrow\mathtt{whistle})$$

These expressions can be reduced in the following way:

$$(\lambda P \lambda Q\ \mathcal{E} d_i[P(\uparrow d_i)\,;Q(\uparrow d_i)])(\uparrow\mathtt{man})(\uparrow\mathtt{walk}) \Leftrightarrow \ (\lambda\text{-conversion})$$
$$\mathcal{E} d_i[\uparrow\mathtt{man}(\uparrow d_i)\,;\uparrow\mathtt{walk}(\uparrow d_i)] \Leftrightarrow \ (\uparrow\text{-export})$$
$$\mathcal{E} d_i[\uparrow(\mathtt{man}(\downarrow\uparrow d_i))\,;\uparrow(\mathtt{walk}(\downarrow\uparrow d_i))] \Leftrightarrow \ (\downarrow\text{-import})$$
$$\mathcal{E} d_i[\uparrow(\mathtt{man}(d_i))\,;\uparrow(\mathtt{walk}(d_i))]$$

$$(\lambda P\ P(\uparrow d_i))(\uparrow\mathtt{whistle}) \Leftrightarrow \ (\lambda\text{-conversion})$$
$$\uparrow\mathtt{whistle}(\uparrow d_i) \Leftrightarrow \ (\uparrow\text{-export})$$
$$\uparrow(\mathtt{whistle}(\downarrow\uparrow d_i)) \Leftrightarrow \ (\downarrow\text{-import})$$
$$\uparrow(\mathtt{whistle}(d_i))$$

The translation of a sequence of two sentences $S.T$ consists in the dynamic conjunction $[S'\,;T']$ of the translations S' and T' of the two sentences. The (reduced) translation of example 1 therefore reads as follows:

$$[\mathcal{E} d_i[\uparrow(\mathtt{man}(d_i))\,;\uparrow(\mathtt{walk}(d_i))]\,;\uparrow(\mathtt{whistle}(d_i))]$$

By associativity this equals:

$$\mathcal{E}d_i[\uparrow(\texttt{man}(d_i))\,;[\uparrow(\texttt{walk}(d_i))\,;\uparrow(\texttt{whistle}(d_i))]]$$

The truth-conditions of example 1 are given by the closure of the above formula:

$$\downarrow\mathcal{E}d_i[\uparrow(\texttt{man}(d_i))\,;[\uparrow(\texttt{walk}(d_i))\,;\uparrow(\texttt{whistle}(d_i))]]$$

Employing $\downarrow$-import, this equals the following formula:

$$\exists d_i(\texttt{man}(d_i)\wedge(\texttt{walk}(d_i)\wedge\texttt{whistle}(d_i)))$$

The example turns out to mean that there is a man who walks and who whistles. We see that the dynamic semantics accounts for the anaphoric relationship in example 1 which holds between the indefinite noun phrase *a man*, and the coindexed pronoun *he*. Notice that the anaphoric relationship in this example is accounted for by assembling, by means of dynamic conjunction, the meanings of the independently interpreted sentences *A man walks in the park* and *He whistles*. Thus, *DMG* gives a truly compositional formulation of the phenomenon that indefinites in one sentence may bind pronouns in subsequent ones.

This concludes the exposition of *DMG*.

Existential disclosure

In *DMG* the emphasis has been on the potential of indefinite and other noun phrases to bind coindexed pronouns. However, the same phenomena can be described as the potential of pronouns to refer to objects introduced in the context. By attaching a certain index to a pronoun it is made to address a preceding coindexed existential quantifier, if there is any. Clearly, the addressed existential quantifiers need not be introduced by explicit noun phrases, since these quantifiers may be included within the translations of (relational) nouns and (eventive) verbs.

It is expedient to elaborate a little more upon the ability to address previously introduced arguments in *DMG*. Suppose that Φ contains an 'active' occurrence of the quantifier $\mathcal{E}d_i$. (An occurrence of $\mathcal{E}d_i$ is active in Φ if it is not followed by another active occurrence of $\mathcal{E}d_i$ in Φ and if it is not in the scope of a negation sign.) Then a *free* variable x can be made to play the role of the bound discourse marker d_i in Φ by conjoining Φ with the formula that asserts the identity of x and d_i. Let us write $\{\uparrow x/d_i\}\Phi$ for such a conjunction $[\Phi\,;(\uparrow x \mathrel{\dot{\tilde{=}}} \uparrow d_i)]$. The following example shows that in the closure of $\{\uparrow x/d_i\}\Phi$ the quantification over the value of d_i in effect disappears:

$$\downarrow\{\uparrow x/d_i\}\mathcal{E}d_i[\uparrow\texttt{man}(\uparrow d_i)\,;\uparrow\texttt{walk}(\uparrow d_i)] =$$
$$\downarrow[\mathcal{E}d_i[\uparrow\texttt{man}(\uparrow d_i)\,;\uparrow\texttt{walk}(\uparrow d_i)]\,;(\uparrow x \mathrel{\dot{\tilde{=}}} \uparrow d_i)] \Leftrightarrow \quad \text{(associativity)}$$

$$\downarrow\mathcal{E}d_i[\uparrow\mathtt{man}(\uparrow d_i)\,;[\uparrow\mathtt{walk}(\uparrow d_i)\,;(\uparrow x \mathrel{\dot{\tilde{=}}} \uparrow d_i)]] \Leftrightarrow \;(\uparrow\text{-export})$$

$$\downarrow\mathcal{E}d_i[\uparrow(\mathtt{man}(\downarrow\uparrow d_i))\,;[\uparrow(\mathtt{walk}(\downarrow\uparrow d_i))\,;\uparrow(\downarrow\uparrow x \mathrel{\dot{\tilde{=}}} \downarrow\uparrow d_i)]] \Leftrightarrow \;(\downarrow\text{-import})$$

$$\exists d_i(\mathtt{man}(d_i) \wedge (\mathtt{walk}(d_i) \wedge (x = d_i))) \Leftrightarrow \;(\text{classically})$$

$$(\mathtt{man}(x) \wedge \mathtt{walk}(x))$$

Here we see that $\{x/d_i\}\Phi$ involves something like the reverse of an operation of existential closure and I will therefore call it the *existential disclosure* of $\mathcal{E}d_i$ in Φ. As the above example shows, *DMG* enables us to associate natural language indefinites with free variables, like Lewis [1975] and Heim [1982] do, by translating them using existential quantifiers in the first place.

It may be noticed that the disclosure of $\mathcal{E}d_i$ in Φ does not fully dissolve an active quantification over the values of d_i, since if Φ contains an active occurrence of $\mathcal{E}d_i$, this quantifier remains active in $\{\uparrow x/d_i\}\Phi$. So, if one really wants to make such a quantifier vacuous, then one has to 'reset' the value of d_i after the disclosure of d_i in Φ to the value d_i had before the processing of Φ. This can be done as follows:

$$\mathcal{E}t[(\uparrow t \mathrel{\dot{\tilde{=}}} \uparrow d_i)\,;\{x/d_i\}\Phi\,;\mathcal{E}d_i(\uparrow t \mathrel{\dot{\tilde{=}}} \uparrow d_i)] \text{ (where } t \text{ does not occur free in } \Phi)$$

In what follows, the possibility of addressing existentially quantified variables in *DMG* will be employed in a compositional treatment of the specification of implicit arguments. Adnominal and adverbial modifiers will be taken to address arguments which are implicitly added to the context by the nouns and verbs on which they operate. These arguments of nouns and verbs make their appearance as supplementary arguments which are existentially closed, but dynamic, and thus remain available for further specification. It may be noticed that this way of storing information about implicit arguments is comparable to the way in which such information is encoded in Bartsch's [1987] lexical representations of nouns and verbs. Bartsch presents a more comprehensive treatment of similar phenomena, but in a less compositional way.

