Institute for Language, Logic and Information

ANAPHORA AND DYNAMIC LOGIC

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ITLI Prepublication Series
for Logic, Semantics and Philosophy of Language LP-90-07

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ITLI Prepublications
for Logic, Semantics and Philosophy of Language
ISSN 0924-2082

Received July 1990

Supported by Dyana, Project EBRA-3715

Anaphora and Dynamic Logic*

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1 Introduction

The main problems I would like to discuss in the present paper are the following:

1. Generalized quantifiers and Discourse Representation Theory
2. Adverbs of quantification and their relation to generalized quantifiers
3. Proportions
4. 'Weak' vs. 'strong' truth-conditions for donkey sentences

Let me elaborate a bit on each of these issues.

As far as 1 is concerned, one of the leading ideas of Discourse Representation Theory (*DRT* – Kamp [19], Heim [13]) is that the treatment of many kinds of anaphora calls for an approach to variable binding that is more 'dynamic' than the one familiar from standard first order logic. Indefinite NPs, it is claimed, set up discourse referents that can bind well beyond their syntactic scope. This is implemented by assimilating indefinites to variables that get their quantificational force from the environment. Determiners like *every* or *most* and adverbs of quantification like *always* or *usually* are analyzed as unselective binders (following a proposal by Lewis [23]), which bind all the variables somehow accessible to them. Prima facie, this seems to lead to a non uniform treatment of NPs. Such treatment contrasts with the view (stemming from classical Montague Grammar) according to which NPs are uniformely analyzed as generalized quantifiers. The latter approach has lead to the discovery of many interesting formal formal properties of natural language determiners (cf., e.g., Barwise and Cooper [1]). It has also provided us with a rather appealing theory of coordinated structures. Consider:

(1) (A man and every woman) are smoking

Here an indefinite NP is coordinated with a universal one. The line of analysis stemming from Montague Grammar resorts to a simple cross-categorial generalization of standard Boolean operators, which results in an approach arguably superior to one based on, e.g., conjunction reduction (cf. Partee and Rooth [26], or Keenan and Faltz [20]). If indefinites and universally quantified NPs are of a different semantic type, it is not clear how such a simple treatment of coordination can be maintained. Several attempts have been made to integrate the DR-theoretic approach with the theory of generalized quantifiers.[1] The present work builds and tries to improve on these proposals.

*This paper was written during a period spent at the University of Amsterdam sponsored by the *Dyana*-project (EBRA-3715), which is gratefully acknowledged. An early version of it was presented at the Amsterdam Colloquium on Formal Semantics in December 1989. Subsequent versions were presented at the University of Edinburgh and the University of Stuttgart. I am indebted to those audiences for many helpful comments. Special thanks are due to Paul Dekker, Jeroen Groenendijk and Martin Stokhof. I alone am responsible for any mistake or inadequacy.

[1] Cf., e.g., Rooth [32], Heim [15, footnote 4] and Groenendijk and Stokhof [11, 12].

With regards to 2, the point to notice is that there appears to be a very tight correspondence between natural language determiners and adverbs of quantification. In particular, each adverb of quantification corresponds to exactly one determiner, so that an adverb of quantification and the corresponding determiner can be viewed, at some level, as one and the same function. For example, one could maintain that *always* is the same function as *every*, only applied to something like, say, spatio-temporal locations. Accordingly, a sentence like (2a) could be analyzed roughly as in (2b)

(2) a. When John is happy, he always sings

b. For every occasion o such that John is happy at o, John sings at o

This idea can be generalized to all adverbs of quantification. In fact, an elegant proposal along these lines was put forth by Stump [33]. Stump proposes that adverbs of quantification be analyzed as generalized quantifiers over occasions as illustrated in the following table:

Adverb of quantification	Analysis	Corresponding Det
always A B	$A \subseteq B$	every
usually A B	$\vert A \cap B\vert > \vert A \cap \overline{B}\vert$	most
sometimes A B	$\vert A \cap B\vert \neq \emptyset$	some
never A B	$\vert A \cap B\vert = \emptyset$	no
often A B	for some contextually specified n, at least n A's are B's	many

On the basis of this analysis, sentences (a) in the following examples would receive the analysis in (b):

(3) a. When John is happy he always sings

b. $\{o\colon \text{John is happy at } o\} \subseteq \{o\colon \text{John sings at } o\}$

(4) a. When John is happy he never sings

b. $\{o\colon \text{John is happy at } o\} \cap \{o\colon \text{John sings at } o\} = \emptyset$

This analysis explains very simply why adverbs of quantification have essentially the same formal properties as the corresponding determiners. For example, just like determiners are conservative, adverbs of quantification are too, where conservativity manifests itself in the validity of the equivalence between (5a) and (5b)

(5) a. Always/sometimes/never/often etc. when John is happy, he sings

b. Always/sometimes/never/often etc. when John is happy, he is happy and sings

By the same token, just like *every* is upward monotone on its second argument, so is *always*, as the fact that (6a) entails (6b) shows:

(6) a. When John is happy, he always sings Verdi arias

b. When John is happy, he always sings

And just like *no* is downward monotone on its second argument, so is *never*, as the validity of inferring (7b) from (7a) shows:

(7) a. When John is happy, he never sings

b. When John is happy, he never sings Verdi arias

And so on. Adverbs of quantification may have, of course, a modal dimension that is absent from the corresponding determiners. But factoring that out, the correspondence with determiners is extremely accurate. Now Stump's pre-*DRT* approach accounts elegantly for such a correspondence, but has no way to account for the type of anaphoric dependencies that arise in *if/when*-clauses. At the same time, it is not immediately clear how to reconstruct Stump's approach within *DRT*. Take for example *sometimes* and its counterpart *some.* The latter supports donkey anaphora and should therefore be treated as a free variable. *Sometimes*, instead, should be a quantifier of some kind, like other adverbs of quantification. From this perspective it is not obvious how the two are related to one another. This relatedness is particularly striking in the case of *some* and *sometimes* for they are even morphologically related in English.

Let me turn next to the problem of proportions, namely point 3 above. This problem is interesting because it is at the center of a number of important questions that have to do with the correct representation of anaphoric relations. The problem, widely discussed in the literature[2], has to do with sentences like (8).

(8) Most of Mary's books that are lent to a student are returned by him with insightful comments

This sentence says roughly that the number of books lent to a student that are returned with insightful comments is larger than the books that aren't. Classical *DRT* gives wrong truth-conditions here. It predicts that (8) should mean that most pairs that satisfy the left argument of *most* satisfy the right argument, which is wrong because (8) requires counting books, not book-student pairs. The reason why *DRT* seems to go wrong here is that *most* is taken to range unselectively over every indefinite in its left argument and thus (8) will involve a quantification over book-student pairs, rather than books.

Sentence (8) contrasts in truth-conditions with (9):

(9) Mostly/most of the times/usually, if Mary lends a book to a student he returns it with good comments

(9) has a reading which amounts to counting lendings (representable as pairs of books and students such that the first is lent to the second on some occasion). This is the so-called *symmetric* reading and is adequately characterized by *DRT*. At the same time, (9) has arguably two further readings. The first is made prominent in (10).

(10) Mary's students have an erratic behaviour.

a. If Mary lends A BOOK to a student, he returns it with good comments (while if she lends them a tape, they don't know how to work with it)

b. Most students that are lent a book by Mary, return it with good comments

In the context set up in (10), the topic is Mary's students and this is what the adverb of quantification appears to quantify over. Let's call this, following the literature, the *indirect object asymmetric* reading (for the indirect object is what we quantify over here). Consider now a different context for the same sentence, namely:

(11) Mary's books have a different effects on her students and on her colleagues

a. If Mary lends a book to A STUDENT, it gets returned with good comments (while if Mary lends one to a colleague, it gets heavily criticized)

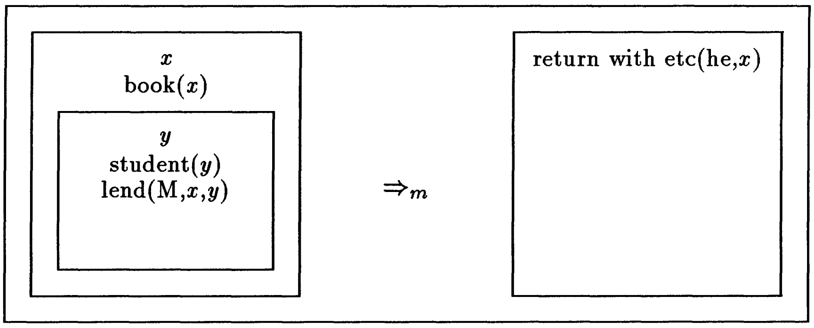
b. Most of Mary's books that are lent to a student are returned with positive comments

Here the topic is the direct object: this what the adverb of quantification appears to quantify over. Accordingly, we shall call it the *direct object asymmetric* reading. All these different readings (i.e. (9)–(11)) are logically independent of one another. Moreover, the generalization that emerges from these facts is that the distribution

[2] My main sources are Kadmon [18], Heim [16], and Kraztzer [21]. Cf. also references therein.

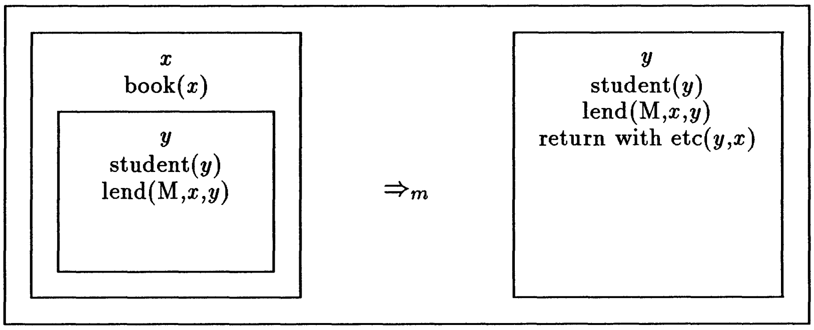
of symmetric vs. asymmetric readings is sensitive to the topic-comment or theme-rheme structuring of conditionals[3]. The whole antecedent can be taken as the topic, or a subpart of it. The distribution of focal stress in the given examples is consistent with this view: stress tends to fall within the comment or rheme (although matters are complex: not always focal stress alligns neatly with theme-rheme structuring). Topics are generally what sets up the range of adverbs of quantification. The problem here is to get this distribution of readings right and to try to understand why they form precisely this pattern.

