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EXISTENTIAL DISCLOSURE

Implicit Arguments in Dynamic Semantics

Paul Dekker

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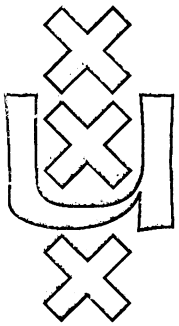

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Existential Disclosure*

implicit arguments in dynamic semantics

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1 Introduction

One of the main themes of semantic theory nowadays concerns the dynamics of natural language interpretation. A lot of attention is and has been paid to the so-called 'context-change-potential' of certain expressions. Prime examples are indefinite noun phrases which seem to introduce discourse referents for subsequent anaphoric pronouns, or, stated differently, which may bind pronouns beyond their syntactic scope. The study of such 'dynamic' semantic properties of expressions by Kamp [19] and Heim [14] in the early eighties originated a whole new branch of semantic theorizing in the format of discourse representation theory (*DRT*). More recently, compositional reformulations of this framework have been given that enhance comparison of *DRT* with more classical semantic theories and that enable an integration of results (Asher and Wada [1], Barwise [2], Groenendijk and Stokhof [13], Muskens [24], Rooth [30], Zeevat [31]). Groenendijk and Stokhof [13] in particular formulates a dynamic Montague grammar (*DMG*), in which the paradigmatic Montague grammar of the seventies is adapted to incorporate *DRT*-results.

In this paper I show how *DMG* can be used to treat relational nouns, adverbial modification and tense in discourse. The choice of these three topics is not arbitrary since all three of them involve some kind of specification of implicit arguments. Relational nouns like 'captain' carry an implicit object argument, which can be specified by a complement phrase; adverbs can be taken to predicate over (parts of) events which are implicitly quantified over by tensed verbs; and in temporal discourse (implicit) reference times get connected. In previous proposals these implicit arguments were treated as free variables, which were available for further specification. Such approaches, however, forced one to postulate an operation of existential closure somewhere in the process of interpretation, an operation that is not syntactically triggered. I show that a compositional dynamic framework allows one to approach the phenomena by a reverse strategy. Implicit arguments can be introduced by existential quantifiers. Since existential quantifiers in *DMG* have binding force beyond their syntactic scope, these implicit arguments can be readdressed and specified further by complements and adverbs. This approach thus enables a uniform treatment of nouns and verbs that come with, and ones that come without (adnominal and adverbial) specification; the approach does not need further operations of existential closure.

Two things must be made clear at the outset. The first is that my proposals are concise, compositional reformulations of existing treatments of relational nouns, adverbs and tense and substantially there is nothing original about them. Moreover,

*I would like to thank Gennaro Chierchia, Jeroen Groenendijk, Herman Hendriks and Martin Stokhof. The music be theirs, mistakes mine.

I must stress that my reformulations do not necessarily imply adherence to the treatments reformulated as against possible rival theories. My point is just to show that a compositional system of dynamic interpretation makes up a natural framework for the description of the phenomena involved. The second point is this. Although I formulated my proposals within *DMG*, they are not restricted to this particular framework. It is my conviction that a completely parallel treatment of the phenomena is possible in any reformulation of the original *DRT*, if only it is a compositional reformulation.

This paper is organized as follows. First I will very shortly review what I take to be the basic characteristics of a compositional dynamic theory. Hereby I will focus on the rudimentary reformulation of *DRT* into *DMG* given by Groenendijk and Stokhof, however, bearing in mind that the proposals to be made straightforwardly carry over to other compositional reformulations. Next I will draw attention to the phenomenon of 'existential disclosure' in *DMG*. Existential disclosure, like dynamic binding, involves addressing the values of variables existentially quantified over, but without the restriction to the explicit terms (indefinite noun phrases) that do the binding. So, with existential disclosure we have the possibility to address *implicit* arguments. In the next sections I give a compositional reformulation of existing treatments of relational nouns, adverbial modification, and tense. In the conclusion I discuss some prospects of the present approach and relate the findings to the main theme of the symposium, that of compositionality. All the way I assume that the reader is acquainted with classical Montague grammar.

2 Dynamic Montague grammar, a crash course

Dynamic Montague grammar (Groenendijk and Stokhof [13]) differs from classical Montague grammar in two respects. In its first presentation, it is restricted to a language without irreducibly intensional expressions and modal operators. States and intensions still play a role, but they are used to establish *DMG*'s so-called 'dynamic intensionality' now. This dynamic intensionality constitutes the second, and most distinctive feature of *DMG*: that it allows indefinite noun phrases (existential quantifiers in the language of translation) to bind pronouns beyond their syntactic scope. The following two equivalences are characteristic for the system of dynamic interpretation (the symbol ; expresses dynamic conjunction, and $\mathcal{E}d$ dynamic existential quantification over the values of the discourse marker d):

Right associativity

- $[\Phi\,;\Psi]\,;\Upsilon = \Phi\,;[\Psi\,;\Upsilon]$
- $\mathcal{E}d\Phi\,;\Psi = \mathcal{E}d[\Phi\,;\Psi]$

Together these equivalences express that an existential quantifier in a dynamic system of interpretation takes scope over sentences which follow it. In this way, the dynamic semantics accounts for the anaphoric relationship in example 1 that holds between the indefinite noun phrase *a man*, translated with an existential quantifier, and the pronoun *he*, translated as a coindexed discourse marker:

(1) A man walks in the park. He whistles.

On the basis of the right associativity laws and on the basis of classical definitions of the universal quantifier and the implication in terms of existential quantification, conjunction and negation, the following equivalence holds as well:

Corollary

- $[\mathcal{E}d\Phi \Rightarrow \Psi] =_{def} \sim[\mathcal{E}d\Phi\,;\sim\Psi] =_{associativity} \sim\mathcal{E}d[\Phi\,;\sim\Psi] =_{def} \mathcal{A}d[\Phi \Rightarrow \Psi]$

This equivalence predicts the universal interpretation of the donkey sentence 2:

(2) If a farmer owns a donkey he beats it.

I will not discuss here the formal tools underlying, in particular, the associativity laws, but I only indicate the properties of the system of dynamic Montague grammar which are required for a proper understanding of the sequel.

An important difference between classical Montague grammar and *DMG* is that sentences are interpreted as objects, not of type t, the type of truth values, but of the dynamic type $\langle\langle s,t\rangle,t\rangle$. Here, the subtype s is the type of states which (by postulate) correspond to discourse marker assignments. A sentence in *DMG* therefore denotes a set of sets of assignments (each set of which contains a verifying assignment, in the terminology of *DRT*). The sentential connectives of *DMG* are ;, $\mathcal{E}d$ and $\sim$ for dynamic conjunction, dynamic existential quantification and negation respectively. They are interpreted as operations on objects of the dynamic type. Furthermore, by a recursively defined operation $\uparrow$, the constants in Montague grammar are raised into *DMG*-counterparts such that in the associated types all occurrences of type t are replaced by $\langle\langle s,t\rangle,t\rangle$. The crucial instance of $\uparrow$ is the raising of an expression of type t into the dynamic type of *DMG* formulas, and a converse static closure $\downarrow$ pulls it down to type t again.