Of course, in order to guarantee proper results we have to make sure that adverbial and adnominal modifiers address the *right* arguments. For this purpose I will employ two slightly different methods. The first method is based on the assumption that certain adnominal (and adverbial) phrases tend to address implicit arguments with specific thematic roles or cases. A specific use of the preposition *of* addresses what may be called the implicit object of relational nouns, as in *sister of John*, or *captain of the ship*. Similarly, *by*-phrases appear to select implicit subjects, as in *the destruction of the city by the enemy*. In order to indicate the kinds of arguments that are addressed by these phrases I will use distinguished discourse markers which each 'label' specific implicit thematic roles and which are referred to by the respective ad-phrases. This way of establishing the connection between complement phrases and addressed arguments is illustrated by the treatment of relational nouns below.

The second way of achieving the same aim consists in an extension of the indexing procedure. For instance, (certain) verbs are assumed to come with argument slots for events which are filled by arbitrary indexed discourse markers which range over events. These events then are available for further specification by coindexed adverbial phrases.

It must be clear that we also have to make sure that the ad-phrases eventually *do* address implicit arguments. For this purpose I assume a meta-rule that forbids vacuous addressing, which prevents adnominals from combining with nouns which lack the addressed argument and which makes sure that the indices on verbs and adverbs coincide. (Such a prohibition can be conceived of as a dynamic analogue of Kratzer's [1988] prohibition against vacuous quantification by means of adverbs of quantification.) Such a prohibition could presumably be implemented in a more compositional and semantic fashion than with a meta-rule, but I will not attempt to do so here. The required restatement of such a rule would ideally be cast within a more general theory of indexing and pronoun resolution than is provided by *DMG*, and the issue is therefore left open for further research.

A final remark concerns possible anaphoric relationships with implicit arguments. Although the noun *captain*, in certain contexts at least, comes with implicit ships which the captains are captains of, we cannot refer back to such ships with a pronoun. So, the pronoun *it* in *A captain whistles. It is ready to leave* seems to be not, or hardly, acceptable. On the other hand, if a sentence describes an event, the event can be referred back to, as in *Mary saw John. He noticed it.* For this reason, we will simply assume that discourse markers that are used to label thematic cases, unlike those which refer to events, are not used in the translations of pronouns. Of course, as in ordinary *DMG*, anaphoric relationships involving ordinary indefinite noun phrases remain possible as well.

2 Relational nouns

Relational nouns like *mother* and *captain* have sometimes been considered 'unsaturated' semantically. Every mother is the mother of someone, and every captain is the captain of some ship (in the default case). However, as is argued in de Bruyn and Scha [1988], this does not imply that relational nouns should be treated syntactically as being subcategorized for certain prepositional phrases. De Bruyn and Scha point out that the syntactic behaviour of relational nouns is very similar to that of 'ordinary' nouns, and they claim that the "overt realization of the arguments of a 'transitive' noun is always optional" (p. 26). Therefore, they propose a treatment of relational nouns which is on a par with that of ordinary nouns in the syntax, and which accounts for the idiosyncratic properties of relational nouns in the semantics. In this section, I subscribe to these general features of de Bruyn and Scha's proposal and give a more uniform elaboration of them in the format of *DMG*.

In de Bruyn and Scha's proposal the complement phrases that combine with relational nouns are considered to be modifiers of the nouns syntactically. Semantically, these complements address arguments of the relations expressed. The semantic part of de Bruyn and Scha's proposal comes down to the following. Relational nouns denote genuine relations, that is, sets of pairs of objects. The relational noun *sisters*, for instance, denotes the set of pairs which consist of an individual and a sister of that individual. Expressions like *Peter's* in *Peter's sisters*, or *of Peter* in *sisters of Peter*, restrict such sets to those containing only pairs of which the first element is Peter. Notice that these phrases still denote sets of pairs of individuals. So, in order to let these expressions combine properly with verbs and other expressions, a meaning postulate is invoked that links up the semantic role of a set of pairs of objects with a corresponding set of objects (a projection of the set of pairs). In the example at hand, the set of all pairs consisting of Peter and a sister of his is linked up with the set of individuals which are Peter's sisters.

So, according to de Bruyn and Scha's proposal, nouns may denote sets of individuals as well as relations between individuals, and verbal predicates are made to apply both to plural noun phrases which denote sets of individuals, and to relational noun phrases which denote relations between individuals. For the purpose of giving an account of relational nouns, such complications can be avoided within a dynamic framework. Restricting ourselves to (singular) relational nouns, we can preserve both a uniform syntax, like de Bruyn and Scha, and a uniform, compositional semantics.

Sketch of a dynamic treatment of relational nouns

In *DMG* all nouns can be assigned the type of dynamic properties (type $\langle\varepsilon,\tau\rangle$), the type of functions from individual concepts to context change potentials. Relational nouns have interpretations in this type which contribute implicit arguments to the context. Complement phrases simply address the contributed arguments and give them a further specification. So, for instance, the relational noun *sister* can be interpreted as the property of being the sister of somebody and the syntactic modifier *of John* may turn this property into the property of being the sister of somebody who is John, that is, into the property of being a sister of John. Clearly, since both the nouns *sister* and *sister of John* denote dynamic properties, they may immediately combine with a determiner to form a noun phrase without assuming type-polymorphism or without the need of applying some operation of existential closure. So, within a dynamic semantics like *DMG* we can treat the prepositional phrase *of John* as an ordinary noun modifier syntactically, whereas it behaves semantically as a specifier of an implicit argument of the noun.

A dynamic treatment of relational nouns can be developed further along the following lines. The treatment of the noun *captain* exemplifies that of relational nouns in general. The expressions *ship* and *captain* belong to the category of common nouns (*CN*), associated with the type $\langle\varepsilon,\tau\rangle$ of dynamic properties. The name *the SS. Enterprise* belongs to the category of noun phrases (*NP*). We use two dynamic determiners, a_i and $every_j$. Finally, we have a complement preposition of_2 which belongs to the category *(CN\CN)/NP*, the category of expressions that, when combined with a noun phrase to their right belong to the category of *CN*-modifiers.

The translations of these expressions are the following (again, P and Q are variables of type $\langle\varepsilon,\tau\rangle$, x and y are variables of type ε, and T is a variable of type $\langle\langle\varepsilon,\tau\rangle,\tau\rangle$; the *DIL* constants `ship`, `captain_of` and `ss.e` are of the types $\langle e,t\rangle$, $\langle e,\langle e,t\rangle\rangle$ and e, respectively; as usual, $\mathcal{A}d\Phi$ is defined as $\sim\mathcal{E}d\sim\Phi$, and $[\Phi \Rightarrow \Psi]$ is defined as $\sim[\Phi\,;\sim\Psi]$):

Translations in a fragment with relational nouns

- $a_i \rightsquigarrow \lambda P\lambda Q\ \mathcal{E}d_i[P(\uparrow d_i)\,;Q(\uparrow d_i)]$
- $every_j \rightsquigarrow \lambda P\lambda Q\ \mathcal{A}d_j[P(\uparrow d_j) \Rightarrow Q(\uparrow d_j)]$
- $ship \rightsquigarrow \uparrow\mathtt{ship}$
- $captain \rightsquigarrow \lambda x\ \mathcal{E}d_2\uparrow\mathtt{captain\_of}(\uparrow d_2)(x)$

- $of_2 \rightsquigarrow \lambda T \lambda P \lambda x \uparrow\downarrow T(\lambda y\ \{y/d_2\}P(x))$
- *the SS. Enterprise* $\rightsquigarrow \lambda Q\ Q(\uparrow\texttt{ss.e})$

This tiny fragment generates sentences like *Every captain whistles*, *A captain of*$_2$ *the SS. Enterprise whistles* and *Every captain of*$_2$ *a ship whistles*. The (reduced) translations of these expressions are, respectively:

(2) Every captain whistles
$\mathcal{A}d_j[\mathcal{E}d_2\uparrow(\texttt{captain\_of}(d_2)(d_j)) \Rightarrow \uparrow(\texttt{whistle}(d_j))]$

(3) A captain of$_2$ the SS. Enterprise whistles
$\mathcal{E}d_i[\uparrow(\texttt{captain\_of}(\texttt{ss.e})(d_i))\ ;\uparrow(\texttt{whistle}(d_i))]$

(4) Every captain of$_2$ a ship whistles
$\mathcal{A}d_j[\uparrow\exists d_i(\texttt{ship}(d_i) \wedge \texttt{captain\_of}(d_i)(d_j)) \Rightarrow \uparrow(\texttt{whistle}(d_j))]$

I now show in some more detail how example 3 is dealt with.