To appreciate the problem more fully, it may be worth considering some of the solutions to it that have been proposed within *DRT*. An interesting one can be found in Kadmon [18]. Her solution is in two steps. First she assumes that relative clauses always introduce a subordinate box. So, for example, (8) would be represented as:



Most of Mary's books that are lent to a student are returned by him with good comments

Second, the content of the relative clause is accomodated in the consequent box. This is necessary in order to make indefinites in the relative clause accessible to pronouns in the consequent box. Accomodation then results in:



The third ingredient to Kadmon's solution is that the antecedent of conditionals optionally can be split up into subordinate boxes. So for example one of the possible logical forms for (10) is the following:

[3]For the purposes of the present paper I will use the pairs topic/comment and theme/rheme equivalently. Roughly, the topic or theme is what the comment or rheme adds new information on.

$$\boxed{\boxed{\begin{array}{c} x \\ \text{student}(x) \\ \boxed{\begin{array}{c} y \\ \text{book}(y) \\ \text{lend}(\text{M},y,x) \end{array}} \end{array}} \quad \Rightarrow_m \quad \boxed{\begin{array}{c} y \\ \text{book}(y) \\ \text{lend}(\text{M},x,y) \\ \text{return with etc}(x,y) \end{array}}}$$

So solutions to the proportion problem within *DRT* are certainly possible. In fact, they are relatively easy to obtain, if one keeps the syntax–semantics map relatively unconstrained. The introduction of boxes correspond to rules of existential closure. Such rules can be associated with VPs or relative clauses or any other constituent. They can be optional or obligatory. And on top of this, we need accomodation: transformations on logical forms. However, having some algorithm or other that gets truth-conditions right, per se does not provide us with much insight as to why things form one pattern rather than the other. Suppose that facts turned to be the opposite of what they are. Suppose that relative clauses like (8) where ambiguous in the way conditionals are. They could be accomodated as readily, it would seem.

More principled approaches to this problem have been worked out. I have in mind, in particular, Heim [15], and Kratzer [21]. But, in my opinion, they still suffer from some drawbacks and one of my objectives is to develop an alternative to them and compare it with their proposals.

Discussing these issues will lead us into problem 4 above, viz., the question of what truth-conditions donkey sentences exactly have. According to standard *DRT*, as is well-known, they are as follows:

(12) a. Every man that owns a donkey beats it

b. Every man that owns a donkey beats all of the donkey he owns

Pelletier and Schubert ([27]), however, have pointed out some cases that do not appear to be analyzable along these lines, but have weaker truth-conditions. For instance:

(13) Every man who has a dime will put it in the meter

I will argue that the weaker truth-conditions that (13) has constitute a phenomenon which is more pervasive than what is generally held. We will also see that in order to decide which donkey sentences have which truth-conditions, we will have to address a very central and difficult question, namely whether pronouns in some of their uses are shorthands for descriptions of some kind (along the lines suggested by Evans [9]) rather than bound variables.

The present paper is organized as follows. In section 2, I will present the formal framework and background assumptions. In section 3, I will discuss the symmetric readings of adverbs of quantification. In section 4, I will address the semantics of *most* and related determiners. In section 5, I will turn to the asymmetric readings of quantificational adverbs. In section 6, I will make a case for the pervasiveness of weaker truth-conditions for donkey sentences. In section 7, I will make a proposal concerning how the stronger truth-conditions generally attributed to (12a) come about which differs significantly from *DRT*'s approach. Finally, in section 8 I will draw some comparisons with other approaches.

2 The framework

The semantic framework I will adopt for the purposes of the present discussion is a higher order dynamic logic (DTT, for 'Dynamic Type Theory'), closely related to the Dynamic Intensional Logic (DIL) recently developed by Groenendijk and Stokhof ([11, 12]). DTT will be, I think, easy to grasp for anyone acquainted with classical Montague Grammar. I will first describe DTT, then indicate the role it is going to play in subsequent discussion.

2.1 The syntax and semantics of DTT

The syntax of DTT differs from the syntax of Montague's IL in two ways:

1. We leave out modal and temporal operators (i.e., $\Box, \Diamond, F, P$); and
2. We add to the individual variables VAR a set of discourse markers DM

That is, we will have two sorts of individual variables: one sort is going to behave classically (i.e., statically) the other is going to behave dynamically. More explicitly, we assume that DM is a proper subset of VAR_e. We will call 'static (individual) variables' members of $VAR_e \setminus DM$. Technically, we can identify DM with the oddly numbered members of VAR_e (i.e., $DM = \{v_{n,e}: n \text{ is odd }\}$) and the static individual variables with the even numbered members of VAR_e. The definition of the set $Type$ of types and of ME_a (meaningful expressions of type a), for any $a \in Type$, remains otherwise the same as for IL, with the definition of ME_t adjusted as mentioned. We keep Montague's cap $^\wedge$ and cup $^\vee$, which are, however, going to interpreted in a new way.

The crucial changes are going to take place in the semantics. First, we define D_a (the denotations of type a, a an arbitrary type) as follows:

Definition 1 (Domains of DTT)

1. $D_e = U$ (individuals)
2. $D_t = \{0, 1\}$
3. $D_{\langle a,b \rangle} = D_b^{D_a}$
4. $D_{\langle s,a \rangle} = D_a^{\Omega}$, where $\Omega = U^{DM}$

Intuitively, Ω is the set of all possible assignments to the discourse markers. So Montague's intensions are going to be reinterpreted as functions from assignments to discourse markers into extensions of the appropriate type. We are going to call members of Ω *cases*, following the suggestions of Lewis [23]. Relativizing the interpretation of DTT to cases will make DTT 'dynamic', as we shall see below.

A model M for DTT is a pair $\langle U, F \rangle$, where U is a domain of individuals and F is a map from $\bigcup_{a \in Type} CON_a$ into D_a. An assignment g is a function from $\bigcup_{a \in Type} VAR_a \setminus DM$ into D_a. An interpretation $[\![\ ]\!]_{M,g,\omega}$ is specified recursively, relative to a model M and an assignment g and a case ω. I will only give here some of the clauses (the remaining ones being completely straightforward) and in doing so, I will omit making explicit reference to the model M.

Definition 2 (Semantics of DTT) If $\alpha \in ME_a$, then:

1. if $\alpha \in DM, [\![\alpha]\!]_{g,\omega} = \omega(\alpha)$
   if $\alpha \in VAR_a \setminus DM, [\![\alpha]\!]_{g,\omega} = g(\alpha)$
   if $\alpha \in CON_a, [\![\alpha]\!]_{g,\omega} = F(\alpha)$
2. $[\![\forall \alpha \phi]\!]_{g,\omega} = 1$ iff either $\alpha \notin DM$ and for all $e \in Da, [\![\phi]\!]_{g[e/\alpha],\omega} = 1$, or $\alpha \in DM$ and for all $e \in U, [\![\alpha]\!]_{g,\omega[e/\alpha]} = 1$
3. $[\![\lambda \alpha \beta]\!]_{g,\omega} = h$, where h is that function in $D_b^{D_a}$ such that for any $e \in D_a$, if $\alpha \notin DM$, then $h(e) = [\![\alpha]\!]_{g[e/\alpha],\omega}$, and otherwise $h(e) = [\![\alpha]\!]_{g,\omega[e/\alpha]}$

4. $[\![{}^\wedge\alpha]\!]_{g,\omega} = h$, where h is that function in D_a^Ω such that, for any $\omega' \in \Omega, h(\omega') = [\![\alpha]\!]_{g,\omega'}$
5. $[\![{}^\vee\alpha]\!]_{g,\omega} = [\![\alpha]\!]_{g,\omega}(\omega)$

The effects of these changes are best illustrated by means of an example. In what follows and throughout this paper, I will use x, y, x_n for discourse markers and u, v, u_n for static individual variables. Consider now:

(14) $^\wedge\mathtt{love}(x)(y)$

The value of this expression is going to be a function from cases into truth-values or, equivalently, a set of cases. The cases in $[\![{}^\wedge\mathtt{love}(x)(u)]\!]_{g,\omega}$ are going to be those those with respect to which $\mathtt{love}(x)(y)$ is true. So the denotation of (19) is simply the set of assignments to the discourse markers that make $\mathtt{love}(x)(y)$ true. Let's call this set *the satisfaction set* of $\mathtt{love}(x)(y)$. In general, for any formula ϕ, the cap operator $^\wedge$ will unselectively abstract over all the discourse markers free in ϕ.

Satisfaction sets are partially ordered by an inclusion relation. For example, for any wffs $\phi$and ψ, it will hold that the satisfaction set associated with $^\wedge[\phi \wedge \psi]$ will be a subset of the satisfaction set associated with $^\wedge\phi$. It is convenient to be able to express this within DTT. Accordingly, we expand the language by saying that for any $\alpha, \beta \in ME_{\langle s,t\rangle}, \alpha \subseteq \beta \in ME_t$. The interpretation of the new relation sign $\subseteq$ is the one transparently suggested by the notation adopted.

The cup operator $^\vee$ in $^\vee\alpha$ applies the value of α to the actual or current case. For expressions of type $\langle s,t\rangle$, e.g., $^\wedge\phi$, the cup operator checks whether ϕ is true relative to the current assignment. As in IL, in DTT it will hold that $[\![{}^\vee{}^\wedge\phi]\!]_{g,\omega} = [\![\phi]\!]_{g,\omega}$.

While DTT has an intensional flavour, because of the presence of Montague's $^\wedge$, its interpretation resorts to purely extensional entities. It is designed to study certain aspects of anaphora that do not interact with intensionality in a crucial way. Of course one will want eventually to turn to an intensional dynamic logic, but I find it useful to postpone for the time being a discussion of the options available in this connection.