From a (restricted version of) classical Montague grammar we can obtain a dynamic Montague grammar in the following way. First, we assign a distinguished subset of the variables of type e the role of discourse markers: $d_i, d_j, \ldots$. Next, translations of natural language expressions are changed in the following way. All operators are replaced by their dynamic counterparts, and constants c are replaced by 'constants' $\uparrow c$; variables bound by λ-operators are assigned the corresponding dynamic type; all other variables are replaced by discourse markers (there is only quantification over objects of type e, and pronouns, translated with free discourse markers, are assigned this type as well). Finally, the truth conditions of a formula Φ in *DMG* are given by its static closure $\downarrow\Phi$.

In the fragment of *DMG* all sentences have a translation Φ in whose static closure $\downarrow\Phi$ has an effectively computable equivalent in the corresponding intensional logic. The following reduction rules suffice to determine it:

- $\downarrow\uparrow A = A$; $\downarrow d_i = d_i$, if d_i is a discourse marker
- $(\lambda T\ B)(A) = [A/T]B$, ($[A/T]B$ is obtained by substituting all free occurrences of T in B by A)
- $\downarrow\lambda T\ B = \lambda t\downarrow[\uparrow t/T]B$, if t is free for T in B and $\uparrow t$ and T have equal type
- $(\uparrow B)(A) = \uparrow(B(\downarrow A))$
- $^\vee{}^\wedge A = A$; $\downarrow{}^\wedge\Phi = {}^\wedge\downarrow\Phi$; $^\vee\uparrow\phi = \uparrow{}^\vee\phi$
- $\downarrow\sim\Phi = \neg\downarrow\Phi$; $\downarrow\mathcal{E}d\Phi = \exists d\downarrow\Phi$
- $\downarrow[\uparrow\phi\,;\Psi] = (\phi\wedge\downarrow\Psi)$; $\downarrow[\sim\Phi\,;\Psi] = (\neg\downarrow\Phi\wedge\downarrow\Psi)$
- $\downarrow[[\Phi\,;\Psi]\,;\Upsilon] = \downarrow[\Phi\,;[\Psi\,;\Upsilon]]$; $\downarrow[\mathcal{E}d\Phi\,;\Psi] = \downarrow\mathcal{E}d[\Phi\,;\Psi]$

If not misled by some of the required technical hanky panky here, we see that $\downarrow$ moves into the λ- and the $^\wedge$-operator, and that $\uparrow$ moves out of the $^\vee$-operator and out of applications (distributing $\downarrow$ over the arguments). The reduction rules guarantee that $\uparrow$ (introduced with the constants and with variables abstracted over) moves outwards until it confronts the intruding closure operator $\downarrow$. The first clause guarantees that they collaps in that case. In the last clause, which rephrases the associativity laws, the real work is done. This clause requires right associative rebracketings of conjunctions that progressively bring bound discourse markers in the syntactic scope of the binding quantifiers. When this has been done, the remaining clauses let the $\downarrow$-operator jump over the dynamic connectives, leaving their classical counterparts behind.

As an example I show how the truth-conditions of example 1 can be determined. We have the following basic translations (with indices on the pronoun and the determiner to indicate the anaphoric relationship):

- $A_i' = \lambda P \lambda Q\ \mathcal{E}d_i[{}^{\vee}P(d_i)\,;{}^{\vee}Q(d_i)]$
- $man' = \lambda x\ \uparrow\mathtt{man}(x)$
- $walks\ in\ the\ park' = \lambda x\ \uparrow\mathtt{walk}(x)$
- $he_i' = \lambda P\ {}^{\vee}P(d_i)$
- $whistles' = \lambda x\ \uparrow\mathtt{whistle}(x)$

Three standard, (dynamic) intensional, applications give us the following translations of the sentences in example 1:

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

These expressions reduce as follows:

$$
\begin{array}{c}
(\lambda P \lambda Q\ \mathcal{E}d_i[{}^{\vee}P(d_i)\,;{}^{\vee}Q(d_i)])({}^{\wedge}\lambda x\ \uparrow\mathtt{man}(x))({}^{\wedge}\lambda x\ \uparrow\mathtt{walk}(x)) \Longleftrightarrow \\
\mathcal{E}d_i[{}^{\vee}({}^{\wedge}\lambda x\ \uparrow\mathtt{man}(x))(d_i)\,;{}^{\vee}({}^{\wedge}\lambda x\ \uparrow\mathtt{walk}(x))(d_i)] \Longleftrightarrow \\
\mathcal{E}d_i[(\lambda x\ \uparrow\mathtt{man}(x))(d_i)\,;(\lambda x\ \uparrow\mathtt{walk}(x))(d_i)] \Longleftrightarrow \\
\mathcal{E}d_i[\uparrow\mathtt{man}(d_i)\,;\uparrow\mathtt{walk}(d_i)]
\end{array}
$$

$$
\begin{array}{c}
(\lambda P\ {}^{\vee}P(d_i))({}^{\wedge}\lambda x\ \uparrow\mathtt{whistle}(x)) \Longleftrightarrow \\
{}^{\vee}({}^{\wedge}\lambda x\ \uparrow\mathtt{whistle}(x))(d_i) \Longleftrightarrow \\
(\lambda x\ \uparrow\mathtt{whistle}(x))(d_i) \Longleftrightarrow \\
\uparrow\mathtt{whistle}(d_i)
\end{array}
$$

The sequencing of two sentences S and T is translated as the dynamic conjunction of the translations of the two sentences: $S'\,;T'$. A (reduced) translation of our example therefore reads:

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

The truth conditions of this formula are given by its static closure. Its classical equivalent is computed as follows:

$$
\begin{array}{c}
\downarrow[\mathcal{E}d_i[\uparrow\mathtt{man}(d_i)\,;\uparrow\mathtt{walk}(d_i)]\,;\uparrow\mathtt{whistle}(d_i)] \Longleftrightarrow \\
\downarrow\mathcal{E}d_i[[\uparrow\mathtt{man}(d_i)\,;\uparrow\mathtt{walk}(d_i)]\,;\uparrow\mathtt{whistle}(d_i)] \Longleftrightarrow \\
\exists d_i\downarrow[[\uparrow\mathtt{man}(d_i)\,;\uparrow\mathtt{walk}(d_i)]\,;\uparrow\mathtt{whistle}(d_i)] \Longleftrightarrow \\
\exists d_i\downarrow[\uparrow\mathtt{man}(d_i)\,;[\uparrow\mathtt{walk}(d_i)\,;\uparrow\mathtt{whistle}(d_i)]] \Longleftrightarrow \\
\exists d_i\downarrow[\uparrow(\mathtt{man}(\downarrow d_i))\,;[\uparrow(\mathtt{walk}(\downarrow d_i))\,;\uparrow(\mathtt{whistle}(\downarrow d_i))]] \Longleftrightarrow \\
\exists d_i\downarrow[\uparrow(\mathtt{man}(d_i))\,;[\uparrow(\mathtt{walk}(d_i))\,;\uparrow(\mathtt{whistle}(d_i))]] \Longleftrightarrow \\
\exists d_i(\mathtt{man}(d_i) \wedge \downarrow[\uparrow(\mathtt{walk}(d_i))\,;\uparrow(\mathtt{whistle}(d_i))]) \Longleftrightarrow \\
\exists d_i(\mathtt{man}(d_i) \wedge (\mathtt{walk}(d_i) \wedge \downarrow\uparrow(\mathtt{whistle}(d_i)))) \Longleftrightarrow \\
\exists d_i(\mathtt{man}(d_i) \wedge (\mathtt{walk}(d_i) \wedge \mathtt{whistle}(d_i)))
\end{array}
$$

This concludes our exposition of the fragment. The interested reader is referred to Groenendijk and Stokhof [13] and Dekker [7]. (The last paper discusses a fragment in which also negation is given a dynamic interpretation, and it adduces some linguistic motivation for such a negation.)

3 Existential disclosure

Up until now, attention has concentrated on the binding potential of (indefinite and other) noun phrases. However, the same phenomena can be viewed from a different perspective. Instead of saying that certain noun phrases have the potential of

binding in subsequent discourse, one may say that pronouns in a dynamic semantics have access to existential quantifiers in preceding discourse. By attaching a certain index to a pronoun, the pronoun addresses a coindexed existential quantifier (if any) and it ends up being bound by it. This point can be strenghthened in the following way. Suppose that a quantifier $\mathcal{E}d_i$ occurs in the translation Φ of some part of discourse, and that it is still active (i.e., it is not followed by another active occurrence of $\mathcal{E}d_i$ in Φ and it is not in the scope of a negation sign). Suppose we next add to Φ the identification of some free variable x with the discourse marker d_i. Then the variable x attaches to whatever value d_i may have, that is, to whatever satisfies the restrictions imposed on d_i at that stage of the discourse. So if d_i is introduced as a man who walks, then the value of x must be a man who walks. Clearly, we know nothing more about x than we know about d_i in that case, but the association of x with d_i is still significant. We can get a *free* variable to play the role of a *bound* discourse marker. I call this the 'existential disclosure' of the quantifier $\mathcal{E}d_i$, since it makes the existential quantifier 'transparent'. I define it as follows:

Disclosure of $\mathcal{E}d_i$

- $\{x/d_i\}\Phi =_{def} [\Phi\,;\uparrow(x = d_i)]$

In the ensueing example I show that the variable x in the disclosure of $\mathcal{E}d_i$ in fact gets associated with the possible values of d_i in the scope of the quantifier $\mathcal{E}d_i$, and that it resolves the whole quantification (I use the static closure $\downarrow$ of the disclosure here in order to clarify its truth conditional import):

$$\begin{gathered}
\downarrow\{x/d_i\}\mathcal{E}d_i[\uparrow\mathtt{man}(d_i)\,;\uparrow\mathtt{walk}(d_i)] = \\
\downarrow[\mathcal{E}d_i[\uparrow\mathtt{man}(d_i)\,;\uparrow\mathtt{walk}(d_i)]\,;\uparrow(x = d_i)] \Longleftrightarrow \\
\downarrow\mathcal{E}d_i[\uparrow\mathtt{man}(d_i)\,;[\uparrow\mathtt{walk}(d_i)\,;\uparrow(x = d_i)]] \Longleftrightarrow \\
\exists d_i(\mathtt{man}(d_i) \wedge (\mathtt{walk}(d_i) \wedge x = d_i)) \Longleftrightarrow \\
\exists d_i(\mathtt{man}(x) \wedge (\mathtt{walk}(x) \wedge x = d_i)) \Longleftrightarrow \\
\mathtt{man}(x) \wedge \mathtt{walk}(x)
\end{gathered}$$

(Since I have introduced a free variable here, I must add that, of course, $\downarrow x = x$ if x is a variable of type e.) We see that the disclosure of an existential quantifier in effect dissolves it, as if the quantifier had only introduced a fresh new variable. This is interesting, since it means that we can treat indefinites as free variables, like Heim [14] does, even though these indefinites introduce existential quantifiers in the first place.

An immediate application of existential disclosure, one that I will only touch upon, concerns plural anaphora. Suppose we translate the sentence *Harry owns some sheep.* as $\mathcal{E}d_i[\uparrow\mathtt{sheep}(d_i)\,;\uparrow\mathtt{own}(d_i)(\mathtt{harry})]$. Then we can disclose the quantifier $\mathcal{E}d_i$ and λ-abstract over the free variable x. The resulting λ-term, which reduces to $\lambda x(\mathtt{sheep}(x) \wedge \mathtt{own}(x)(\mathtt{harry}))$, denotes the set of sheep owned by Harry. This set may serve as the interpretation of the pronoun *them* in a subsequent statement *Bill shaves them.* The resulting reading is that Harry owns some sheep and that Bill shaves all the sheep owned by Harry. This, in fact, is the reading argued for by Evans [12]. However, like I said, I will not pursue an analysis of plurals here.

What I want to propose in this paper is to treat implicit arguments as existentially quantified over. Certain nouns and verbs come with implicit argument slots which, in their translation, are existentially closed. Optional specification of such arguments then involves disclosure of the relevant quantifiers. A noun modifier or adverb discloses the intended implicit argument of the noun or verb and gives it a further specification. For instance, I propose to interpret the common noun *mother* as the (dynamic) property of being the mother of someone. This is expressed by the translation $\lambda x\ \mathcal{E}d_2\uparrow\mathtt{mother\_of}(d_2)(x)$. The noun *mother* in other

words is assigned the same type as other nouns in *DMG*, and it can immediately be combined with a determiner to form a noun phrase. However, the common noun can also be combined with a complementizing phrase to form a compound noun like *mother of John*. In that case the prepositional phrase *of John* discloses the quantifier that covers the implicit argument and fills the slot up with John again. This operation is expressed by the translation: $\lambda P \lambda x \uparrow\downarrow\{\mathtt{john}/d_2\}^{\vee} P(x)$. When the prepositional phrase combines with the common noun, one λ-reduction yields the translation $\lambda x \uparrow\downarrow\{\mathtt{john}/d_2\}\mathcal{E}d_2\uparrow\mathtt{mother\_of}(d_2)(x)$ which is equivalent with: $\lambda x\ \mathtt{mother\_of}(\mathtt{john})(x)$. (Use the reduction rules to see this).