The translation of the expression *of*$_2$ *the SS. Enterprise* consists in the application of the translation of *of*$_2$ to that of *the SS. Enterprise*. By means of λ-conversion this translation can be reduced as follows:

$$
\begin{aligned}
&(\lambda T \lambda P \lambda x \uparrow\downarrow T(\lambda y\ \{y/d_2\}P(x)))(\lambda Q\ Q(\uparrow\texttt{ss.e})) \Leftrightarrow \\
&\lambda P \lambda x \uparrow\downarrow(\lambda Q\ Q(\uparrow\texttt{ss.e}))(\lambda y\ \{y/d_2\}P(x)) \Leftrightarrow \\
&\lambda P \lambda x \uparrow\downarrow(\lambda y\ \{y/d_2\}P(x))(\uparrow\texttt{ss.e}) \Leftrightarrow \\
&\lambda P \lambda x \uparrow\downarrow\{\uparrow\texttt{ss.e}/d_2\}P(x)
\end{aligned}
$$

If we apply this expression to the translation of *captain* we get the translation of the complex common noun *captain of*$_2$ *the SS. Enterprise*, which, again by means of λ-conversion, can be reduced in the following way:

$$
\begin{aligned}
&(\lambda P \lambda x \uparrow\downarrow\{\uparrow\texttt{ss.e}/d_2\}P(x))(\lambda x\ \mathcal{E}d_2\uparrow\texttt{captain\_of}(\uparrow d_2)(x)) \Leftrightarrow \\
&\lambda x \uparrow\downarrow\{\uparrow\texttt{ss.e}/d_2\}(\lambda x\ \mathcal{E}d_2\uparrow\texttt{captain\_of}(\uparrow d_2)(x))(x) \Leftrightarrow \\
&\lambda x \uparrow\downarrow\{\uparrow\texttt{ss.e}/d_2\}\mathcal{E}d_2\uparrow\texttt{captain\_of}(\uparrow d_2)(x)
\end{aligned}
$$

By the definition of existential disclosure, this expression is equivalent with the following expression, and with the subsequent reductions of it:

$$
\begin{aligned}
&\lambda x \uparrow\downarrow[\mathcal{E}d_2\uparrow\texttt{captain\_of}(\uparrow d_2)(x)\ ;\uparrow\texttt{ss.e} \,\tilde{=}\, \uparrow d_2] \Leftrightarrow \text{(associativity)} \\
&\lambda x \uparrow\downarrow\mathcal{E}d_2[\uparrow\texttt{captain\_of}(\uparrow d_2)(x)\ ;\uparrow\texttt{ss.e} \,\tilde{=}\, \uparrow d_2] \Leftrightarrow (\uparrow\text{-export}) \\
&\lambda x \uparrow\downarrow\mathcal{E}d_2[\uparrow(\texttt{captain\_of}(d_2)(\downarrow x))\ ;\uparrow(\downarrow\uparrow\texttt{ss.e} = \downarrow\uparrow d_2)] \Leftrightarrow (\downarrow\text{-import}) \\
&\lambda x \uparrow\exists d_2(\texttt{captain\_of}(d_2)(\downarrow x) \wedge \texttt{ss.e} = d_2) \Leftrightarrow \\
&\lambda x \uparrow(\texttt{captain\_of}(\texttt{ss.e})(\downarrow x))
\end{aligned}
$$

The sentence *A captain of$_2$ the SS. Enterprise whistles* has a (reduced) translation which consists in the application of the translation of *a* to the translations of *captain of$_2$ the SS. Enterprise* and *whistles*, respectively. The translation of the sentence can be reduced in the following way, again by means of λ-conversion:

$$(\lambda P \lambda Q\ \mathcal{E}d_i[P(\uparrow d_i)\ ;Q(\uparrow d_i)])(\lambda x\ \uparrow(\texttt{captain\_of}(\texttt{ss.e})(\downarrow x)))(\uparrow\texttt{whistle}) \Leftrightarrow$$
$$\mathcal{E}d_i[(\lambda x\ \uparrow(\texttt{captain\_of}(\texttt{ss.e})(\downarrow x)))(\uparrow d_i)\ ;\uparrow\texttt{whistle}(\uparrow d_i)] \Leftrightarrow$$
$$\mathcal{E}d_i[\uparrow(\texttt{captain\_of}(\texttt{ss.e})(\downarrow\uparrow d_i))\ ;\uparrow\texttt{whistle}(\uparrow d_i)]$$

Using $\uparrow$-export and $\downarrow$-import, the translation of example 3 turns out to be equivalent with the following expression:

$$\mathcal{E}d_i[\uparrow(\texttt{captain\_of}(\texttt{ss.e})(d_i))\ ;\uparrow(\texttt{whistle}(d_i))]$$

This formula is true iff there is an object z such that the pair of z and the denotation of `ss.e` are in the extension of `captain_of` and z is in the extension of `whistle`. Furthermore, under this dyanmic translation the captain who whistles can be referred back to by a pronoun as in a continuation of the example with the sentence *He is glad to leave*.

The rudimentary fragment above shows how determiners may be uniformly combined with ordinary common nouns and relational nouns either with or without complement phrases. The treatment of the adnominals crucially relies on reference to objects which are implicitly introduced by relational nouns. As was argued above, however, it must be ensured that these phrases address real arguments. This is done by means of the meta-rule prohibiting vacuous addressing. A complement phrase like *of$_2$ John* is only allowed to apply to nouns that come with implicit object arguments, that is, to nouns whose translations contain an active occurrence of the quantifier $\mathcal{E}d_2$. This prohibition against vacuous addressing prevents anomalous constructions like, for instance, *a ship about syntax*.

Notice that the above translation of the preposition *of$_2$* involves an operation of static closure by means of $\uparrow\downarrow$. This closure operation annihilates the dynamic potential of implicit arguments and indefinite noun phrases which occur in constructions of the form *CN of$_2$ NP*. There are two reasons for choosing to adopt this closure. In the first place, an indefinite noun phrase *a man* in a construction like *sister of a man* does not seem to be eligible as an antecedent for subsequent pronominal coreference. In the second place, if an implicit argument of a relational noun has been specified by an adnominal *of$_2$*-phrase, the argument does not seem to be available for further adnominal specification either. So, since in the translation of the complex common noun *brother of$_2$ Mary* no quantifiers are active, the rule against vacuous addressing excludes the construction of a complex noun *brother of$_2$ John of$_2$ Mary*. It must be noticed, however, that the translation of functionally used prepositions with an operation of static closure may be too restrictive to account for noun phrases such as *the destruction of$_2$ the city by the enemy* and *a letter from John to Harry about this issue*. Suitable adaptations have to be made in order to deal with these examples, but detailing the required amendments would lead us too far from the (programmatic) purposes of this paper.