Notice that just like in IL we don't have variables ranging over worlds, in DTT we don't have variables ranging over cases (s is not a type) and so we cannot directly refer to or quantify over them. We can only refer to and quantify over sets of cases ($\langle s,t\rangle$), sets of sets of cases ($\langle\langle s,t\rangle,t\rangle$) and so on. If we want to reproduce a Lewis-style theory of adverbs of quantification, we might want, however, to quantify directly over cases. Using $\subseteq$, referring to and quantifying over cases is relatively easy. We can define a predicate *is a case* that singles out those members of $D_{\langle s,t\rangle}$ (i.e., those sets of cases) which are true of exactly one case (i.e., singletons of the form $\{\omega\}$). We can then identify cases with their singleton sets. More explicitly, let $\mathtt{cs}$ (for 'case') be a member of $ME_{\langle\langle s,t\rangle,t\rangle}$ defined as follows:

(15) $\mathtt{cs} = \lambda p[p \neq {}^\wedge[x \neq x] \wedge \forall q[q \subseteq p \rightarrow [p = q \vee q = {}^\wedge[x \neq x]]]$

The expression defined in (15) picks out the smallest non-empty sets of assignments with respect to the ordering $\subseteq$, i.e., it picks out singletons of the form $\{\omega\}$. For all practical purposes, these can be identified with cases. Let variables of the form c_n range over cases. Quantification and abstraction over such variables is defined in the following fashion:

(16) a. $\exists c_n\phi = \exists p[\mathtt{cs}(p) \wedge \phi]$
b. $\forall c_n\phi = \forall p[\mathtt{cs}(p) \rightarrow \phi]$
c. $\lambda c_n\phi = \lambda p[\mathtt{cs}(p) \wedge \phi]$[4]

[4] In a parallel fashion, one can define worlds in Montague's IL. The point is to identify a world w with the maximally specific proposition $\{w\}$ that uniquely characterizes it. In IL, $\subseteq$ can be

I will now give an indication of how DTT is going to be used for semantic purposes. I assume that English is compositionally translated into DTT, in a Montaguesque fashion. I assume, further, that the syntactic structures which are mapped into DTT contain an explicit representation of scopal and anaphoric relations. What I have to say is largely neutral as to how NP scope is characterized. However, for the sake of explicitness, I will assume that surface syntactic structures undergo a process of quantifier raising (QR) that maps them into a disambiguated language ('L(ogical) F(orm)'). The LF structures obtained by QR are then compositionally mapped into DTT expressions. This map only exploits a restricted set of semantic rules, like function application and composition and certain type-shifting principles (cf., e.g., Partee and Rooth [26]).

The way the dynamics gets in builds on previous work in DRT. I will now summarize what the main ideas are. The proposals that follow are lifted from Groenendijk and Stokhof [11, 12], but are partially recast in my terminology.

2.2 Dynamic semantics via DTT

The utterance of a formula ϕ affects the context of utterance in a number of ways, for example it narrows down the number of possibilities under consideration and puts certain constraints on possible ways of continuing the discourse. Within the present set up, we are mainly interested in the binding potential associated with a formula. This can be thought of in terms of the cases that are 'active' after the formula gets uttered. Formally, we can flesh out this idea with the help of an operator defined as follows:

(17) a. $\uparrow : t \rightsquigarrow \langle\langle s,t\rangle,t\rangle$

b. $\uparrow\phi = \lambda p[\phi \wedge {}^{\vee}p]$

The $\uparrow$-operator can be viewed as mapping a formula into its possible continuations. The variable p in (17b) plays the role of a peg to which the content of subsequent sentences is going to be attached. I will call what an expression like $\uparrow\phi$ denotes an 'update function'. I will use $A, B, \ldots$ as variables ranging over updates. The idea is that the value of $\uparrow\phi$ updates the context in which ϕ is uttered by characterizing the sets of cases that are still open after the utterance of ϕ. We shall use *up* to abbreviate the type $\langle\langle s,t\rangle,t\rangle$ and use the term 'dynamic formulae' for expressions of type *up*.

It is worth pointing out a couple of things concerning update functions. The first is that these functions, as defined, are upward monotone. That is, whenever B is an update we have that:

(18) $\forall p \forall q[[B(p) \wedge p \subseteq q] \rightarrow B(q)]$

The second point is that $\uparrow$ is an operator defined primaraly on type t, but can be generalized in a natural way to all the types that 'end in t (i.e., all the conjoinable types of Partee and Rooth [26]), just like Boolean operators can:

(19) If B is of a conjoinable type $\langle a,b\rangle$, then:
$\uparrow B = \lambda\alpha\uparrow[B(\alpha)]$ (α a static variable of type a)

Thus $\uparrow$ can be viewed as a type shift that maps functions of various types into functions of the type we need to build update functions.

To get an idea of how update functions can be exploited to build a dynamic semantics, let's consider an example. The update value of a sentence like (20a) can be naturally set to (20b).

defined in terms of $\Box$ (as $\lambda p\lambda q\Box[{}^{\vee}p \rightarrow {}^{\vee}q]$), and then the definition of *is a world* would be fully parallel (20) in the text. But in DTT, it doesn't make much sense to define $\subseteq$ in terms of $\Box$, for DTT is extensional.

(20) a. A man walked in

b. $\lambda p \exists x[\mathtt{man}(x) \wedge \mathtt{walk\_in}(x) \wedge {}^{\vee}p]$

In this way, continuations of (20a) are going to land in the slot occupied by p and thus inside the scope of $\exists x$. This makes that occurence of $\exists x$ 'active', i.e., capable of binding discourse markers which lie outside of its syntactic scope. To illustrate, imagine continuing (20a) with (21a).

(21) a. He was wearing a hat

b. $\lambda p[\mathtt{wear\_a\_hat}(x) \wedge {}^{\vee}p]$

The update value of a sentence like (21a) will be (21b) (ignoring tense). The functions in (20b) and (21b) can be composed. And we can interpret a discourse made up of (20a) followed by (21a) as the composition of (20b) and (21b), as shown:

(22) a. $\lambda p \exists x[\mathtt{man}(x) \wedge \mathtt{walk\_in}(x) \wedge {}^{\vee}p] \circ \lambda p[\mathtt{wear\_a\_hat}(x) \wedge {}^{\vee}p] =$

b. $\lambda q[\lambda p \exists x[\mathtt{man}(x) \wedge \mathtt{walk\_in}(x) \wedge {}^{\vee}p]({}^{\wedge}\lambda p[\mathtt{wear\_a\_hat}(x) \wedge {}^{\vee}p](q))] =$

c. $\lambda q \exists x[\mathtt{man}(x) \wedge \mathtt{walk\_in}(x) \wedge \mathtt{wear\_a\_hat}(x) \wedge {}^{\vee}q]$

Function composition brings the value of the pronoun *he* in (21b) (i.e., the discourse marker x) in the scope of the quantifier associated with *a man*. This may give the reader the feeling of an improper λ-reduction, where a free occurence of a variable (the third occurence of x in (22b)) ends up being bound. This is not so, however, for the cap-operator in (22b) binds all the discourse markers free in its scope, which makes the reduction from (22b) to (22c) sound.

It is clear that any true formula ϕ will yield a non empty update function $\uparrow\phi$, i.e. will admit possible continuations. We can exploit this observation to define a converse of $\uparrow$, namely $\downarrow$, which retrieves, so to speak, the static value or truth-conditional import of a formula ϕ from its dynamic value. The point is that if an update function is non-empty, because of upward monotonicity it will contain the maximal element ${}^{\wedge}\top (= {}^{\wedge}[x = x])$ of type $\langle s, t\rangle$, i.e., the set of all cases. Thus to say that ϕ is true is the same as saying that its update function $\uparrow\phi$ is non-empty, which in turn is the same as saying that it contains ${}^{\wedge}\top$. We use this fact to define $\downarrow$:

(23) a. $\downarrow B = B({}^{\wedge}\top)$

b. $\downarrow\uparrow\phi = \phi$

Example:

(24) $\downarrow\uparrow\mathtt{run}(x) = \downarrow[\lambda p[\mathtt{run}(x) \wedge {}^{\vee}p]] = \lambda p[\mathtt{run}(x) \wedge {}^{\vee}p]({}^{\wedge}\top) = [\mathtt{run}(x) \wedge {}^{\vee\wedge}\top] = \mathtt{run}(x)$

Interestingly, the converse of (23b) does not hold in general:

(25) $\uparrow\downarrow B \neq B$

Let's check this with the example given in (20):

(26) a. $\uparrow\downarrow[\lambda p \exists x[\mathtt{man}(x) \wedge \mathtt{walk\_in}(x) \wedge {}^{\vee}p]] =$

b. $\uparrow[\lambda p \exists x[\mathtt{man}(x) \wedge \mathtt{walk\_in}(x) \wedge {}^{\vee}p]({}^{\wedge}\top)] =$

c. $\uparrow\exists x[\mathtt{man}(x) \wedge \mathtt{walk\_in}(x)] =$

d. $\lambda p[\exists x[\mathtt{man}(x) \wedge \mathtt{walk\_in}(x)] \wedge {}^{\vee}p]$

The variable p in (26d) is outside the scope of $\exists x$. Thus further occurences of x that will land in the position of p will not be bound by $\exists x$, unlike what happens with (20). Thus, in a sense, $\uparrow\downarrow$-sequences 'close off' all the active quantifiers in an update function. In what follows, we will write ${}^{C}B$ for $\uparrow\downarrow B$.

We can generalize the present approach, by defining connectives and quantifiers directly on update functions along the following lines:

(27) a. Conjunction
$A \,; B = \lambda p[A({}^\wedge B(p))]$

b. Negation
$\sim A = \uparrow\neg\downarrow A$

c. Disjunction
$A \,\mathbf{or}\, B = \sim[\sim A \,; \sim B]$

d. Implication
$A \Rightarrow B = \sim[A \,; \sim B]$

e. $\mathcal{E}$-quantifier
$\mathcal{E}xA = \lambda p \exists x[A(p)]$

f. $\mathcal{A}$-quantifier
$\mathcal{A}xA = \sim\mathcal{E}x\sim A$

These definitions provide us with a dynamic logic for updates. I won't discuss here the properties of this logic in detail (referring for this the work of Groenendijk and Stokhof ([11, 12])) except for noticing the following points. First, the definitions in (27) preserve the upward monotonicity of their input. I.e., if A and B are upward monotone, $A \,; B$, A **or** B etc., will also be. Second, dynamic conjunction is the operation of composition we used in the example (22). Dynamic $\mathcal{E}$-quantification is also a form of composition. This is what we have exploited in (22) to get the effect of binding beyond the syntactic scope of a formula. And this is the mechanism we will exploit to handle discourse sequencing in general. Third, dynamic negation is not defined as a form of complementation. The reason for this is quite clear. The effect of analyzing negation as complementation (along the lines given in (28a)) would make, for example, (28b) equivalent to (28c):

(28) a. $\sim A = \lambda p \neg[A(p)]$

b. John doesn't smoke. John drinks.

c. John doesn't smoke and drink.