The last term clearly expresses the intended interpretation of the compound noun *mother of John* in the format of *DMG*. I want to stress here that both *mother* and *mother of John* are assigned the same type in this proposal. Both behave as ordinary common nouns in *DMG*. The point is that *DMG* allows us to 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. It is the dynamics of the implicit noun here that enables such further specification.

From this introductory exposition it may already be evident what is needed, on and above existential disclosure, to give a satisfactory account of adverbs and adnominals along the present lines. In the first place it requires 'lexical decomposition' of expressions that carry an implicit argument. (See for instance Dowty [8] for the use of lexical decomposition in Montague grammar.) In my proposal it is crucial that the noun *mother* itself conveys the information that every mother is the mother of someone. It would not do to introduce this information by meaning postulate, since then the complement phrase *of John* would find no argument slot to attach to in the noun *mother*. In the second place, in the translations of natural language expressions we must encode what argument slots can be addressed by what kind of specifiers or complementizers. Here I use distinguished discourse markers that carry an index for the kind of 'case' they label. In the example above I used d_2 to indicate the object argument of a relational noun. The idea is that a complementizing use of the preposition *of* selects this slot of the nouns with which it is combined. Below we will find other distinguished discourse markers, discourse markers, for instance, that label the events or reference times associated with finite verbs.

Notice that this approach doesn't commit us to some kind of case grammar. The question what kind of arguments may be specified by a certain prepositional phrase may be of a purely semantic nature. A warning should be issued here as well. One shouldn't use a discourse marker in a pronoun translation if it may label implicit arguments. The reason is obvious. If we use d_2 in the translation of *it* in the sequence *A captain whistles. It is in the harbour*, then the pronoun would select as its antecedent the ship of which the person mentioned in the first sentence is the captain. Clearly, such anaphoric relations are prohibited in English. (On the other hand, definite descriptions have much more freedom in this respect.)

4 Applications (1): Relational nouns

Now we have developed the formal tools to be used in a treatment of implicit arguments, we turn to the treatments themselves. I start with relational nouns, which are already discussed to some extent.

Relational nouns, like *mother* and *captain*, are nouns that can be 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 [4], this does not imply that relational nouns should be treated syntactically as being subcategorized for certain prepositional phrases. De Bruyn and Scha point at the syntactic behaviour of relational nouns, which is very similar

to 'ordinary' nouns, and they claim that the "overt realization of the arguments of a 'transitive' noun is always optional" (p. 26). They, therefore, 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*.

De Bruyn and Scha treat complement phrases, syntactically, as modifiers of the (relational) nouns with which they combine. Still, semantically, the complements address arguments of the relations expressed. The semantic part of de Bruyn and Scha's proposal comes down to this. Relational nouns like *sisters* denote genuine relations, that is, sets of pairs of objects. In the case of *sisters* the set contains pairs consisting of an individual and a sister of that individual. Expressions like *Peters'* in *Peters' sisters*, or *of Peter* in *sisters of Peter*, next restrict the set of pairs to the pairs consisting of Peter and a sister of his. Notice that these phrases still denote sets of pairs of individuals. So, in order to let these expressions combine properly, 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 resulting set consists of Peters' sisters.

De Bruyn and Scha's proposal is tied up with a computational framework of interpretation that diverges quite a bit from more orthodox semantic frameworks. This impedes a dissection of their proposal about relational nouns from the specific framework used. Nevertheless, I want to recast (part of) their proposal in more familiar terms in order to compare it with my own. So, be aware that this rephrasal may not be as faithful to the original as might be desirable. According to de Bruyn and Scha then, a relational noun R expresses a relation. In Montagovian terms this means that it has the type $\langle e, \langle e, t\rangle\rangle$. A complementizing phrase *of John* takes such a relation as an argument and assigns the second argument of the relation to John. We may leave it undecided here whether the result of adding this complement expresses a relation or a set (that is, whether it reduces to $\lambda y \lambda x\ (R'(y)(x) \wedge y = \mathtt{john})$ or to $\lambda x\ R'(\mathtt{john})(x)$ respectively). In any case, a determiner (that combines with a noun to form a noun phrase) must be made semantically applicable to relation- as well as to set-expressions (that is, take objects of both the types $\langle e, \langle e, t\rangle\rangle$ and $\langle e, t\rangle$ as an argument). The meaning postulate mentioned above then identifies the application of the determiner to a relation-expression with an application of it to the set-expression which is made up from the relation by existentially closing the object argument of it. In other words, *DET'(R')* is ordered to be equivalent with $DET'(\lambda x\ \exists y R'(y)(x))$.

We see here that de Bruyn and Scha's proposal involves complications in the category to type assignment, as well as in the semantics. Common nouns are not assigned a uniform type, since some of them express relations and others sets; and either we must take determiners to range over these two kinds of argument expressions (with an added meaning postulate to get the semantics right) or we must postulate an operation of existential closure that reduces relations to sets whenever this operation is needed. In the framework of *DMG* we can avoid these complications. As we indicated above, all nouns can be assigned the type of dynamic properties (type $\langle e, \tau\rangle$, where τ $(= \uparrow t)$ is the dynamic type of formulas). A relational noun of this type brings along with it an existential quantification over its (implicit) object argument slot. A complementizing phrase simply reopens this case by means of existential disclosure.

My proposal is contained in the following definitions of the category to type assignment T and the translation of some expressions involved (τ is the dynamic type of formulas again):

$$T(CN) = \langle e, \tau \rangle$$
$$T(NP) = \langle \langle s, \langle e, \tau \rangle \rangle, \tau \rangle$$
$$T(B/A) = T(A\backslash B) = \langle \langle s, T(A) \rangle, T(B) \rangle$$

ship	*CN*	$\uparrow\mathbf{ship}$
captain	*CN*	$\lambda x\ \mathcal{E}d_2 \uparrow \mathbf{captain\_of}(d_2)(x)$
of_2	*(CN\CN)/NP*	$\lambda T \lambda P \lambda x\ {}^{\vee}T(\hat{}\lambda y\ \uparrow\downarrow\{y/d_2\}{}^{\vee}P(x))$
the ss. enterprise	*NP*	$\lambda Q\ {}^{\vee}Q(\mathbf{ss.e})$
a_i	*NP/CN*	$\lambda P \lambda Q\ \mathcal{E}d_i[{}^{\vee}P(d_i)\,;{}^{\vee}Q(d_i)]$
$every_j$	*NP/CN*	$\lambda P \lambda Q\ \mathcal{A}d_j[{}^{\vee}P(d_j) \Rightarrow {}^{\vee}Q(d_j)]$

These definitions allow us to generate noun phrases like *every captain*, *a captain of the ss. enterprise* and *every captain of a ship*. The (reduced) translations of these expressions are, respectively:

$$\lambda Q\ \mathcal{A}d_j[\uparrow\mathbf{captain}(d_j) \Rightarrow {}^{\vee}Q(d_j)]$$
$$\lambda Q\ \mathcal{E}d_i[\uparrow\mathbf{captain\_of}(\mathbf{ss.e})(d_i)\,;{}^{\vee}Q(d_i)], \text{and}$$
$$\lambda Q\ \mathcal{A}d_j[\mathcal{E}d_i[\uparrow\mathbf{ship}(d_i)\,;\uparrow\mathbf{captain\_of}(d_i)(d_j) \Rightarrow {}^{\vee}Q(d_j)]$$

These are correct, dynamic, translations of the noun phrases. As in Montague's proposal they express generalized quantifiers, be it that they are *dynamic* generalized quantifiers this time. Notice that the noun phrases are derived in a completely uniform fashion, irrespective of whether they comprise a relational noun. Notice furthermore that there is no need to use optional closure operations. I conclude, therefore, that (my reformulation of) de Bruyn and Scha's treatment of relational nouns is more elegantly formulated in the framework of *DMG*.