3 Non-temporal adverbial phrases

The modification of verbs by adverbial phrases (among which I include prepositional phrases for simplicity) is in some respects similar to the modification of nouns. In contrast with direct and indirect object phrases, for which verbs may be subcategorized, adverbial phrases behave syntactically like verb (phrase) modifiers. (I disregard sentential adverbs, or 'ad-sententials', here.) However, many adverbial phrases are not arbitrary modifiers semantically, but appear to make a genuine contribution to the information expressed by the verbs they modify. Consider the following examples:

(5) Harry walks from Amsterdam to Budapest.

(6) Mary hits the nail with a hammer on the head.

In Montague [1970] phrases like *from Amsterdam* and *with a hammer* express functions from properties to properties. For instance, sentence 5 gets translated, roughly, as `to(b)(from(a)(walk))(h)`. Such an approach, however, does not validate two inference schemes discussed in Parsons [1989], which seem to give a correct characterization of the logical behaviour of many adverbial phrases:

Scope entailment

$$ADV_1(ADV_2(\phi)) \rightarrow ADV_2(ADV_1(\phi))$$

Diamond entailment

$$\begin{array}{ccccc} & \nearrow & ADV_1(\phi) & \searrow & \\ ADV_1(ADV_2(\phi)) & & & & \phi \\ & \searrow & ADV_2(\phi) & \nearrow & \end{array}$$

Adverbial phrases for which the scope entailment holds can be reordered in a sentence without changing the sentence's meaning. For instance, *Harry walks to Budapest from Amsterdam* and *Mary hits the nail on the head with a hammer* have the same truth conditions as the examples 5 and 6 respectively, disregarding other aspects of meaning such as topic and focus. Likewise, the deletion of adverbial phrases which respect to the diamond entailment weakens a sentence's truth conditions. So, example 5 entails that Harry walked from Amsterdam, that Harry walked to Budapest, and that Harry walked. (At first glance one might think that all adverbial phrases respect these entailment schemes, but this is not true. Montague [1970] offers the example *in a dream*.)

Montague himself observed this inferential behaviour of many ad-phrases, and he proposed to account for it by assigning such phrases the 'intersection-property' ([1970, pp. 211–213]). This does not seem to be completely satisfactory. On the intersective interpretation of an adverbial phrase, the phrase expresses a property of the subject of the verb modified. But if the adverbial phrases in the examples above express properties, then it can hardly be properties of the subject of the sentences. For instance, if the intersection property were to hold for the adverbials in 6, then 6 together with the premise that Mary sings would allow us to conclude that Mary sings with a hammer on the (i.e., the nail's) head. This, of course, should not be the case.

Alternative analyses of adverbial modification have been given by, among others, Davidson [1967], Bartsch [1972], Parsons [1989, 1991] and Dowty [1989]. In these analyses (certain) verbs are taken to express properties of events (states, processes, space/time regions, ...), or to express relations between events (...) and some number of other arguments. Adverbial phrases are taken to be verb phrase modifiers which impose further restrictions on the events described by the verbs phrases to which they apply.

For instance, the verb phrase *hits the nail* is interpreted as the relation between individuals and events that holds of an individual x and an event e iff e is an event of x's hitting the nail. An adverbial phrase like *with a hammer* is analyzed as a verb modifier that, roughly, requires the event associated with the verb to which it applies to be with a hammer, or to be performed with a hammer. Similarly, the adverbial phrase *on the head* is taken to impose the condition that the event of hitting is a hitting on the head. Passing over details, the sentence *Mary hits the nail with a hammer on the head* is eventually associated with the following translation:

$$\exists e(\mathtt{hit}(e)(\mathtt{n})(\mathtt{m}) \wedge \mathtt{with\_a\_hammer}(e) \wedge \mathtt{on\_the\_head}(e))$$

which states that there is an event of Mary's hitting the nail such that the hitting is performed with a hammer and such that the hitting is on the head (of John).

It is easily seen that if adverbial phrases impose conditions on events in the way sketched then they validate the aforementioned diamond and scope entailments. These entailments correspond to conjunction reduction and conjunction commutation respectively.

Matters are simplified here and, of course, the authors mentioned above have made many refinements. For instance, the condition that the event e is 'with a hammer' has been further analyzed as the condition that the 'instrument' relation holds between e and a hammer. Furthermore, the condition that e is an event of Mary's hitting the nail has been analyzed as the condition that e is a hitting event, and that the relation 'being the agent of' holds of Mary and e and the relation 'being the direct object of' holds of the nail and e. Complications like these, and simplifications like mine, however, are not relevant for the present discussion.

It may be noticed that in these Davidsonian treatments of adverbial modification an operation of existential closure has to apply at some stage in the process of interpretation. In order for the events described by verb phrases to be available for adverbial modification they are indicated by free variables, the values of which may be abstracted over in the translations of the verb phrases. However, a finite sentence is generally taken to state the existence of an event of the kind described by the sentence. For this reason an operation of existential closure has to apply somewhere in the process of interpretation. In the proposals at issue, which are cast within static frameworks, such a closure has drawbacks. The closure precludes the possibility of anaphoric reference to described events, despite the fact that such anaphors to events make up one of the arguments for positing the existence of events in the first place.

Sketch of a dynamic treatment of adverbial modification

Analogous to the preceding treatment of relational nouns and their complements, the treatments of adverbial modification can be cast within the framework of *DMG*, without the need to postulate an additional operation of existential closure. As we have seen, such intermediary closures can be dispensed with in a dynamic semantics, since the arguments involved can already be assumed to be existentially closed in the translation of the (finite) verbs themselves. Due to the dynamics of the system of interpretation, these arguments can still be addressed by adverbial phrases.

We can adopt the analyses of adverbs sketched above within *DMG*, roughly, in the following way. A finite form of the verb *walk* belongs to the category IV. The prepositions *from* and *to* belong to the category $(IV\backslash IV)/NP$, the category of expressions that form an intransitive verb phrase when combined with a noun phrase to their right, and then with an intransitive verb phrase to their left. The names *Harry*, *Amsterdam* and *Budapest* belong to the category of noun phrases. The model is assumed to be extended with some appropriate domain of events, and the translation language is extended with discourse markers $e_i, e_j \ldots$ which range over events. The lexical expressions involved can be translated in the following way (variables are typed as above):

Translations in a fragment with adverbial phrases

- *Harry* $\rightsquigarrow \lambda Q\ Q(\uparrow\mathtt{h})$
- *walks*$_i$ $\rightsquigarrow \lambda x\ \mathcal{E}e_i{\uparrow}\mathtt{walk}(\uparrow e_i)(x)$
- *from*$_i$ $\rightsquigarrow \lambda T \lambda P \lambda x\ T(\lambda y\ [P(x)\,;{\uparrow}\mathtt{from}(y)(\uparrow e_i)])$
- *Amsterdam* $\rightsquigarrow \lambda Q\ Q(\uparrow\mathtt{a})$
- *to*$_i$ $\rightsquigarrow \lambda T \lambda P \lambda x\ T(\lambda y\ [P(x)\,;{\uparrow}\mathtt{to}(y)(\uparrow e_i)])$
- *Budapest* $\rightsquigarrow \lambda Q\ Q(\uparrow\mathtt{b})$

The constant `walk` is interpreted as a relation between individuals and events, to be understood as the relation which holds of an object x and an event e iff e is an event of x's walking. In the translation of the expression *walks*, the event argument slot of `walk` is closed by a dynamic existential quantifier. A sentence like *Harry walks* thus introduces an event of Harry's walking which is available for subsequent anaphoric reference and adverbial modification.