That is, in sequencing a set of sentences in a discourse, each member of the sequence would be brought inside the scope of an initial negation, and we would absurdly get weaker and weaker statements: not an efficient way to communicate. This is why negation must be defined as in (27b), by looking merely at the 'static' value of the input. This extends, of course, to all the connectives and quantifiers which are defined in terms of negation.[5]

Having defined a logic of update functions, we can use it for semantic purposes. That is each expression can receive a dynamic value (defined in terms of $\uparrow$). Dynamic values can then be composed in familiar ways. I will not define here an explicit sample grammar (i.e., a fragment), but will limit myself to indicate one of several ways in which such a fragment can be constructed.

Let us start by the meaning of the determiners *a* and *every*. They can be given as follows:

(29) a. $\mathbf{a} = \lambda P \lambda Q \mathcal{E}x[P(x) \,; Q(x)]$

b. $\mathbf{every} = \lambda P \lambda Q \mathcal{A}x[P(x) \Rightarrow Q(x)]$

where the types of P and Q are $\langle e, up\rangle (= \langle e, \langle\langle s,t\rangle, t\rangle\rangle)$. As the reader can see, we are simply lifting the standard meanings of these determiners to the level of updates function. In this way, determiners no longer relate sets (i.e., $\langle e,t\rangle$) but functions from individuals into updates (i.e., $\langle e, up\rangle$). Let us call functions from individuals into updates 'dynamic properties'. This terminology is slightly misleading since

[5] See Dekker [5] for further discussion of the options available in this connection.

properties are regarded, in general, as intensional entities, while DTT is extensional. But this defect can and will be corrected by shifting to an intensional version of DTT. We can call the functions defined in (29) 'dynamic determiners'.

Let us assume that unless otherwise specified, expressions of various categories translate at the lowest possible type. This means that for example a common noun like man will translate into an expression of type $\langle e, t\rangle$. This expression can combine with a dynamic determiner using $\uparrow$ to shift its type to that of dynamic properties.

(30) a. $a + man \rightsquigarrow \mathtt{a}(\uparrow \mathtt{man}) = \mathtt{a}(\lambda u \lambda p[\mathtt{man}(u) \wedge {}^{\vee}p])$

b. $\lambda Q \mathcal{E} x[\lambda p[\mathtt{man}(x) \wedge {}^{\vee}p] \,; Q]$

c. $gq = \langle dp, up\rangle$ (where $dp = \langle e, up\rangle$)

Thus *a man* receives the translation in (30b). This can be viewed as a dynamic generalized quantifier. While static generalized quantifiers are sets of sets (i.e. functions from predicate denotation into truth-values), dynamic generalized quantifiers can be viewed as functions from dynamic properties into updates.

A dynamic generalized quantifier combines with a predicate to give an update function in the obvious way:

(31) a. $a\ man + walks \rightsquigarrow \mathtt{a}(\uparrow \mathtt{man})(\uparrow \mathtt{walk})$

b. $\lambda p \exists x[\mathtt{man}(x) \wedge \mathtt{walk}(x) \wedge {}^{\vee}p]$

(31b) gives us the reduced value of (31a). This shows how the meaning of sentences such as those in the example in (20a) can be build up compositionally.

Without getting into too many details, it is not hard to see that this method assigns compositionally to (32a) the reading in (32c) and to (33a) the one in (33c).

(32) a. A man who owns a donkey beats it

b. $\mathtt{a}(\lambda u[\uparrow \mathtt{man}(u) \,; \mathcal{E} y[\uparrow \mathtt{donkey}(y) \,; \uparrow \mathtt{own}(y)(u)]])(\uparrow \mathtt{beat}(y))$

c. $\lambda p \exists x \exists y[\mathtt{man}(x) \wedge \mathtt{donkey}(y) \wedge \mathtt{own}(y)(x) \wedge \mathtt{beat}(y)(x) \wedge {}^{\vee}p]$

(33) a. Every man who owns a donkey beats it

b. $\mathtt{every}(\lambda u[\uparrow \mathtt{man}(u) \,; \mathcal{E} y[\uparrow \mathtt{donkey}(y) \,; \uparrow \mathtt{own}(y)(u)]])(\uparrow \mathtt{beat}(y))$

c. $\lambda p[\forall x \forall y[[\mathtt{man}(x) \wedge \mathtt{donkey}(y) \wedge \mathtt{own}(y)(x)] \rightarrow \mathtt{beat}(y)(x)] \wedge {}^{\vee}p]$

Let us comment briefly on these examples. The a-sentences translate into the b-formulae. The determiners *a* and *every* are treated uniformely. In particular, indefinites are treated as being existentially quantified whenever they occur. In the b-formulae the translation of the pronoun it is not in the syntactic scope of the translation of a donkey. In virtue of the definitions of $\mathtt{a}$ and $\mathtt{every}$, the b-formulae are logically equivalent to the c-formulae, where the discourse marker associated with it is bound by the quantifier associated with a donkey. We leave it to the reader to figure out the steps of the reductions from the b-formulae into the c-formulae (or to look them up in Groenendijk and Stokhof [12]).

Note, however, that there is an interesting difference between (32c) and (33c). If we continue (32a) with some other sentence, the new pieces of discourse will land inside the scope of the quantifiers associated with *a man* and *a donkey*. Thus for example, the following discourse is predicted to be grammatical:

(34) A hunter$_1$ who spotted a beautiful deer shot at it. Luckily, his$_1$ aim was faulty

For (33c) things are different. Here, possible continuations will land outside of the scope of the quantifiers contained in it. Accordingly, sentences like (35) are expected to be impossible on the reading indicated by the indeces:

(35) *Every hunter$_1$ who spotted a deer shot at it. Luckily, his$_1$ aim was faulty

This follows from the fact that dynamic $\mathcal{A}$ is defined in terms of negation, which, as we saw, only looks at the 'static' value of its input and in doing so shuts off all active quantifiers in its scope.

The contrast in (34)–(35) is by and large borne out. Accordingly, we shall say, following Groenendijk and Stokhof [11, 12], that *a* and *every* are both internally open (in that they allow an active quantifier in their left argument (the restriction, in Heim's terms) to bind a pronoun in their right argument (the nuclear scope in Heim's terms)). Only *a*, however, is also externally open, while *every* is externally closed. This yields a notion of 'accessibility' of a pronoun from an antecedent which parallels exactly the one we find in classical *DRT*. There are well-known problems for this characterization of accessibility. The most widely discussed ones are those having to do with 'modal subordination' (see, e.g., Roberts [29]), illustrated by examples of the following type:

(36) Every chess_1 set comes with a spare pawn_2. It_2 is taped under its_1 box

I think that the present framework has the potential to make these cases tractable, but I will not have much to say on them here.[6]

To summarize, an approach along the lines we have sketched enables us to recast the achievements of *DRT* in an arguably more compositional way (cf., Groenendijk and Stokhof [11, 12]). Moreover, we can to justice to the intuitions that indefinites 'set up a discourse referent' while universals don't and simultanuously regard all NP-meanings in a uniform way as dynamic generalized quantifiers.

I think that the advantages of this approach are not just methodological or aesthetic, but also empirical. More specifically, one reasonable diagnosis for the proportion problem is that it stems from regarding determiners like *every* and *most* as unselective binders: we seem to run into trouble as soon as we assimilate indefinites to free variables and let *most* bind all the accessible free variables. But on the present approach indefinites are quantified elements and, moreover, if determiners relate two properties, binding more than one variable is anyhow out of the question. Thus, we wouldn't expect any problem to arise, if the meaning of *most* is of the same type as the meaning of *a* and *every*. In order to see whether this expectation is borne out, we have to be more explicit on adverbs of quantification and on the nature of determiners like *most*, for one cannot claim to have a solution to the proportion problem without dealing with the contrasts discussed in the introduction. Accordingly, we now try to flesh out this expectation by addressing the problem of adverbs of quantification.

3 Adverbs of quantification

The leading idea developed within *DRT* is that the logical form of sentences with adverbs of quantification is as follows:

(37) $\text{ADV}(\phi)(\psi)$

where *if/when*-clauses provide the left argument of adverbs of quantification, while the main clause provides the right argument. ADV binds unselectively every indefinite in its scope. It is furthermore generally assumed that an adverb of quantification roughly equivalent to 'always' is implicitly present in examples like (38):

(38) When a man is in the bathtub, he sings

It is also generally assumed that the restriction of a quantificational adverb can be left implicit, as in :

(39) John always sings

[6] See again Groenendijk and Stokhof [12] and Dekker [5] for relevant discussion.

(39) does not mean that John sings at all times, but only that he does so whenever some implicit conditions are satisfied (e.g., when he is happy, his mouth isn't full, etc.). This also illustrates that adverbs of quantification are associated with an implicit modality. This modal dimension of adverbs of quantification complicates the picture substantially, and for now we will have to ignore it.

On our approach, indefinite NPs are quantified NPs, not free variables. Hence the standard *DRT* account cannot be simply taken over. At the same time, the dynamic value of a sentence is a set of sets of cases. Thus we can rebuild in our framework Lewis's ideas in a fairly direct way. Intuitively, an adverb of quantification compares two sets of cases. For example, in *When a man is in the bathtub, he always sings*, we are comparing the cases in (40a) with those in (40b).

(40) a. $\lambda c \exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge {}^{\vee}c]$

b. $\lambda c \exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge \mathtt{sing}(x) \wedge {}^{\vee}c]$

(40a) and (40b) denote sets of assignments. Which assignments they denote can be specified as follows:

(41) a. Those assignments that differ from the current one at most in that x is mapped onto a man in the bathtub

b. Those assignments that differ from the current one at most in that x is mapped onto a man who is in the bathtub and sings

To say that when a man is in the bathtub he always sings, is to say that the set (40a) is a subset of (40b). To say, instead, that when a man is in the bathtub, he never sings is to say that (40a) and (40b) have no members in common. And so on. So adverbs of quantification can in general be viewed as relations between sets like those denoted by (40a) and (450b). And it is easy to see how to arrive compositionally at these sets. (40a) is simply the denotation of the *when*-clause (40a) restricted to cases, namely:

(42) a. A man is in the bathtub $\rightsquigarrow \lambda p \exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge {}^{\vee}p]$

b. $!\lambda p \exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge {}^{\vee}p] =$
$\lambda c[\exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge {}^{\vee}c]]$

c. $!A = \lambda c[A(c)]$

! is an operator over sets of sets of cases. For any such set A, $!A$ is the singletons in A.