A few remarks about my proposal may be added here. In the first place, compound nouns give rise to scope ambiguities. For instance, the sentence *The captain of every ship went ashore.* has two readings. One reading says that someone is the captain of every ship and that he went ashore; the other reading says that for every ship there is a definite captain who went ashore. These readings can easily be accounted for by means of Montague's quantification rules. However, Hendriks' [15] elegant alternative for treating quantifier scope can be used as well. If we adopt his type flexibility, then the translations above can be simplified considerably. For instance, the basic translation of of_2 then may come to read $\lambda y \lambda P \lambda x\ \uparrow\downarrow\{y/d_2\}{}^{\vee}P(x)$. (See Dekker [7] for the formulation of a combined flexible dynamic Montague grammar.)

The second remark concerns the mysterious index $_2$ with which we adorned the preposition *of*. This index distinguishes a 'functional' use of the preposition, which addresses arguments of relations, from other uses like the possessive. A motivation for such a distinction is that even the noun phrase *the mother of Jack* can be assigned two different readings. When the preposition is used functionally, then the noun phrase denotes the female which gave birth to Jack. When it is used possessively on the other hand, the noun phrase selects the female among Jack's belongings who is the mother of someone. Clearly, the assumption of slavery may seem quite absurd to us now, but the distinguished reading, I think, is definitely possible.

A final remark concerns the use of complement phrases with non-relational nouns. A fragment along the lines sketched above allows for the derivation of noun phrases like *a man* of_2 *John*, *a ship about syntax* and also *the mother* of_2 *Peter* of_2 *John*. (Notice that the compound noun *mother* of_2 *Peter* does not contain an

active implicit argument anymore on behalf of the closure $\downarrow$ in the translation of of_2.) In all three cases we find an intended specification of an implicit argument, which is absent. The oddness of these phrases is therefore accounted for in the semantics. For instance, *a man of$_2$ John* turns out to mean a man such that the object d_2 is John, and *a ship about semantics* becomes a ship such that the topic d_a is syntax. In other words, the complements in these examples address free discourse markers and their semantic contribution remains entirely disconnected from that of the noun. This explains why the examples are marked. (We must be careful here though. In the process of interpretation an implicit argument that derives from another part of discourse may come to bind an addressed free discourse marker and this might give wrong results. We can exclude this possibility by incorporating in the translation of sentence- and noun phrase-forming expressions an operation that cancels the addressibility of embedded implicit arguments. I will not go into this issue here, since it does not arise in the examples discussed in this paper.)

5 Applications (2): Non-temporal adverbial phrases

The modification of verbs by adverbial phrases (among which we include prepositional phrases for simplicity) is in many 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.) Still, many adverbials do not behave like irreducible modifiers at the semantic level.

Consider the following examples (an adverb like *quickly* can be added at several positions):

(3) Harry walks from Amsterdam to Budapest.

(4) Mary hits John with a hammer on his head.

In Montague [23] phrases like *from Amsterdam* and *with a hammer* express functions from properties to properties. For instance, sentence 3 is analyzed, roughly, as `to(b)(from(a)(walk(h)))`. This approach, however, does not validate two inference schemes discussed in Parsons [25], which seem to give a correct characterization of the logical behaviour of most adverbial phrases:

Diamond entailment

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

Scope entailment

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

Adverbial phrases for which the scope entailment hold, can be reordered in a sentence without changing the sentence's meaning. For instance, *Harry walks to Budapest from Amsterdam.* and *Mary hits John on the head with a hammer.* have the same truth conditions as the examples 3 and 4 respectively. Likewise, the deletion of adverbial phrases which respect the diamond entailment, weakens a sentence's truth conditions. So 3 entails that Harry walked from Amsterdam, that Harry walked to Budapest, and that Harry just walked. (At first glance one might think that all adverbial phrases respect these entailment schemes, but this is not true. Montague [23] offers the example *in a dream.*)

Montague himself has observed this inferential behaviour of many ad-phrases, and he proposes to account for it by assigning such phrases the 'intersection-property' ([23] pp. 211–213). We can elaborate this by associating with each intersective adverb A a meaning postulate that guarantees that A expresses an inter-

sective function and consequently respects the entailment schemes. An alternative might be to use lexical decomposition of the adverbs. Still, I think that this approach is not satisfactory yet. 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 that come to the subject of the sentences. For instance, if the intersection property were to hold for the adverbials in 4, then 4 together with the premiss that Mary sings would allow us to conclude that Mary sings with a hammer on John's head. This is quite absurd.

Alternative approaches to adverbial phrases are given by Parsons [25], [26] and Dowty [11]. Both authors let these phrases express properties, not of objects that fill the subject argument slot of verbs, but of objects that fill some added event argument slot. Elaborating on the work of Davidson, they assume that (certain) verbs predicate over events (or express relations between events and some number of other arguments), and that adverbial phrases express properties of the events described by the verbs. For instance, example 4 is assigned an interpretation which can be rephrased as: $\lambda e\ (\mathtt{hit}(e)(\mathtt{j})(\mathtt{m}) \wedge \mathtt{with\_a\_hammer}(e) \wedge \mathtt{on\_his\_head}(e))$.

I have refrained from further analyzing the adverbial phrases here. But, for instance, the condition that the event e is 'with a hammer' can be further analyzed as the condition that the 'instrument' relation holds between e and a hammer. Furthermore, in Parsons' proposal subjects and objects do not appear as arguments of the verb, but they are related to the described event by the primitive relations 'agent' and 'object'. Complications like these, and simplifications like ours, are not relevant for the present discussion though. I only give an indication of the main ideas of the proposal, and show how proposals along these lines can be more elegantly reformulated in the framework of *DMG*.