An adverbial phrase like *from Amsterdam* addresses the event introduced by the verb to which the phrase applies. Recall that we have assumed a rule prohibiting vacuous addressing. So, with regards to the verb phrase *walks from Amsterdam*, the verb *walks* and the preposition *from* are required to be coindexed. The verb phrase therefore denotes the dynamic property which can be paraphrased as the property of being an object that figures in an event of walking which starts from Amsterdam (A' indicates the translation of A):

$$\textit{from}_i{}'(\textit{Amsterdam}')(\textit{walks}_i{}') =$$
$$\lambda T \lambda P \lambda x\ T(\lambda y\ [P(x)\,;{\uparrow}\mathtt{from}(y)(\uparrow e_i)])(\lambda Q\ Q(\uparrow\mathtt{a}))(\lambda x\ \mathcal{E}e_i{\uparrow}\mathtt{walk}(\uparrow e_i)(x)) \Leftrightarrow$$
$$\lambda x\ (\lambda Q\ Q(\uparrow\mathtt{a}))(\lambda y\ [(\lambda x\ \mathcal{E}e_i{\uparrow}\mathtt{walk}(\uparrow e_i)(x))(x)\,;{\uparrow}\mathtt{from}(y)(\uparrow e_i)]) \Leftrightarrow$$
$$\lambda x\ (\lambda y\ [\mathcal{E}e_i{\uparrow}\mathtt{walk}(\uparrow e_i)(x)\,;{\uparrow}\mathtt{from}(y)(\uparrow e_i)])(\uparrow\mathtt{a}) \Leftrightarrow$$
$$\lambda x\ [\mathcal{E}e_i{\uparrow}\mathtt{walk}(\uparrow e_i)(x)\,;{\uparrow}\mathtt{from}(\uparrow\mathtt{a})(\uparrow e_i)] \Leftrightarrow$$

$$\lambda x\ \mathcal{E} e_i[\uparrow\texttt{walk}(\uparrow e_i)(x)\ ;\ \uparrow\texttt{from}(\uparrow\texttt{a})(\uparrow e_i)]$$

The translation of the sentence *Harry walks$_i$ from$_i$ Amsterdam* is obtained by applying the translation of *Harry* to that of *walks$_i$ from$_i$ Amsterdam*, the result of which reduces as follows:

$$(\lambda Q\ Q(\uparrow\texttt{h}))(\lambda x\ \mathcal{E} e_i[\uparrow\texttt{walk}(\uparrow e_i)(x)\ ;\ \uparrow\texttt{from}(\uparrow\texttt{a})(\uparrow e_i)]) \Leftrightarrow$$
$$\mathcal{E} e_i[\uparrow\texttt{walk}(\uparrow e_i)(\uparrow\texttt{h})\ ;\ \uparrow\texttt{from}(\uparrow\texttt{a})(\uparrow e_i)] \Leftrightarrow$$
$$\mathcal{E} e_i[\uparrow(\texttt{walk}(e_i)(\texttt{h}))\ ;\ \uparrow(\texttt{from}(\texttt{a})(e_i))]$$

The sentence turns out to mean that there is an event of Harry's walking which is from Amsterdam.

The event introduced by the verb *walk$_i$* remains available for further specification or modification after the adverbial phrase *from$_i$ Amsterdam* has been applied to it. Hence, a second adverbial modifier *to$_i$ Budapest*, with the same index again, may apply to the phrase *walks$_i$ from$_i$ Amsterdam*, and a sentence like *Harry walks$_i$ from$_i$ Amsterdam to$_i$ Budapest* turns out to mean that there is an event of Harry's walking which is from Amsterdam and which is to Budapest:

$$[[\mathcal{E} e_i\uparrow(\texttt{walk}(e_i)(\texttt{h}))\ ;\ \uparrow(\texttt{from}(\texttt{a})(e_i))]\ ;\ \uparrow(\texttt{to}(\texttt{b})(e_i))] \Leftrightarrow$$
$$\mathcal{E} e_i[\uparrow(\texttt{walk}(e_i)(\texttt{h}))\ ;\ [\uparrow(\texttt{from}(\texttt{a})(e_i))\ ;\ \uparrow(\texttt{to}(\texttt{b})(e_i))]]$$

Clearly, the sentences are assigned the truth-conditions argued for, and in a relatively uniform way. The present exposition may serve as an indication of how to give a reformulation in *DMG* of any of the analyses of adverbial modification referred to above.

McConnell-Ginet [1982] and Larson [1988] have presented alternative analyses in which adverbial phrases express properties of objects that are derived from the verb interpretation in some way or other. For instance, according to the proposal of McConnell-Ginet the interpretation of the verb *walks* (a property) can be turned into a two place relation which holds between walkers and walking rates. An adverb like *quickly* can be applied to such an inflated interpretation of the verb, and impose the condition that the 'added' rate is quick. In Larson's proposal, which is cast within a situation theoretic framework, a walking event is taken to 'involve' an event in which an agent changes position. An adverbial like *to Budapest* then imposes the condition that Budapest is the goal of the change of location which is involved by the situation described by verb.

Again passing over all kinds of details, I think the essence of these last two treatments of adverbials can be wormed from their original theoretical frameworks and cast in the mould of dynamic semantics. McConnell-Ginet says: "Ad-verbs typically have a dual function: they augment the order of the verb on which they operate, and they specify the value(s) of the added argument place(s)" (p. 168). In the format of *DMG* we can restate this function of adverbial phrases as their potential to disclose (and specify) implicit arguments in the verbs on which they operate. So, where McConnell-Ginet would have an augmentation of a verb with an added rate (manner, ...) argument place, we could propose an initial rate (manner, ...) argument place that is existentially closed in the translation of the verb. The essence of Larson's proposal, as far as the semantics is concerned, may be clarified if we take constraints to be meaning postulates (disregarding the fact that they were *not* intended to be taken that way), and introduce the involved situations or involved objects in the lexical translations of the involving verbs themselves.

It must be remarked, however, that it is not a trivial matter to elaborate a comprehensive treatment of adverbial phrases along these lines. The facts at issue are much more entangled then appears from the present discussion. Bartsch [1972], in particular, presents a large number of observations which a full-blown theory of adverbs should account for, about the kinds of objects which are available for adverbial modification, and about the particular properties of various different kinds of adverbial modification. The ways in which one extends the present treatments of adverbial modification will probably depend on the ontological commitments one wishes to make and on what one considers to be an economical way to account for the semantic facts involved. I will not discuss such extensions of the analysis sketched above: I have merely aimed to demonstrate that existing proposals for the treatment of adverbial modification can be perspicuously formulated within the framework of a dynamic system of interpretation.

4 Tense in discourse

The final application of existential disclosure concerns temporal adverbs and tense in discourse. Since the syntactic category of (temporal) adverbs is plausibly that of verb (phrase) modifiers, it is tempting to treat them as modifiers at the semantic level too. As regards tense one might think of a Priorian analysis of temporal operators as operators that quantify over times of evaluation. We can use the operator P of classical tense logic to translate verbs in the past tense. A past-tensed sentence is then translated as $P(\phi)$, where $P(\phi)$ is true at some time of evaluation iff ϕ is true at some earlier time of evaluation. Likewise, the adverb *yesterday* can be translated as the operator Y which shifts back the time of evaluation to the day before the original evaluation time. Dowty [1982] (among others) has argued that this is not a tenable analysis.

Consider the following example:

(7) Bill left yesterday.

On a Priorian analysis this sentence translates either as $Y(P(\texttt{leave(b)}))$ or as $P(Y(\texttt{leave(b)}))$. Neither translation gives the right truth conditions, since both are verified if Bill did not leave yesterday, but, for instance, two days ago.