(40b) is the result of conjoining dynamically the *when*-clause with the main clause and taking the correponding set of cases. I.e. :

(43) a. $![\lambda p \exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge {}^{\vee}p] \,;\, \lambda p[\mathtt{sing}(x) \wedge {}^{\vee}p]]$

b. $![\lambda p \exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge \mathtt{sing}(x) \wedge {}^{\vee}p]]$

c. $\lambda c \exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge \mathtt{sing}(x) \wedge {}^{\vee}c]$

(43a) reduces to (43c) (= (40b)).

We can then analyze (44a) as (44b):

(44) a. When a man is in the bathtub, he always sings

b. $\mathtt{every}(\lambda c \exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge {}^{\vee}c])(\lambda c \exists x[\mathtt{man}(x) \wedge$
$\mathtt{in\_the\_bathtub}(x) \wedge \mathtt{sing}(x) \wedge {}^{\vee}c)]$

Here **every** is the ordinary static meaning of the determiner *every*, only applied to cases. In *DTT*, **every** will be represented as $\lambda P \lambda Q \forall c[P(c) \rightarrow Q(c)]$, where P and Q are of type $\langle\langle s, t\rangle, t\rangle$). So (48b) says that every case in which a man is in the bathtub, is a case in which that man sings. This seems to be as good an approximation to the meaning of (44a) as the one we find in classical *DRT*. To convince the reader that this is indeed the reading we get, we reduce (44b) by applying the relevant definitions:

(45) a. $\texttt{every}(\lambda c \exists x[\texttt{man}(x) \wedge \texttt{in\_the\_bathtub}(x) \wedge {}^{\vee}c])(\lambda c \exists x[\texttt{man}(x) \wedge \texttt{in\_the\_bathtub}(x) \wedge \texttt{sing}(x) \wedge {}^{\vee}c])$

b. $\lambda P \lambda Q \forall c[P(c) \rightarrow Q(c)](\lambda c \exists x[\texttt{man}(x) \wedge \texttt{in\_the\_bathtub}(x) \wedge {}^{\vee}c])(\lambda c \exists x[\texttt{man}(x) \wedge \texttt{in\_the\_bathtub}(x) \wedge \texttt{sing}(x) \wedge {}^{\vee}c])$

c. $\forall c[\exists x[\texttt{man}(x) \wedge \texttt{in\_the\_bathtub}(x) \wedge {}^{\vee}c] \rightarrow \exists x[\texttt{man}(x) \wedge \texttt{in\_the\_bathtub}(x) \wedge \texttt{sing}(x) \wedge {}^{\vee}c]]$

The semantics of (45c) should be reasonably transparent. It says roughly: take any assignment to discourse markers such that x is mapped onto a man in a bathtub. Such an assignment must also be such that x is mapped onto someone who is singing. So (45c) has the same truth-conditions as:

(46) $\forall x[[\texttt{man}(x) \wedge \texttt{in\_the\_bathtub}(x)] \rightarrow \texttt{sing}(x)]$

In appendix I, I provide a proof of the DTT equivalence of (45c) and (46).

This method of handling adverbs of quantification is perfectly general. Consider, for instance:

(47) Usually, if Mary lends a book to a student, he returns it with insightful comments

The meaning of *if*-clause and of the main clause in (47) are going to be as in (48a) and (48b) respectively:

(48) a. $\lambda p \exists x \exists y[\texttt{book}(x) \wedge \texttt{student}(y) \wedge \texttt{lend}(y)(x)(m) \wedge {}^{\vee}p]$

b. $\lambda p[\texttt{return\_with\_insightful\_comments}(x)(y) \wedge {}^{\vee}p]$

And the meaning of the whole clause (47) will be:

(49) $\texttt{most}(\lambda c \exists x \exists y[\texttt{book}(x) \wedge \texttt{student}(y) \wedge \texttt{lend}(y)(x)(m) \wedge {}^{\vee}c])(\lambda c \exists x \exists y[\texttt{book}(x) \wedge \texttt{student}(y) \wedge \texttt{lend}(y)(x)(m) \wedge \texttt{return\_with\_insightful\_comments}(x)(y) \wedge {}^{\vee}c])$

Standard interpretations of *most* regard it as a relation between two sets X and Y that holds just in case the intersection of X and Y is larger than the intersection of X with the complement of Y (or, equivalently, larger than $|X|/2$, where $|X|$ is the cardinality of X). Under such an interpretation, the truth-conditions of (49) can be described as follows: the number of assignments such that x is a book, y a student, Mary lends x to y, and y returns x with insightful comments must be greater than the number of assignments such that x is a book, y a student, Mary lends x to y but y does not return x with insightful comments. This reading is correct for (47) and gives us its symmetric interpretation.

We have to fine tune our analysis slightly. If we apply it exactly as described to examples which contain indefinites in the main clause such as (50), we get wrong truth-conditions.

(50) When a man is in the bathtub he always sings a love song

The semantics which we would get is:

(51) $\forall c[\exists x[\texttt{man}(x) \wedge \texttt{in\_the\_bathtub}(x) \wedge {}^{\vee}c] \rightarrow \exists x \exists y[\texttt{man}(x) \wedge \texttt{in\_the\_bathtub}(x) \wedge \texttt{love\_song}(y) \wedge \texttt{sing}(y)(x) \wedge {}^{\vee}c]]$

By working out the truth-conditions of (51) it is not hard to see that they turn out to be equivalent to

(52) $\forall x \forall y[[\texttt{man}(x) \wedge \texttt{in\_the\_bathtub}(x)] \rightarrow [\texttt{love\_song}(y) \wedge \texttt{sing}(y)(x)]]$

But this is wrong. What we need is an analogue of the existential closure of the nuclear scope of an adverb of quantification which we find in *DRT*. The right truth-conditions are given by the formula:

(53) $\forall c[\exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge {}^{\vee}c] \rightarrow \exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge [\exists y[\mathtt{love\_song}(y) \wedge \mathtt{sing}(y)(x)] \wedge {}^{\vee}c]]$

The only difference between (51) and (53) is that the second occurrence of c in (53) is outside of the scope of $\exists y$. This makes (53) equivalent to:

(54) $\forall x[[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x)] \rightarrow \exists y[\mathtt{love\_song}(y) \wedge \mathtt{sing}(y)(x)]]$

We can emend our analysis accordingly by defining a quantifier **every′** as follows:

(55) $\mathtt{every}'(A)(B) = \mathtt{every}(!A)(![A;\ {}^{C}B])$, where the type of A and B is *up* and ^{C} is the closure operator defined in (30)[7]

A relatively straightforward computation shows that this definition yields the desired results. We illustrate it by working out the truth-conditions for (50).

(56) a. $\mathtt{every}'(\lambda p\exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge {}^{\vee}p])$
$(\lambda p\exists y[\mathtt{love\_song}(y) \wedge \mathtt{sing}(y)(x) \wedge {}^{\vee}p])$
unreduced translation

b. $\mathtt{every}(!\lambda p\exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge {}^{\vee}p])(![\lambda p\exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge {}^{\vee}p]\,;\ {}^{C}\lambda p\exists y[\mathtt{love\_song}(y) \wedge \mathtt{sing}(y)(x) \wedge {}^{\vee}p]])$
from (a) by definition (58)

c. $\mathtt{every}(!\lambda p\exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge {}^{\vee}p])(![\lambda p\exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge {}^{\vee}p]\,;\lambda p[\exists y[\mathtt{love\_song}(y) \wedge \mathtt{sing}(y)(x)] \wedge {}^{\vee}p]])$
from (b) by definition of ^{C}

d. $\mathtt{every}(!\lambda p\exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge {}^{\vee}p])(![\lambda p\exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge \exists y[\mathtt{love\_song}(y) \wedge \mathtt{sing}(y)(x)] \wedge {}^{\vee}p]])$
from (c) by definition of ;

e. $\mathtt{every}(\lambda c\exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge {}^{\vee}c])(\lambda c\exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge \exists y[\mathtt{love\_song}(y) \wedge \mathtt{sing}(y)(x)] \wedge {}^{\vee}c]])$
from (d) by definition of !

f. $\forall c[\exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge {}^{\vee}c] \rightarrow \exists x[\mathtt{man}(x) \wedge \mathtt{in\_the\_bathtub}(x) \wedge \exists y[\mathtt{love\_song}(y) \wedge \mathtt{sing}(y)(x)] \wedge {}^{\vee}c]]$
from (e) by definition of **every**

We have now arrived at a simple characterization of adverbs of quantification in terms of the meaning of the corresponding determiners. If D is an ordinary determiner meaning (raised to the level of *up*), D' will be the meaning of the corresponding adverb of quantification, where D' is defined on the model of (55), i.e.:

(57) $D'(A)(B) = D(!A)(![A\,;\ {}^{C}B])$

Adverbs of quantification are relations among sentence denotations (i.e., update functions). Given two updates $\uparrow\phi$ and $\uparrow\psi$, we first extract the satisfaction sets of ϕ and ψ (i.e., the set of cases relative to which they hold). We then conjoin dynamically these satisfaction sets while closing the right argument. Finally we quantify, in the ordinary, static sense over the resulting sets. This enables us to see adverbs of quantification as generalized quantifiers of a kind and to relate their meanings in a systematic way to the meanings of the corresponding determiners. We can thus cash in the insights of Stump [33], while at the same time getting anaphoric links right.

[7] I am indebted to Paul Dekker for pointing out a mistake with a previous formulation.

It may be worth noticing that the present approach predicts the right truth-conditions for problematic examples involving symmetric predicates, discussed extensively in the literature (see, e.g., Heim [16]).

(58) a. If a cardinal meets someone, he blesses him (Kamp)

b. If a man shares an apartment with another man, he shares the housework with him (van Eijck)

Our analysis will yield (59) as the meaning of, for example, (58a).