In Parsons' and Dowty's proposal adverbial phrases are predicates over the events in the argument slot of a verb, and it is easy to see that they validate the diamond and the scope entailments. (These correspond to conjunction reduction and conjunction commutation respectively.) Still, one crucial element is missing in the presentation of their theory sofar, since, intuitively, a finite sentence does not denote a set of events, but it conveys the information that an event of the type described exists. For this reason, the authors introduce an operation of existential closure at the level of sentence formation.

In fact, this closure is triggered by a final syntactic rule of sentence formation the only motivation for which in Parsons' proposal seems to be that it effectuates the closure. This is rather unelegant. It also has a drawback, since in Parsons' proposal it precludes the possibility of anaphoric reference to described events, notwithstanding the fact that such anaphors make up one of his arguments for the existence of events.

Completely analogous to our treatment of relational nouns and their complements, we can recast Dowty's and Parsons' proposal in *DMG*, without needing to add an operation of existential closure. As we have seen, such intermediary closures can be dispensed with in a dynamic semantics, just by introducing the existential closure already in the translation of the (finite) verbs. On behalf of the dynamics of the system of interpretation, these arguments can still be addressed by adverbial phrases. So if we were to adopt the analyses of Parsons and Dowty, we might translate a finite form of the verb *walk* as $\lambda x\ \mathcal{E}d_e\uparrow\mathtt{walk}(d_e)(x)$, where d_e is the distinguished discourse marker used for (specifications of) implicit event arguments; likewise, a finite form of the verb *hit* might be translated as $\lambda T\lambda x\ {}^{\vee}T(^{\wedge}\lambda y\ \mathcal{E}d_e\uparrow\mathtt{hit}(d_e)(y)(x))$.[1] In the translation of an adverbial

[1] I assume an extension of our models with a domain of events here, and an extension of our language with expressions of this type. Of course, any proposal along these lines commits itself to

phrase like *with a hammer*, we make sure that it gives a further specification of the event described by the verb that constitutes the argument of the adverbial: $\lambda P \lambda x\ [^{\vee}P(x)\,;\uparrow\mathtt{with\_a\_hammer}(d_e)]$. (Here we can address the implicit event argument, without using the operation of existential disclosure itself.) If we combine the verb *hit* with the noun phrase *John* and next apply the adverbial to the result, we arrive at the (reduced) translation: $\lambda x\ \mathcal{E}d_e[\uparrow\mathtt{hit}(d_e)(\mathtt{j})(x))\,;\uparrow\mathtt{with\_a\_hammer}(d_e)]$. Similarly, the translation of the whole example 4 reduces to the dynamic formula:

$$\mathcal{E}d_e[\uparrow\mathtt{hit}(d_e)(\mathtt{j})(\mathtt{m}))\,;\uparrow\mathtt{with\_a\_hammer}(d_e)\,;\uparrow\mathtt{on\_his\_head}(d_e)]$$

The present discussion serves to indicate how we can give a straighforward reformulation in *DMG* of Dowty's and Parsons' interpretive procedure, whatever its details are. As was the case with our treatment of adnominals, this can be done on the basis of a uniform syntactic treatment of adverbial phrases. The discussion also shows that we can do without an (ad hoc) operation of existential closure. So, again *DMG* is shown to provide for a suitable framework for the description of the phenomena at stake.

Other analyses of adverbial phrases have been proposed by McConnell Ginet [22] and Larson [21]. Although their proposals differ from each other considerably, in the present global perspective they can be treated on a par. In the proposals of McConnell Ginet and Larson adverbial phrases express properties of objects that are related to the verb in some or other way. (The verb again is subject to adverbial modification syntactically.) For instance, in the proposal of McConnell Ginet an adverb *quickly* expresses a property of the *rate* of the verb modified by the adverb; in Larson's proposal the verb *walked* is taken to 'involve' an agent's change of position, the source location of which can be specified by a phrase *from Amsterdam*, and the goal location by a phrase *to Budapest*.

In the formulation of both proposals some operation is used which sends the interpretation of a verb to an associated semantic object with added constituents. These added constituents are the subject of adverbial modification. In McConnell Ginet's proposal the interpretation of the verb *walks* (a property) can be send to a two place relation which holds between walkers and walking rates. In the interpretation of *walks quickly*, the adverb *quickly* applies to this inflated verb interpretation and imposes the condition that the added rate is quick. In Larson's proposal they are situation theoretic constraints that relate described walking situations with situations that comprise a change in position with a source and a goal. The adverbial *to Budapest* then imposes the condition that Budapest is the goal of the change of location which is 'involved' by the situation described by the sentence.

There are some problems with both proposals. McConnell Ginet imposes no (semantic) restrictions on the admissible augmentations of verbs with argument slots (p. 169). An augmentation of the interpretation of *walks* may contain arbitrary rates, which are not related to what, intuitively, the rate of a specific walking would be. This seems to render adverbial modification as a whole vacuous. Larson on the other hand draws from a situation theoretical account of constraints. But as far as I know, a full-fledged theory of constraints has never been stated. Moreover, in Larson's approach it is essential that a type of situations that by constraint is involved by another type of situations S, contains free paramaters (or roles) not present in S. But (Barwise and Perry [3], p. 146): "In the book (Situations and Attitudes, PD), we allowed constraints of the form $S_1 \Rightarrow S_2$ where there were roles in the defining conditions for S_2 that were not in S_1. I think that was a mistake and was really just what our computer scientist friends call a "hack", to sneak in existential quantification." Here the founding fathers of situation semantics are

such extensions. Since I am only interested in the reformulation of the interpretive mechanism, I can leave the required model-theoretic elaboration to the original proponents.

speaking to themselves. Neglecting such a statement with respect to such a matter of debate doesn't put one on the safe side.

Notwithstanding these criticisms, I think we can worm the essence of the treatments of adverbials from their theoretical frameworks and mould it in our dynamic semantic framework. 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. This clearly circumvents the problem with McConnell's proposal, and still allows for adverbial specification by means of existential disclosure.

The essence of Larson's proposal, for as far as the semantics is concerned, is clarified if we take constraints to be (what they definitely were not intended to be): meaning postulates. However, instead of reformulating the relevant constraints in the form of meaning postulates, we would choose to frame them in the translations of verbs by means of lexical decomposition. There are several ways to go then. One can assign motion verbs (existentially closed) argument slots for the 'source' and 'goal' of the motions, and make *from*- and *to*-phrases (existentially disclosing) specifiers of these slots; or one may think of assigning motion verbs an (existentially closed) argument slot for the path through space-time along which the motion takes place. A *from*-phrase then predicates something about the location of the start of the path. I don't know. What one takes to be a suitable choice will depend on the ontological commitments one wishes to make and on what one thinks an opportune way to account for the semantic facts involved (which are much more entangling then appears from the present discussion). In any case, if one conceives of a treatment along the lines of Larson or of McConnell Ginet, I claim that a compositional dynamic system of interpretation allows it to be given a semantically sound formulation.