Reference time, speech time and event time

Alternative approaches to tense have been offered by Bäuerle [1979], Dowty [1982, 1986], Kamp and Rohrer [1983], Partee [1984] and Hinrichs [1986], to name just a few. Common to all of these approaches is that they elaborate upon Reichenbach's distinction between speech time, reference time and event time. This distinction can be illustrated by the sentence *Bill had gone*. This sentence describes a state of affairs at a reference time before the speech time such that at the reference time it holds that Bill left at a preceding (event) time (cf., Reichenbach [1947, pp. 287–298]).

In all the approaches mentioned, tenses express conditions on the ordering of the three points or intervals of time, and temporal adverbs impose conditions on the reference time. For instance, a simple past (future) indicates that the reference time lies before (after) the speech time and the adverb *yesterday* imposes the condition that the reference time is located the day before the speech time. The past perfect furthermore locates the (current) reference time in the past, and assigns the tensed verb a reference or event time before the current reference time.

Reference times also play an important role in the temporal connectedness of 'temporal', or 'narrative', discourse. It is commonly assumed that narrative discourses describe successions of events. A restatement of this is that the reference time in such a discourse moves forward sentence by sentence. (We can take this to be the default case. There are quite a lot of adjustments to be made here, but these need not interfere with the present discussion.) Dowty [1986] formulates it as follows: "The reference time of a sentence is interpreted to be a time consistent with the definite time adverbials, if there are any; otherwise, a time which immediately follows the reference time of the previous sentence." This is what he calls the 'temporal discourse interpretation principle (TDIP)'.

In the proposals of Kamp and Rohrer, Hinrichs and Partee, which are cast within the framework of *DRT*, something like the TDIP is formulated in the discourse representation construction algorithm. The picture is a bit more involved here, since the proposals make a distinction between eventive and stative sentences. Eventive sentences are taken to describe events which occur at a time contained in the current reference time. These sentences are supposed to move the reference time forward within a discourse. Stative sentences, on the other hand, describe states which obtain at a stretch of time which itself contains the reference time. These sentences are assumed to keep the reference time the same.

One difference between the *DRT* analyses and Dowty's is worth mentioning. In the *DRT* proposals the reference time is eventually existentially quantified over. In Dowty's proposal, on the other hand, reference times are definite parameters of interpretation. The adoption of a definite reference time is, among others, motivated by Partee's example *I didn't turn off the stove*. The idea is that if reference times are existentially quantified over, then the example would mean either that there is a time in the past where the speaker did not turn off the stove (and be trivially true under common circumstances), or that there is no time in the past where she turned off the stove (and be trivially false then). On Dowty's account the example will be probably taken to mean that the speaker did not turn off the stove at the reference time. It appears to me that something like Dowty's interpretation can also be obtained by means of restricted existential quantification over reference times. If the reference time, which is existentially quantified over, is required to be found within a restricted (temporal) domain of quantification, then both analyses may turn out equivalent if the domain chosen in the existential analysis coincides with the choice of the reference time in Dowty's analysis.

In the approaches mentioned, the interpretation of tensed verbs is in some way or other related to (event) times. We need not go into the required ontology of events and times here, but simply assume some suitable domain of events which comes with a temporal order. Verbs can be taken to have argument slots for events with associated event times, and temporal adverbs and tense operators are taken to impose conditions on the times of the events that fill these slots, for instance, by relating them in certain specific ways to the speech and/or reference time.

Again, the semantic contribution of the respective verbs, temporal adverbs and temporal operators can be perspicuously formulated within the framework of *DMG*. In what follows I will partly reformulate the proposals of Partee, which are by and large based upon the work of Hinrichs. I will pass over the details of the proposals, and only consider simple, linear, narrative discourse.

Sketch of a dynamic treatment of tense

In the *DMG* treatment of tense and temporal predication it is expedient to have at our disposal three distinguished discourse markers d_s, d_a and d_b. The first one of these (d_s) is used to indicate the speech time. The two other discourse markers (d_a and d_b) can be used to refer to the current reference time, and, if necessary, to reset it. Initially, the reference time is existentially quantified over.

In the translation of a sentence with an eventive verb the current reference time labeled by d_a is pushed forward by requiring it to precede the next reference time labeled by d_b. As we will see presently, the value of d_b will figure as the reference time for a subsequent sentence, since in the conjunction of two sentences S and T in a temporal discourse the (input) reference time for T (i.e., the value of the occurrence of d_a in T) is equated with the (output) reference time delivered by S (i.e., the value of the occurrence of d_b in S). The translation of a stative verb leaves the reference time untouched by equating the 'input' reference time with the 'output' reference time.

In the following fragment the translation of the intransitive verb *arrive* illustrates the interpretation of eventive verbs, and the translation of *sleep* that of stative verbs. The past tense affix *–ed* is defined as an operator that turns an untensed intransitive verb into a tensed intransitive verb. I have added a temporal sentential connective *when* and a sequencing operator '$._t$' which is used in temporal or narrative discourse. (Think of $._t$ as the childish connective *And then* ....)

Translations in a fragment with temporal operators

- $\textit{arrive}_i \rightsquigarrow \lambda x\ \mathcal{E}d_a\mathcal{E}d_b\mathcal{E}e_i\ [(\uparrow e_i \mathrel{\tilde{\subseteq}} \uparrow d_a)\,;[\uparrow\mathtt{arrive}(\uparrow e_i)(x)\,;(\uparrow e_i \mathrel{\tilde{<}} \uparrow d_b)]]$
- $\textit{sleep}_i \rightsquigarrow \lambda x\ \mathcal{E}d_a\mathcal{E}d_b\mathcal{E}e_i\ [(\uparrow d_a \mathrel{\tilde{\subseteq}} \uparrow e_i)\,;[\uparrow\mathtt{sleep}(\uparrow e_i)(x)\,;(\uparrow d_a \mathrel{\tilde{=}} \uparrow d_b)]]$
- $\textit{-ed} \rightsquigarrow \lambda P\lambda x\ [P(x)\,;(\uparrow d_a \mathrel{\tilde{<}} \uparrow d_s)]$
- $S._t T \rightsquigarrow \mathcal{E}t\ [\{\uparrow t/d_b\}S'\,;\{\uparrow t/d_a\}T']$
- *when* S, $T \rightsquigarrow \mathcal{E}t\ [\{\uparrow t/d_a\}S'\,;\{\uparrow t/d_a\}T']$

The temporal relation expressions $\tilde{\subseteq}$ and $\tilde{<}$ are the *DMG* counterparts of *DIL* expressions $\subseteq$ and $<$ which express the relation of being temporally contained in and that of temporal precedence, respectively. Formulas containing these operators observe the $\uparrow$-export equivalences which also apply to identity statements:

$$\alpha \mathrel{\tilde{\subseteq}} \beta \Leftrightarrow \uparrow(\downarrow\alpha \subseteq \downarrow\beta)$$
$$\alpha \mathrel{\tilde{<}} \beta \Leftrightarrow \uparrow(\downarrow\alpha < \downarrow\beta)$$

The verb *arrive* holds of objects which arrive at an event time which is contained in the reference time and the verb *sleep* holds of objects which are in a state of sleep at the reference time. When we use the past tense of a verb, the past tense affix requires that the implicit reference time of the verb is located in the past. In the temporal sequencing of two sentences S and T, the input reference time of the second sentence T is equated with the output reference time of the first. If the two sentences are combined by means of the connective *when*, then they are both evaluated with respect to the current reference time. In both the sentential constructions $S ._t T$ and *when* S, T the existential quantifier $\mathcal{E}t$ binds a variable, not a discourse marker. These two instances of existential quantification are thus static.