(59) $\forall c[\exists x \exists y[\mathtt{cardinal}(x) \wedge meet(y)(x) \wedge {}^{\vee}c] \rightarrow \exists x \exists y[\mathtt{cardinal}(x) \wedge \mathtt{meet}(y)(x) \wedge \mathtt{bless}(y)(x) \wedge {}^{\vee}c]]$

Thus, in particular, when a cardinal a meets another cardinal b, there will be (at least) two cases that satisfy the antecedent: one when x is mapped onto a and one when x is mapped onto b; (59) requires that both result in blessings. I.e., a must bless b and b must bless a for (59) to be true. This result seems to be supported by intuitions concerning (58a) and related examples.

The theory we have developed so far accounts in a simple way for symmetric readings of *if/when*-clauses. What about asymmetric readings? We saw in the introduction that the latter type of readings involve counting not cases in general, but members of the denotation of the topic. In other terms, the salient reading of, for example, (60a) involves counting books and is roughly equivalent to (60b).

(60) a. When Mary lends a book to A STUDENT, he usually returns it with insightful comments (while if she lends one to a colleague, it gets heavily criticized)

b. Most books that are lent by Mary to a student are returned by him with insightful comments.

This means that in order to say something intelligeable about asymmetric readings, we must get clearer on the nature of determiners like *most*. Therefore, to this task, I now turn.

4 The semantics of *most*

Consider a sentence like (61):

(61) Most men that own a donkey beat it

What are its truth-conditions? In the literature, we find essentially two proposals. According to one proposal, (61) is taken to have the following truth-conditions:

(62) The number of men that own and beat a donkey is greater than the number of men that own but don't beat one.

An alternative proposal, is to analyze instead (61) as follows:

(63) The number of men that own a donkey and beat every donkey they own is greater than the number of men that own a donkey but do not beat every donkey they own.

The differences between (62) and (63) come out only if our domain contains men that own more than one donkey. In such a case, for (62) to be true, it suffices that the majority of men beat one of their donkeys, while for (63) to be true the majority of men have to beat all of their donkeys. So, (63) is stronger than (62): the former entails the latter. Accordingly, I will refer to (62) as the weak reading of (61) and to (63) as the strong reading.

If we look at this example in isolation, intuitions are not sufficiently clear cut to enable us to choose between the strong and the weak reading. But there are cases which clearly seem to favour one of the readings over the other. For example, the following example (from Heim [16]) seems to favour the strong reading:

(64) Most men that owned a slave owned its offspring

This sentence seems to say that the majority of men that owned a slave owned the offspring of all their slaves, not just some of them.

Contrast this with:

(65) a. Most men that have a dime will put it in the meter (Pelletier and Schubert [27])

b. Most men that have a nice suit will wear it to church

Here it clearly suffices that the majority of men put one of their dimes in the meter to make (65a) true. In fact, it is highly implausible that they will empty their pockets of all their dimes. Analogous considerations apply to (65b).

Confronted with these data, a first hypothesis that comes to mind is that the sentences in question are ambiguous between the strong and the weak readings and that pragmatic factors (such as the inherent plausibility of the situation described) determine which reading is intended. When no external factor helps us select between the two readings, our intuitions will be unclear.

So let us see how the weak and the strong reading can be obtained. Let us begin with the weak reading. The meaning of the standard, 'static' determiner *most* is generally taken to be, as we saw, something like:

(66) $\mathtt{most}(X)(Y) = |X \cap Y| > |X|/2$ (where X and Y range over sets)

Let $\mathtt{most}^+$ be the dynamic counterpart of $\mathtt{most}$. If $\mathtt{most}^+$ is to be of the same type as $\mathtt{a}$ and $\mathtt{every}'$, it will be a function from dynamic properties into updates (i.e., $\langle dp, \langle dp, up\rangle\rangle$). The question is whether there is a natural way to define $\mathtt{most}^+$ in terms of $\mathtt{most}$ so as to obtain the weak truth-condition for sentences like (61). There are, in fact, various ways to go. The simplest I can think of is as follows:

(67) $\mathtt{most}^+(P)(Q) = \mathtt{most}(\lambda u{\downarrow}P(u))(\lambda u{\downarrow}[P(u)\,;Q(u)])$, where P, Q are of type dp

Let's illustrate with the example in (61). The denotation of the left and the right argument of $\mathtt{most}$ in this case will end up being respectively:

(68) a. $\lambda u \lambda p[\mathtt{man}(u) \wedge \exists x[\mathtt{donkey}(x) \wedge \mathtt{own}(x)(u) \wedge {}^{\vee}p]]$

b. $\uparrow\mathtt{beat}(x) = \lambda u[\mathtt{beat}(x)(u) \wedge {}^{\vee}p]$

By applying (67) to (68) and performing standard reductions we get:

(69) $\mathtt{most}(\lambda u[\mathtt{man}(u) \wedge \exists x[\mathtt{donkey}(x) \wedge \mathtt{own}(x)(u)]])(\lambda u[\mathtt{man}(u) \wedge \exists x[\mathtt{donkey}(x) \wedge \mathtt{own}(x)(u) \wedge \mathtt{beat}(x)(u)])$

In (69) the denotation of the pronoun *it* is bound by the quantifier associated with the denotation of *a donkey* and furthermore the truth conditions are the weak ones, as desired.

Let us now see how the strong truth-conditions can be defined. The game is the same: we want to define a dynamic determiner $\mathtt{most}^{\circ}$ in terms of the static $\mathtt{most}$, but this time in such a way as to get out the strong truth-conditions. As pointed out in the literature[8], the target is something like:

(70) For most men who own a donkey, for every donkey they own, they beat it

Here we have a primary quantification (*most*) and a secondary one (*every*). The secondary one ought to be 'unselective', i.e., affect all the indefinites in its domain. In the present set up, unselective quantification can be cast exploiting cases. The

[8] See, e.g., Rooth [32], Root [30], Heim [16].

general schema will be:

(71) $\texttt{most}^\circ(P)(Q) = \texttt{most}(\lambda u{\downarrow}P(u))(\lambda u[\texttt{every}'(P(u))(Q(u))])$, where P, Q are of type *dp*

Let us see how this works in the case of (61). If we define $\texttt{most}^\circ$ as per the schema in (71), the left argument of the static determiner $\texttt{most}$ is built in the same way as before. The right argument, however, is different and according to the schema in (71) ends up being:

(72) $\lambda u \forall x[[\texttt{man}(u) \wedge \texttt{donkey}(x) \wedge \texttt{own}(x)(u)] \rightarrow \texttt{beat}(x)(u)]$

See appendix II for the derivation of (72) by means of (71). Intuitively, (72) denotes the set of those e's such that if e is a man, then e beats every donkey he owns. This is just the set we want to compare with the set of donkey owning men. The intersection between these two sets must be larger than half of the donkey-owning men. No matter how many indefinites there are in the restriction, they will all get universal force in this way.

We thus have reached our goal, which was to characterize the seemingly ambiguous truth-conditional import of *most* in such a way as to get anaphoric links right. Now, it is apparent that similar considerations apply more widely to other externally closed determiners, like *every*. The following examples illustrate:

(73) a. Every man that owned a slave owned its offspring

b. Every man who has a dime will put it in the meter

Quite clearly, (73a) would be falsified by a single man-slave pair $\langle a, b\rangle$ such that a owns b but not b's offspring. Thus, (73a) is interpreted according to the strong reading: a man must own the offspring of all his slaves, for (73a) to be true. Things are different for (73b). Here it suffices that a man puts in the meter one of his dimes for (73b) to be true. In fact, the strong reading is totally implausible for (73b).

In cases where our intuitions are not as clear cut, it is possible to bring out one of the interpretations over the other by manipulating the context. So, for example, the weak reading of the classic (74a) can be made salient by imagining it uttered against the background described in (74b) (which was suggested to me by Paolo Casalegno).

(74) a. In Ithaca, every farmer who owns a donkey beats it

b. The farmers of Ithaca are stressed out. They are constantly arguing and often even beat each other. To put an end to it, they go to the local psychologist who recommends that rather than beating each other, every farmer who owns a donkey should beat it. They follow her advice, and things improve.

The truth of (74a) in the scenario given in (74b) does not demand that the farmers beat all of their donkeys (nor excludes from consideration, I believe, farmers that own more than one donkey). This is further evidence that if *most* is ambiguous between the strong and the weak reading, so is *every*. We can accomodate these facts easily, by simply generalizing the schemata we used in connection with *most*. Given a static determiner D, we can define its (closed) dynamic counterpart in the following way:

(75) a. $D^+(P)(Q) = D(\lambda u{\downarrow}P(u))(\lambda u{\downarrow}[P(u)\,;Q(u)])$

b. $D^\circ(P)(Q) = D(\lambda u{\downarrow}P(u))(\lambda u[\texttt{every}'(P(u))(Q(u))])$
where $D = \texttt{every}, \texttt{most}, \ldots$

I leave it to the reader to check that if D is $\texttt{every}$, $\texttt{every}^\circ$ will be equivalent to $\lambda P \lambda Q \forall x[P(x) \Rightarrow Q(x)]$.

The case of determiners like *no* call for some discussion. It is clear that such a determiner cannot be defined using the schema in (75b). Take the following example:

(76) a. No parent with a teenage son lends him the car (Rooth)

b. For no parent with a teenage son, for every teenage son he has, he lends him the car

c. For no parent with a teenage son, for some teenage son he has, he lends him the car

Clearly, the truth-conditions of (76a) are those in (76c), not those in (76b). The truth-conditions in (76c) are those that correspond to the weak readings of *most* and *every*. So we must conclude that *no* has to be defined using the schema in (75a).

To summarize, we have discussed in this section the semantics of *most* and provided some evidence for what looks like a general ambiguity in the meaning of several (but not all) closed determiners. This situation leaves many puzzles open. Why should some closed determiner select univocally the weak reading, while others be ambiguous between a weak and a strong reading? In section 6 below I will try to address this question. But first I would like to fulfill the promise of discussing the asymmetric readings of *if/when*-clauses in the light of the present analysis of *most*.