6 Applications (3): Tense in discourse

The last application of existential disclosure concerns temporal adverbs and tense in discourse. Since the syntactic category of (temporal) adverbs is most likely that of verb (phrase) modifiers, one again might be tempted to treat them also as modifiers at the semantic level. 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 then is 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. However, Dowty [9] (among others) has argued that this is not the right approach.

Consider the following example:

(5) Bill left yesterday.

In the Priorian proposal this sentence translates either as $Y(P(\texttt{leave(b)}))$ or as $P(Y(\texttt{leave(b)}))$. None of both translations gives the right truth conditions, since both are verified if Bill did not leave yesterday, but, for instance, two days ago.

Alternative approaches to tense have been offered by Dowty [9], [10], Kamp and Rohrer [20], Hinrichs [16] and Partee [27]. 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 an event time before that. (For further motivation, see Reichenbach [29] pp. 287–298.) In the approaches mentioned tenses express conditions on the ordering of the three times 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. Clearly, example 5 is analyzed correctly along these lines. Below I indicate how to elaborate a treatment of tense along the present lines. Before that I discuss another application of the notion 'reference time'.

Reference times also play an important role in an account of 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.[2] Dowty [10] 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)'.

It is not quite clear what the status is of Dowty's principle, and how it should be incorporated in a formal theory of discourse interpretation. Dowty just calls it "the primary principle for interpreting successive sentences in a discourse temporally" (p. 45) and later on he remarks: "(...) one is entitled to ask whether the TDIP is to be regarded as an independent principle of discourse interpretation per se, or merely as a description of the typical outcome of the interaction of various conversational principles and the speakers'/hearers' knowledge of typical events and typical goals of narratives (...)" (p. 58/9). Without regard to the discussion that could emerge on this point, I think we can elaborate Dowty's proposal in one of the following two ways.

We can introduce reference times as a contextual parameter of utterances next to the speech time parameter. (This 'two-dimensional' approach is the one Dowty himself suggests.) Verbs then are assigned interpretations which depend on the reference time and the temporal sequencing of two sentences is (by default) associated with an operation that effectuates the required shift in the reference time when going from the evaluation of the first to that of the second sentence sequenced. The alternative is to introduce with verbs argument slots for reference times. (In the models we have sorted domains then: a domain of individuals, a domain of time(-interval)s, and possibly more.) The operation of temporal sequencing in that case does not only conjoin two sentences, but also adds the condition that the reference time of the first sentence precedes that of the second.

The second alternative can be given a straightforward formulation in a dynamic framework. Within such a framework we can use distinguished discourse markers t_r and t_s for reference time and speech time respectively. The discourse marker d_r fills the reference time argument slot in the translation of verbs and is existentially quantified over.[3] Since the existential quantifier is dynamic, temporal adverbs can

[2] 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.

[3] Partee's example *I didn't turn off the stove* makes up a reason for Dowty to introduce reference times as (definite) parameters of interpretation. The idea is that if tense comes in by existential quantification, then the sentence 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). In Dowty's proposal the sentence (probably) means that the speaker did not turn off the stove at reference time. However, Dowty's proposal still assumes a proper choice of the intended reference time. I think that we get the interpretation of this sentence right also with an existential treatment of

still give a further specification of the reference time. Furthermore, by means of existential disclosure we can still connect the reference times of the sentences in a piece of (temporal) discourse. As an indication of how things might work out, think of the following basic translations. *Walk* translates as $\lambda x\ \mathcal{E}t_r[\uparrow\mathbf{walk}(t_r)(x)]$, the past tense operator *-ed* translates as $\lambda P\lambda x\ [P(x)\,;\uparrow(t_r < t_s)]$, and *yesterday* translates as $\lambda P\lambda x\ [P(x)\,;\uparrow Y(t_r)]$.[4] Temporal sequencing is defined as follows:

$$\Phi\ ;_t \Psi = \mathcal{E}y[\Phi\,;\uparrow(t_r < y)\,;\{y/t_r\}\Psi]$$

This operation of temporal sequencing sets the reference time of the first sentence sequenced before that of the second one, again, by means of existential disclosure. The reader may verify for himself that these translations comprise in a rudimentary form the basic ingredients of Dowty's proposal. Notice again that my proposal is built up from verb translations with a reference time existentially quantified over. In the dynamic system this allows for a correct and compositional treatment of the tensing of verbs, of temporal adverbs and of temporal sequencing.

Kamp and Rohrer, Hinrichs and Partee have given an account of tense in discourse within the framework of *DRT*. Since *DMG* offers a compositional reformulation of *DRT*, we can expect it to allow for a reformulation of these treatments as well. This expectation comes true. Some of the basic properties of the proposals can be reformulated as follows. (I will again generalize over the differences and pass over the details.)

First, verbs are translated with constants of the logical language that have an argument slot for the time at which the extension of the verb is evaluated. This argument slot is filled by the distinguished discourse marker t_e which labels event times.[5] In the translation of verbs two more distinguished discourse markers t_{r_1} and t_{r_2} show up. These label reference times. The first one labels the reference time of the verb, and the second one serves a technical purpose as we will see presently. The distinction between reference time and event time is already present in the translations of verbs. For instance, when the verb describes a 'real' event, the event time is supposed to be contained in the reference time; if it describes a state, then the event time (the time of the state's duration) is supposed to contain the reference time. (See the literature for motivation and details.) Finally, the discourse marker t_{r_2} is used to reset the reference time in case the verb figures in a piece of discourse. (If it doesn't, then the discourse marker will not be addressed any further.) In the default case, an eventive sentence passes on a reference time to the next sentence which lies after its own event time. A stative sentence keeps the reference time the same.[6] The temporal sequencing of two sentences finally sets the input reference time of the second sentence, which is labeled by t_{r_2}, equal to the output reference time of the first, which is labeled by t_{r_1}. The following definitions illustrate this rudimentary reformulation of the *DRT* treatment of tense in discourse:

- *arrive'* $= \lambda x\ \mathcal{E}t_{r_1}\mathcal{E}t_{r_2}\mathcal{E}t_e\ [\uparrow(t_e \subseteq t_{r_1})\,;\uparrow\mathbf{arrive}(t_e)(x)\,;\uparrow(t_e < t_{r_2})]$
- *be happy'* $= \lambda x\ \mathcal{E}t_{r_1}\mathcal{E}t_{r_2}\mathcal{E}t_e\ [\uparrow(t_{r_1} \subseteq t_e)\,;\uparrow\mathbf{happy}(t_e)(x)\,;\uparrow(t_{r_1} = t_{r_2})]$
- $\Phi\ ;_t \Psi = \mathcal{E}y\ [\{y/t_{r_2}\}\Phi\,;\{y/t_{r_1}\}\Psi]$

tense, by assuming a properly restricted domain of quantification (instead of a properly chosen reference time.

[4] According to Dowty's TDIP, 'definite time adverbials' may disregard the reference time as it is generated by preceding discourse. I neglect this complication here.