These translations merely formalize the treatment of tense as it was described above. As an illustration of the present fragment I indicate how it deals with an example discussed in Partee [1984, pp. 258ff].

An example

Partee discusses the following example:

(8) Mary turned the corner. When John saw her, she crossed the street.

The three verbs in this example are assumed to be eventive. So, the first sentence in this example, and the two constituent sentences of the second sentence are assigned the following (simplified) translations (I have omitted the clauses which locate the events in the past):

Mary turned$_i$ the corner.

$$\mathcal{E}d_a\mathcal{E}d_b\mathcal{E}e_i\ [(\uparrow e_i \mathrel{\tilde{\subseteq}} \uparrow d_a)\,;\uparrow\mathtt{turn}(\uparrow e_i)(\uparrow\mathtt{m})\,;(\uparrow e_i \mathrel{\tilde{<}} \uparrow d_b)]$$

John saw$_j$ her.

$$\mathcal{E}d_a\mathcal{E}d_b\mathcal{E}e_j\ [(\uparrow e_j \mathrel{\tilde{\subseteq}} \uparrow d_a)\,;\uparrow\mathtt{see}(\uparrow e_j)(\uparrow\mathtt{m})(\uparrow\mathtt{j})\,;(\uparrow e_j \mathrel{\tilde{<}} \uparrow d_b)]$$

She crossed$_k$ the street.

$$\mathcal{E}d_a\mathcal{E}d_b\mathcal{E}e_k\ [(\uparrow e_k \mathrel{\tilde{\subseteq}} \uparrow d_a)\,;\uparrow\mathtt{cross}(\uparrow e_k)(\uparrow\mathtt{m})\,;(\uparrow e_k \mathrel{\tilde{<}} \uparrow d_b)]$$

By means of $\uparrow$-export and $\downarrow$-import the translations of the three constituent sentences can be reduced to the following formulas:

$$\mathcal{E}d_a\mathcal{E}d_b\mathcal{E}e_i\ [\uparrow(e_i \subseteq d_a)\,;\uparrow(\texttt{turn}(e_i)(\texttt{m}))\,;\uparrow(e_i < d_b)]$$
$$\mathcal{E}d_a\mathcal{E}d_b\mathcal{E}e_j\ [\uparrow(e_j \subseteq d_a)\,;\uparrow(\texttt{see}(e_j)(\texttt{m})(\texttt{j}))\,;\uparrow(e_j < d_b)]$$
$$\mathcal{E}d_a\mathcal{E}d_b\mathcal{E}e_k\ [\uparrow(e_k \subseteq d_a)\,;\uparrow(\texttt{cross}(e_k)(\texttt{m}))\,;\uparrow(e_k < d_b)]$$

The last two sentences are combined with the connective *when*, and the result of this is conjoined with the first sentence by means of the temporal sequencing operator $\cdot_t$. Spelling out the involved existential disclosures, we arrive at the following translation of example 8:

$$\begin{aligned}&\mathcal{E}t\ [\mathcal{E}d_a\mathcal{E}d_b\mathcal{E}e_i\ [\uparrow(e_i \subseteq d_a)\,;\uparrow(\texttt{turn}(e_i)(\texttt{m}))\,;\uparrow(e_i < d_b)]\,;\uparrow(t = d_b)\,;\\&\mathcal{E}t'\ [\mathcal{E}d_a\mathcal{E}d_b\mathcal{E}e_j\ [\uparrow(e_j \subseteq d_a)\,;\uparrow(\texttt{see}(e_j)(\texttt{m})(\texttt{j}))\,;\uparrow(e_j < d_b)]\,;\uparrow(t' = d_a)\,;\\&\mathcal{E}d_a\mathcal{E}d_b\mathcal{E}e_k\ [\uparrow(e_k \subseteq d_a)\,;\uparrow(\texttt{cross}(e_k)(\texttt{m}))\,;\uparrow(e_k < d_b)]\,;\uparrow(t' = d_a)]\,;\uparrow(t = d_a)]\end{aligned}$$

Using the associativity equivalences, this formula turns out to be equivalent with:

$$\begin{aligned}&\mathcal{E}t\mathcal{E}d_a\mathcal{E}d_b\mathcal{E}e_i\ [\uparrow(e_i \subseteq d_a)\,;\uparrow(\texttt{turn}(e_i)(\texttt{m}))\,;\uparrow(e_i < d_b)\,;\uparrow(t = d_b)\,;\\&\mathcal{E}t'\mathcal{E}d_a\mathcal{E}d_b\mathcal{E}e_j\ [\uparrow(e_j \subseteq d_a)\,;\uparrow(\texttt{see}(e_j)(\texttt{m})(\texttt{j}))\,;\uparrow(e_j < d_b)\,;\uparrow(t' = d_a)\,;\\&\mathcal{E}d_a\mathcal{E}d_b\mathcal{E}e_k\ [\uparrow(e_k \subseteq d_a)\,;\uparrow(\texttt{cross}(e_k)(\texttt{m}))\,;\uparrow(e_k < d_b)\,;\uparrow(t' = d_a)\,;\uparrow(t = d_a)]]]\end{aligned}$$

Applying the closure operator $\downarrow$ we get the truth conditions of example 8. By means of $\downarrow$-import, the result can be reduced to the following formula:

$$\begin{aligned}&\exists t\exists d_a\exists d_b\exists e_i((e_i \subseteq d_a) \wedge \texttt{turn}(e_i)(\texttt{m}) \wedge (e_i < d_b) \wedge (t = d_b) \wedge\\&\exists t'\exists d_a\exists d_b\exists e_j((e_j \subseteq d_a) \wedge \texttt{see}(e_j)(\texttt{m})(\texttt{j}) \wedge (e_j < d_b) \wedge (t' = d_a) \wedge\\&\exists d_a\exists d_b\exists e_k((e_k \subseteq d_a) \wedge \texttt{cross}(e_k)(\texttt{m}) \wedge (e_k < d_b) \wedge (t' = d_a) \wedge (t = d_a))))\end{aligned}$$

Using some standard reductions, this is equivalent with the following formula:

$$\begin{aligned}&\exists t\exists d_a\exists e_i(e_i \subseteq d_a \wedge \texttt{turn}(e_i)(\texttt{m}) \wedge e_i < t \wedge\\&\exists d_b\exists e_j(e_j \subseteq t \wedge \texttt{see}(e_j)(\texttt{m})(\texttt{j}) \wedge e_j < d_b \wedge\\&\exists d_b\exists e_k(e_k \subseteq t \wedge \texttt{cross}(e_k)(\texttt{m}) \wedge e_k < d_b)))\end{aligned}$$

In other words, example 8 is true iff Mary turns the corner at an original reference time (labeled by d_a), and if after Mary's turning there is a reference time (t) at which John sees her and at which she crosses the street. Together with the condition that all three events are to be located before the speech time, these are the truth-conditions that Partee ends up with. Furthermore, as in Partee's analysis, after example 8 has been processed the reference time is located after the time of Mary's crossing the street.

We see that the *DRT* treatment of tense can be formulated relatively perspicuously within the *DMG* framework. The reformulation can even be argued to be an improvement. The following observation comes from Partee: "(...) Hinrich's rules refer to 'the current reference time r_p', which changes in the course of construction (...); only the most recent of them is in effect at any given point in the construction of the representation. (...) The resulting DRS is in a sense then a dynamic representation rather than a static one." (Partee [1984, p. 258]) This observation implies that for a treatment of example 8 along the present lines, *DRT* is in need of further 'dynamification'. Notice that a compositional reformulation of *DRT* is not only seen to be easily extended with a *DRT*-like treatment of tense, but that such an extension does not require such a further dynamification.