5 Asymmetric readings of *if/when*-clauses

The approach to adverbs of quantification we have considered in section 2 only accounts for symmetric readings of conditionals and *when*-clauses. We now turn to asymmetric ones. We saw in the introduction that the latter type of readings are very sensitive to focal (or theme-rheme) structure. This is true quite generally for adverbs of quantification. Rooth [32], for example, gives the following nice minimal pair:

(77) a. A u usually follows $\underline{\text{a } q}$

b. $\underline{\text{A } u}$ usually follows a q

where underlining marks focal stress. Here there is no restrictive *if/when*-clause and the content of the left argument of *usually* must be reconstructed from contextual clues. One such important clue is of course focal stress. Now, it seems that the most prominent (perhaps the only) interpretation of (77a) is that most u's follow a q. This is false of, say, English texts. On this reading, *is a u* is mapped onto the restriction (i.e., the left argument) of the adverb of quantification. In contrast with this, the most prominent interpretation of (77b) is that most q's are followed by a u, which is true of English texts. On this reading, it is *is a q* that is construed as the left argument of *usually*. Rooth discusses a theory of focus that accounts for the contrast in (77). His theory, however, does not extend in an obvious way (as far as I can tell) to the theme-rheme structuring of *if/when*-clauses.

Here, I will assume such a structuring as a given and provide a way (which is relatively straightforward within the present set of assumptions) to obtain the desired asymmetric reading. It is clear, however, that no fully satisfactory treatment of this phenomenon will be forthcoming till focus isn't understood better.[9]

To facilitate things, let us consider a concrete example, say the direct object asymmetric reading of:

(78) When Mary lends a book to A STUDENT, he usually returns it with insightful comments (while when she lends one to a colleague, he returns it with narrow minded criticisms).

[9] I think that this applies not only to my story but to all the other attempts I am familiar with.

Here we don't want the whole *when*-clause in the restriction of *usually*. We only want the unstressed material in the restriction. In other terms, the left argument of *usually* should be something like 'books that are lent by Mary to a student'. Now, the meaning of the *when*-clause, according to our proposals so far, will be:

(79) $\lambda p \exists x \exists y[\mathtt{book}(x) \wedge \mathtt{student}(y) \wedge \mathtt{lend}(y)(x)(m) \wedge {}^{\vee}p]$

The desired restriction for the antecedent can be obtained by a type shift of the following kind:[10]

(80) a. $\lambda u[\lambda p \exists x \exists y[\mathtt{book}(x) \wedge \mathtt{student}(y) \wedge \mathtt{lend}(y)(x)(m) \wedge {}^{\vee}p] \,;\, \uparrow x = u]$

b. $\lambda u[\lambda p \exists x \exists y[\mathtt{book}(x) \wedge \mathtt{student}(y) \wedge \mathtt{lend}(y)(x)(m) \wedge x = u \wedge {}^{\vee}p]$

c. $\lambda u[\lambda p \exists x[\mathtt{book}(u) \wedge \mathtt{student}(y) \wedge \mathtt{lend}(y)(x)(m) \wedge {}^{\vee}p]$

(80a) reduces to (80c), viz. the property that u has just in case u is a book lent to a student by Mary. This is what we want.

More generally, if A is an update function which contains an active occurrence $\exists x_n$ of an existential quantifier, we can turn it into a dynamic property $\lambda u[_n A]$ as follows:

(81) $\lambda u[_n A] = \lambda u[A \,;\, \uparrow u = x_n]$

We can then define an adverb of quantification $\mathtt{most}_n$ as follows:

(82) $\mathtt{most}_n(A)(B) =$
$\mathtt{most}''(\lambda u[_n A])(\lambda u[_n B])$, where $\mathtt{most}''$ is either $\mathtt{most}^{+}$ or $\mathtt{most}^{\circ}$

In appendix III, I provide an example of a complete derivation using this definition. Here let me expand intuitively on what this analysis delivers. The idea is that adverbs of quantification can associate with a topic contained in an *if/when*-clause. This means that they must have access to the index of the theme or topic. How one accomplishes this, depends on one's favourite theory of binding, scope and focus. For example, one can assume that the topic NP moves and adjoins to a position where it is governed by the adverb of quantification. Or one can try to work out a mechanism such as the one developed by Rooth [31, 32]. Be that as it may, having access to the index of the topic enables us to turn the arguments of the adverb of quantification into dynamic properties and to use the (dynamic) meaning of the determiner *most* to combine them (whichever of its interpretations may be appropriate). The net outcome of this is that, for example, a sentence like (83a) gets the same reading as (83b), as desired.

(83) a. When Mary lends a book to A STUDENT, he usually returns it with insightful comments (while if she lends one to a colleague, it gets heavily criticized)

b. Most books that are lent by Mary to a student are returned by him with insightful comments.

So *usually* can be interpreted as $\mathtt{most}'$ or $\mathtt{most}_n$. $\mathtt{most}'$ gives us the symmetric reading, $\mathtt{most}_n$ the asymmetric one. The approach I have sketched extends to all adverbs of quantification, as far as I can tell.

One question that comes to mind is whether there can be multiple topics. On the line we are taking this would mean that adverbs of quantification would be polyadic quantifiers which select the topics (rather than the unselective binders of classical *DRT*). The question is whether a sentence like (84a) can mean something like (84b):

(84) a. When a teacher lends A BOOK to a boy, she usually wants it back from

[10] This too owes to a suggestion by Paul Dekker.

him on time.

b. For most teachers and most boys such that the teachers lend a book to the boys, the teachers want the book back from the boys on time.

Sorting out what the facts are won't be easy, and I will not attempt to do so here.

In conclusion, the asymmetric readings of *if/when*-clauses are obtained by associating the adverb of quantification with an element selected from the *if/when*-clause that constitutes the topic. The tight and systematic connection between adverbs of quantifications and determiners makes this a relatively straightforward task.

6 Are determiners ambiguous?

One of the interim conclusions we reached by the end of section 3 is that certain closed determiners may be ambiguous between a strong and a weak reading. We proposed to account for this by assuming that such determiners could be defined using two different schemata, repeated here:

(85) a. $D^{+}(A)(B) = D(\lambda u{\downarrow}A(u))(\lambda u{\downarrow}[A(u)\,;B(u)])$

b. $D^{\circ}(A)(B) = D(\lambda u{\downarrow}A(u))(\lambda u[\mathbf{every}'(A(u))(B(u))])$
where $D = \mathbf{every}, \mathbf{most}, \ldots$

Now it seems to me that from an intuitive point of view the definition in (85a) is simpler than the one in (85b), for the latter involves a double quantification (the D and the $\mathbf{every}'$). This intuition can be substantiated by a formal criterion which I am now going to discuss. That criterion is an important formal property of determiners, namely *conservativity.*

For static determiners conservativity is defined as follows:

(86) $D(X)(Y) \leftrightarrow D(X)(X \cap Y)$

A well-known and up to now unfalsified universal is that every determiner in every natural language is conservative. This constraint is fairly substantive as it rules out many a priori conceivable determiners, such as those in (87):

(87) $\lambda P \lambda Q \forall x[\neg P(x) \rightarrow Q(x)]$
$\lambda P \lambda Q \forall x[Q(x) \rightarrow P(x)]$, where P and Q are of type $\langle e,t \rangle$

It is easy to see that the functions in (87) are not conservative and hence, if the conservativity universal is right, they do not constitute possible determiner-meanings. The question that naturally arises in this connection is whether dynamic determiners can be said to be conservative. The obvious extension of the notion of conservativity to dynamic determiners is the following:

(88) $D'(A)(B) = D'(A)(A\,;B)$, where $A\,;B = \lambda u[A(u)\,;B(u)]$

Clearly, (86) is the same as (88), modulo lifting of (86) to the type of updates. Now the reader should be able to see that if a determiner is defined by the schema in (85a) it will be conservative in the sense just given, for the definiens in (85a) is essentially the right hand side of (88) (I enclose in IV in the appendix an elementary proof of this statement).

For determiners defined by the schema in (85b), I see no non-trivial sense in which they may be said to be dynamically conservative. Thus, the schema in (85a), which gives us the weak truth-conditions for donkey sentences, preserves conservativity, while the schema (85b), which gives us the strong truth-conditions for donkey sentences, doesn't. In this sense, weak dynamic determiners are formally simpler than strong ones.

In fact, the schema in (85a), unlike the one in (85b), could be parametrized in such a way as to provide a general characterization of dynamic determiners that includes open as well as closed ones. Such a parametrization of (85a) goes as follows:

(89) $D^{+}(P)(Q) = {}^{(C)}\lambda p D(\lambda x{\downarrow}P(x))(\lambda x[[P(x)\,;Q(x)](p)])$[11]

The parenthesized closure operator in (89) is a parameter that is left in for closed determiners and taken out for open determiners. I leave it to the reader to check that leaving ^{C} in brings us back to (85a) and that if we leave it out $\lambda p\,\mathtt{some}(\lambda x{\downarrow}P(x))$-$(\lambda x[[P(x)\,;Q(x)](p)])$, where **some** is the static meaning of *a* or *some*, is equivalent to $\lambda P\lambda Q\exists x[P(x)\,;Q(x)]$.

We know that not always reality fits simple formal schemata. But it is a good strategy to push a formally simpler hypothesis as far as possible. Accordingly, I wish to explore the idea that dynamic determiners are not ambiguous but are all uniformely defined by the schema in (89). In this way we would get rid of a puzzling ambiguity in favour of an extremely general and formally simple characterization of the type of functions needed to interpret members of the syntactic category DET.

For this idea to be empirically teneable, we have to come up with a story as to how the strong reading of donkey sentences arises, for determiners as defined by the schema in (89) will only yield weak readings. I think that there is hope to find such a story if we recognize that pronouns can play a double role: on the one hand as (dynamically) bound variables and on the other as descriptions in disguise (Evans's E-type pronouns). I now turn to a discussion of the issues involved.

7 On E-type pronouns

There are many anaphoric dependencies that, at our current level of understanding, do not seem analyzable in terms of a direct form of variable binding (be it static or dynamic). A case in point is constituted by functional readings of questions, illustrated by examples such as the following:

(90) Who does no man like? His mother in law

It can be argued[12] that the semantics of the question in (90) involves an anaphoric dependency between the quantified NP *no man* and the gap that has to be mediated by a function from individuals to individuals. Consider the following formula:

(91) $\neg\exists u[\mathtt{man}(u) \wedge \mathtt{like}(f(u))(u)]$

The meaning of the question in (90) can be thought of as asking for the value(s) of the variable f that would make (91) true. The answer in (90) informs us that the function that does the job in the actual world is the one that maps each man into his mother in law.