[5] We need not go into the question here what kind of things this discourse marker stands for. I simply take it to denote event time intervals. It may as well denote entities from a domain of events which carries a temporal order.

[6] All kinds of alternatives are conceivable. These need not concern us, since the present proposal is only intended to be indicative of the scheme of reformulation. See the literature again for further discussion.

These definitions merely formalize the treatment of tense as I described it above. It is easily verified that the temporal sequencing operator gives the intended results. The concisely reformulated Dowtian treatment of the tensing of verbs and of temporal adverbs can be added as well, if only we substitute the discourse marker t_r by t_{r_1} in them. The formulation of a proper translation of the past perfect tense, which locates the event time before the reference time in the past, is left as an exercise to the reader.

As for a comparison between the present approach and a *DRT* one, it is worthwhile to point at an interesting observation in Partee [27]: "(...) 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, p. 258) This is strange, because it had always seemed to me that the *DRSs* themselves were already designed to account for (some of) the dynamics of discourse. More interesting, however, is that where Partee in 1984 said not to see how to compositionalize the *DRT* treatment of tense (p. 279), it now turns out that a compositionalization of *DRT* itself easily extends to cover a *DRT*-like treatment of tense, this *without* further dynamification.

7 Conclusions

(1) *DMG* provides for a powerful framework for treating the semantics of natural language, and other compositional dynamic systems of interpretation probably do likewise. *DMG* captures, within a compositional Montagovian framework, basic *DRT* results such as a treatment of anaphoric relationships (Groenendijk and Stokhof [13], Dekker [7]), of unselective quantification (Chierchia [5]), and of tense in discourse (Muskens [24] and the present paper). The framework of a compositional dynamic semantics also allows us to incorporate in Montague grammar treatments of adverbial modification and of relational nouns.

What one may take to be the main result of *DMG* is that it has given the context dependence and the context change potential of natural language expressions an integrated formulation within dynamic intensional logic. Technically this is achieved by two things: The first one is to allow the logical language of translation to quantify over states (assignments or stores), which encode information conveyed by the linguistic context. (In fact, this corresponds to the possibility to quantify over worlds in *IL* or *TY2*.) The second one is a shift of the type of the meanings of sentences (to $\langle s, \langle s, t\rangle\rangle$ in *DPL*, or to $\langle s, \langle\langle s, t\rangle, t\rangle\rangle$ in *DMG*). The type shift allows for a compositional account of the directed (left to right) building up of contexts of interpretation in the processing of discourse.

The point made in this paper is that the increased expressive power of the language of translation not only allows for a compositional treatment of anaphoric relationships, but easily generalizes to other topics. Since the contexts of interpretation used are assignments, or stores, they can encode all different sorts of contextual information. Apart from the possible satisfiers of existential quantifications, states can encode reference times and implicit arguments of nouns and verbs. These can on their turn be addressed in the course of interpreting temporal operators, prepositional and adverbial phrases and the temporal sequencing operation in discourse.

(2) As I stressed every now and then, my proposals or proposed reformulations basically consist of existentially closing implicit argument slots in the translations of lexical expressions. The dynamic character of the existential quantifier allows further specification and restriction of the arguments, whatever their type is. My claim is that all kinds of expressions that address implicit arguments thus can be

given a uniform treatment.

In this sense, my proposals contribute more to semantic theory than mere reformulation and integration. The general approach to the phenomena consists of an initial existential closure and optional subsequent disclosure of implicit arguments which uses distinguished discourse markers to label the cases (dis)closed. It is not self-evident that this approach to implicit arguments is 'the right one'. Other constructions that address implicit arguments (or whatever they may be called), constitute a test for the present proposal. Such constructions might turn out to be hardly (acceptably) formalizable within the present approach. Compound nominalizations constitute such a challenging case. In these constructions (*the destruction* ...), *by-* and *of-* phrases play an as yet not completely clear role. However, I will not go into these constructions here, I only mention them as indicative of the 'falsifiability', or 'rejectability', of my approach.

The present proposal may also seem to be too laborious. Yet in a small, but full-blown, 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 makes up a real objection to my proposal. Whichever way one turns, when implicit arguments are addressed they must somehow be there. Of course, one might choose to await their appearance in a 'context' whose formulation is not expedient from a considered semantic point of view. But one can also take them for what they are: generated by the linguistic context. It then may remain a question whether they are better situated in some pragmatic or in the purely semantic part of a theory of interpretation. I won't take a definite stand in this issue. From a computational perspective, it may be opportune to use a comparatively simple semantics and next to that a well-defined procedure of data-base construction and data-based interpretation. In that perspective I might have put too much of the interpretation algorithm in the semantics. But even then, the information laid down in the proposed lexical decompositions can be easily dissected from the semantics and incorporated within the data-base eliciting part of the interpretation procedure. So it may be arbitrary to have my proposals framed in a semantic rather than in a computational framework. However, the semantics/pragmatics distinction (if tenable) has to be rethought within the perspective of dynamic interpretation anyhow, and I just didn't want to run ahead of such a discussion here.

(3) 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 ventilating proposals concerning the semantics of natural language expressions and operators. This, one might say, brought Groenendijk and Stokhof to their, at first glance seemingly technical, but explicitly formalized, proposals concerning the meaning of dynamic natural language noun phrases. And the pay off of it is that their rigourous reformulation of *DRT*'s treatment of anaphoric relationships has shown forceful enough to capture other *DRT* results in a compositional framework. Furthermore, as has been indicated in this paper, this reformulation also allows for connection with proposals concerning quite different semantic phenomena and for any further compositionalization of these.

Here, again, I must emphasize that it is not *DMG* in specific that has this extended potential, but that any compositionalization of *DRT* probably equals *DMG* in this expressive force. In the introduction we mentioned variant compositionalizations, some of which are more faithfull to *DRT* as it was originally proposed, one that is more *IL*-oid, and another *TY2*-ic. I cannot think of any substantial reason here for prefering any one over the other. As for logical issues, Muskens *TY2*-like variant might be preferable, since his language of translation is more explicit about what is going on technically speaking. As a tool for describing natural language phenomena on the other hand, one might prefer *DMG*, for a part because

its language itself obeys the intuitively right associativity laws. Whatever it is, the choice between anyone of these systems may be guided by personal preference and purposes; the main point is, I think, that such a choice does not affect potential empirical coverage.

(4) One last thing remains to be concluded. I argued that a compositional dynamic semantics is quite powerful and that the adherence to compositionality pays off. However, the major pay off was a further compositionalization of other, differently oriented, semantic proposals. And in fact, what we have done in this paper was nothing more than incompletely (but compositionally) reformulating independently proposed partial descriptions of the semantics of natural language phenomena. Our final conclusion, therefore, cannot be other than that non-compositionality apparently pays off as well (at least sometimes).

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