5 Conclusions

Implicit arguments are generally assumed to be genuine semantic arguments of nouns and verbs which need not be realized syntactically. The translations of such nouns and verbs are conceived of as having an added argument slot, for complements, events, or times, and these can be, but need not be, addressed by optional complement or other adjoining phrases. In most existing proposals it is assumed that these argument slots are eventually saturated and that, somewhere in the process of interpretation, they are existentially closed.

Within a dynamic Montague grammar the implicit arguments of nouns and verbs can be assumed to be existentially quantified over right from the start, i.e., in the translation of the nouns and verbs themselves. Since existential quantification in *DMG* is dynamic, such closed arguments can still be addressed afterwards and made subject to further adnominal or adverbial specification. Despite the programmatic nature of the proposals made in this paper, they demonstrate the usefulness of a dynamic approach to interpretation also at the intrasentential level. The advantage of using a dynamic framework is that it enables us to deal with implicit arguments merely by lexical specification without complicating the syntax/semantics interface with optional closure operations. Furthermore, it enables us to give a uniform treatment of relational and non-relational nouns, and similarly of eventive and non-eventive verbs.

Of course, the present proposals may seem a bit laborious. In what is only a small Montagovian fragment of natural language elaborated along the present lines, quite some encoding (and concomitant technical book-keeping) has to be done in the translation of the lexical items. I don't think this is a real objection to the spirit of the proposals. Whichever way one turns, when implicit arguments are addressed they must somehow be present, and they are objects brought to the fore by the linguistic context. Clearly, one might ask oneself whether or not the emergence of these objects ought to be dealt with in a pragmatic rather than in a purely semantic component of the theory of interpretation. However, the semantics/pragmatics distinction might have to be rethought within a theory of dynamic interpretation anyhow, if it is eventually tenable at all. With the reformulations above I have tried not to be hampered by such a distinction.

The third point I want to make is that compositionality pays off. Adhering to this (methodological) principle, one is forced to observe ultimate explicitness and generality when making proposals concerning the semantics of natural language expressions and operators. This brought Groenendijk and Stokhof to their highly explicit proposals concerning the dynamic meaning of natural language noun phrases. The pay-off of it is that their rigourous reformulation of *DRT*'s treatment of anaphoric relationships has shown to provide for a framework broad enough to deal with other *DRT* results and with other semantic phenomena.

Here, again, it must be emphasized that it is not just *DMG* that has this extended potential, but that any compositionalization of *DRT* will probably be on a par with *DMG* regarding relevant expressive force. In the introduction I mentioned alternative compositional reformulations, some of which are more faithful to original *DRT*, one that is more *IL*-oid, and another *TY2*-ic. I cannot think of any substantial reason here for preferring any one over the other. As for logical issues, Muskens' [1990] *TY2*-like variant might be preferable, being a more 'orthodox' logic (cf., Muskens [1990], p. 413). As a tool for describing natural language phenomena, on the other hand, one might prefer *DMG*, since the translations of natural language expressions within the *DMG* language have a structure which more closely resembles the structure of the natural language expressions themselves. The choice between any one of these systems may be guided by personal preference and purposes. Such a choice does not affect potential empirical coverage in any obvious way.

References

Asher, N., and H. Wada. H. 1988. 'A computational account of syntactic, semantic and discourse principles for anaphora resolution'. Journal of Semantics 6, 309–344.

Bäuerle, R. 1979. Temporale Deixis, temporale Frage. Gunter Narr Verlag, Tübingen.

Bartsch, R. 1972. Adverbialsemantik [The grammar of adverbials]. Athenäum Verlag, Frankfurt am Main.

Bartsch, R. 1987. 'Frame representations and discourse representations'. Theoretical Linguistics 14, 65–117.

Barwise, J. 1987. 'Noun phrases, generalized quantifiers and anaphora'. In P. Gärdenfors, ed., Generalized quantifiers. Reidel, Dordrecht. 1–29.

Bruyn, J. de and R. Scha R. 1988. 'The interpretation of relational nouns'. Proceedings of the 26-th annual meeting of the Association for Computational Linguistics. State University of New York at Buffalo.

Davidson, D. 1967. 'The logical form of action sentences'. In N. Rescher, ed., The logic of decision and action. University of Pittsburgh Press. 81–95

Dekker, P. 1993. Sense beyond the sentence. Dissertation, University of Amsterdam.

Dowty, D. 1982. 'Tenses, time adverbs, and compositional semantic theory'. Linguistics and Philosophy 5, 23–57.

Dowty, D. 1986. 'The effects of aspectual class on the temporal structure of discourse: semantics or pragmatics?'. Linguistics and Philosophy 9, 37–61.

Dowty, D. 1989. 'On the semantic content of the notion "thematic role" '. In G. Chierchia, B. Partee, and R. Turner, eds., Properties, types and meaning VOL II. Kluwer, Dordrecht. 69–129.

Groenendijk, J. and M. Stokhof. 1990. 'Dynamic Montague grammar'. In L. Kálmán and L. Pólos, eds., Papers from the second symposium on logic and language. Akadémiai Kiadó, Budapest. 3–48.

Heim, I. 1982. The semantics of definite and indefinite noun phrases. Dissertation, University of Massachusetts, Amherst.

Hinrichs, E. 1986. 'Temporal anaphora in discourses in English'. Linguistics and Philosophy 9, 63–82.

Janssen, T. 1986. Foundations and applications of Montague grammar. CWI, Amsterdam.

Kamp, H. 1981. 'A theory of truth and semantic representation'. In J. Groenendijk, T. Janssen and M. Stokhof, eds., Formal methods in the study of language. Mathematical Centre, Amsterdam. 277–322.

Kamp, H. and C. Rohrer. 1983. 'Tense in texts'. In R. Bäuerle, C. Schwarze and A. von Stechow, eds., Meaning, use and interpretation of language. De Gruyter, Berlin. 250–269.

Kratzer, A. 1988. 'Stage-level and individual-level predicates'. Manuscript, University of Massachusetts, Amherst.

Larson, R. 1988. 'Implicit arguments in situation semantics'. Linguistics and Philosphy 11, 169–202.

Lewis, D. 1975. 'Adverbs of quantification'. In E. Keenan, ed., Formal semantics of natural language. Cambridge University Press, Cambridge. 3–15.

McConnell-Ginet, S. 1982. 'Adverbs and logical form: a linguistically realistic theory'. Language 58, 144–184.

Montague, R. 1970. 'English as a formal language'. In R. Thomason, ed., 1974, Formal Philosophy, selected papers of Richard Montague. Yale University Press, New Haven. 188–221.

Montague, R., 1973, 'The proper treatment of quantification in ordinary English'. In R. Thomason, ed., 1974, Formal Philosophy, selected papers of Richard Montague. Yale University Press, New Haven. 247–270.

Muskens, R. 1990. 'Anaphora and the logic of change'. In J. van Eijck, ed., Logics in AI. Springer-Verlag, Berlin. pp 412–427.

Parsons, T. 1989. 'The progressive in English: events, states and processes'. Linguistics and Philosphy 12, 213–241.

Parsons, T. 1990. Events in the semantics of English. MIT press, Cambridge, Massachusetts.

Partee, B. 1984. 'Nominal and temporal anaphora'. Linguistics and Philosphy 7. 243–286.

Prior, A. 1967. Past, present and future. Clarendon, Oxford.

Reichenbach, H. 1947. Elements of symbolic logic. Macmillan, New York/London.

Rooth, M. 1987. 'Noun phrase interpretation in Montague grammar, file change semantics, and situation semantics'. In P. Gärdenfors, ed., Generalized quantifiers. Reidel, Dordrecht. 237–269.

Zeevat, H. 1989. 'A compositional approach to discourse representation theory'. Linguistics and Philosophy 12. 95–131.