This kind of indirect anaphoric links are not attested only in questions, which involve gaps, but also in declarative sentences with overt pronouns. A particularly clear case is represented by Karttunen's famous paycheck sentences:

(92) Every man except John gave his paycheck to his wife. John gave it to his mistress. (Cooper's variation on Karttunen's theme)

Here the antecedent of the pronoun *it* is the NP *his paycheque*. Yet, there is no way to analyze this sentence by trying to have *his paycheque* bind the pronoun directly. A reasonable first approximation to what the second sentence in (92) means seems to be the following:

(93) $\mathtt{gave\_to\_his\_mistress}(f(j))(j)$

where f is a function that maps people into their paycheque. The idea here is that

[11] Actually, to avoid that x may get accidentally bound by quantifiers active in A, the definiens should be: $\lambda p D(\lambda x{\downarrow}A(x))(\lambda x[\lambda u[[A(u)\,;B(u)](p)](x)])$.

[12] For relevant arguments and a discussion of the semantics of these construction see Engdahl [8] and Groenendijk and Stokhof [10].

the pronoun *it* is interpreted similarly to the definite description *his paycheque* and that the latter can be analyzed as a function from individuals into individuals.

Other well-known cases that are not directly analyzable in terms of the kind of dynamic binding we have studied here, but that could fairly straightforwardly be analyzed as E-type pronouns are the following:

(94) a. It is not true that John doesn't have a car. It is parked in front of the house (Partee?)

b. Hob believes that a witch blighted his cow and Nob believes that she stole his pig (Geach)

c. A: every time I was there, a man jumped off the cliff
B: I bet that in most cases he didn't jump, he was pushed
(Heim's variation on Strawson's theme)

In (94a) the definite description that does the job would be something like 'John's car', which could represented as $f(j)$, where f is a function that maps individuals into their cars. In (94b), the relevant definite description could be something like 'the witch that people in Hob's and Nob's village believe to be around'. This could be represented as a function f that maps x into the witch that people in x's village believe to be around. And in (94c) something like 'the man that A believes jumped off the cliff at t' would probably do. As Heim points out, this description could be represented as a function f from times into the people that A thinks jumped off the cliff at that time.

All the case in (92)–(94) could be analyzed in way which is fully parallel to the way gaps in questions like (90) have been treated: as contextually specified functions from individuals into individuals.[13]

So, there appears to be a host of phenomena that is not known how to handle in terms of dynamic binding, while they seem to be within easy reach of a fairly simple E-type approach. One is lead to conclude that pronouns can indeed function as definite descriptions. This immediately raises the issue of whether it is possible to do away with dynamic binding altogether (be it of the *DRT* or of the *DTT* variety) in favour of an E-type only approach. I think not. With Kratzer [21], I believe that a mixed theory (i.e., one that assumes that pronouns can behave either as bound variables or as descriptions) is better off. The possibility of an E-type only theory has recently been (re)discussed in Heim [16]. Below I will comment on her proposals.

When is a pronoun a bound variable and when is it an implicit description? This question is not going to have a straightforward answer at this stage of our understanding of the issues involved. There is, however, a plausible starting point, which is immediately suggested by the nature of the dependencies involved. Dynamic binding, as we understand it, is hard wired in the syntax and semantics of language. E-type pronouns involve, instead, searching the context in order to identify the relevant description. They involve a consideration of pragmatic factors and are not determined by the grammar strictu sensu. In this sense, the bound variable strategy is 'stronger'. Accordingly, Gricean maxims (do not under- or over-inform, etc.) suggest that, everything else being equal, the bound variable strategy should be preferred. These sketchy considerations could be fleshed out more fully, following parallel arguments that have been made in connection with non coreference constraints (cf., e.g., Dowty [7], Reinhart [28]). But I will refrain from doing so here.

Assuming something like this, immediately explains, for example, contrasts like the following (also amply discussed in the literature):

[13] For more discussion, see Evans [9] and Cooper [3]

(95) a. Every man who owns a donkey beats it

b. *Every donkey owner beats it

In oversimplified form, the reasoning goes as follows. The pronoun *it* in (95b) is accessible from the subject position. Hence, the stronger bound-variable strategy should be used, unless there are clear reasons to avoid it. The deviance of (95b), on the intended interpretation (i.e., the one corresponding to (965a)), can be blamed on considerations of this kind.

The broadening of our perspective that derives from a consideration of the double role of pronouns is what I would like to suggest can also help explaining how the strong reading of donkey sentences comes about. I will provide two ways in which this line can be pursued. I will then discuss some potential problems for it.

Both stories I'd like to tell start from a common assumption. If the bound variable strategy only delivers weak truth-conditions (as per our hypothesis), such strategy will be of no use in a context where the strong reading of a donkey sentence is called for. Thus in such a context there are reasons to avoid the bound-variable strategy and we are free to go for the E-type strategy.

That granted, the first story could go as follows. Take a donkey sentence that favours the strong reading such as the following:

(96) Every landowner that owned a slave exploited him

The very utterance of (96) will make prominent a function f that maps landowners into the slaves they own. Accordingly, the meaning of (96) can be represented as:

(97) $\forall x[[\mathtt{landowner}(x) \wedge \exists y[\mathtt{slave}(y) \wedge \mathtt{own}(y)(x)]] \rightarrow \mathtt{exploit}(x, f(x))]$, where $f(x)$ is the group of slaves that x owns

This gives us the desired interpretation for (97). Notice that an aspect of this proposal is that a singular pronoun *it* is taken to refer, possibly, to a group or a plural entity. Notice also that the pronoun in question ends up referring to a group only indirectly, i.e., via a contextually salient function. This means that the sole assumption which is called for is that pronouns in their E-type uses are semantically unmarked for plurality. This would allow for morphologically singular pronouns (like *it* in (96)) to denote groups. Constructions of this sort are well attested in English. Consider for example free relatives such as the following:

(98) John ate what Mary had left on her plate (namely potatoes and beans)

The free relative *what Mary had left on her plate* is morphologically singular (as it triggers singular agreement), but semantically is a definite description that can denote a plural entity (like potatoes and beans). If what I am suggesting is on the right track, E-type pronouns are just like free relatives in this respect.

The second story one could tell is borrowed from Kadmon [18].[14] We can suppose that the strong reading of (96) is represented still by (97) but that the function f in (97) maps x not into the group of x's slaves but into one of x's slave. Which one? The answer is: it does not matter to the truth-conditions of (96). Anyone will do. And thus any arbitrary function from x into one of x's slave can be selected as the value of f in (97). This essentially means that the way in which the context determines the right function has to be understood properly. There are basically two possiblities. The context may determine exactly one function. Or it may determine a range of functions, each of which does equally well. This second possibility can be exploited iff the choice of function doesn't make a difference to truth-conditions. In the case at hand, the choice of slave per owner doesn't matter. This can be the case iff all the slaves a slaveowner x has are exploited by x. But these are just the

[14] Kadmon, however, develops it with very different goals in mind and embeds it in a very different approach.

strong truth-conditions for (96) we were seeking. On this second story, we don't need to assume that E-type pronouns are semantically unmarked for plurality. We can maintain that singular pronouns can only refer to singular entities.

As far as I can tell, both stories extend naturally to more complex cases. Consider for instance the strong reading of a sentence like the following:

(99) Every teacher who gave a book to a student got it back from him on time.

Such a reading would involve two interdependent E-type pronons. There are many options here. One that fits the first of our stories could go roughly as follows. We can take the logical form of (99) to be:

(100) $\forall x[\mathtt{teacher}(x) \wedge \exists y \exists z[\mathtt{student}(y) \wedge \mathtt{book}(z) \wedge \mathtt{gave}(y)(z)(x)]] \rightarrow$
$\mathtt{got\_back}(f_1(x))(f_2(x))(x)]$

In a context that supports the strong reading of (99), two functions are going to be salient: a function f_1 from x into the people to whom x gave a book and a function f_2 from x into the books that x gave out. This means that (100) is going to have the same truth-conditions as:

(101) Every teacher who gave a book to a student got back the books he gave out from the students to whom he gave books.

The fact that there is a dependency between books and students (such that if x gave y to z, he got back y from z and not from somebody else) is pragmatically inferred. As far as I can see, (99) and (101) are indeed truth-conditionally equivalent, if we put the plurality presupposition of (101) aside.

An approach that fits best our second story could go as follows. The logical form of (99) could be:

(102) $\forall x[\mathtt{teacher}(x) \wedge \exists y \exists z[\mathtt{student}(y) \wedge \mathtt{book}(z) \wedge \mathtt{gave}(y)(z)(x)]] \rightarrow$
$\mathtt{gotback}(f_1(x, f_2(x)))(f_2(x))(x)]$

Here, f_2 maps x into a book that x gives out and f_1 maps a pair x and y into a student to whom x gave y. So the second conjunct ends up saying that x got back a book he gave out, namely $f_2(x)$, from a student that he gave that book to. Which book and which student doesn't matter. This yields as a result the strong truth-conditions, following Kadmon's reasoning.

Something we have to worry about is whether an approach such as the one I have sketched overgenerates. Consider for example the contrast in (103):

(103) a. *Every man$_1$ walked in. He$_1$ was wearing a hat

b. Every man$_1$ walked in. They$_1$ were wearing hats

Why this contrast? To my knowledge no fully explicit account for it is currently available. There are strategies one can pursue, however. For example in the general spirit of *DRT* one can say something along the following lines. In (103a) the pronoun is not accessible to the NP *every man* (modal subordination cases aside), whence its ungrammaticality. At the same time, *every man* introduces a superordinate group-level discourse marker, to which a plural pronoun can be linked.

What strategy could we pursue, from the point of view adopted in this paper? The point is that we have the same notion of accessibility as *DRT*, which makes *he*$_1$ in (104a) inaccessible from *every man*$_1$. But this will let the E-type strategy lose and couldn't there be some function around to interpret the pronoun? It seems so: we seem to need such a function to interpret (103b). But then we should be able to use the same function to interpret (103a). So why is (103a) ungrammatical?

Of the two stories we have considered, the one based on Kadmon's approach, appears to be reasonably well off. What function would the first sentence of (103a) make salient? Presumably, a function from something like times or occasions into the set of people that walked in at that time or in that occasion. Not a function from occasions to one man, for NP's like *every man* carry a plurality presupposition (unlike what happens with singular indefinites). So the representation of (103a) should be something like:

(104) $\exists o[\forall x[\mathtt{man}(x) \rightarrow \mathtt{walk\_in}(o)(x)] \wedge \mathtt{wear\_a\_hat}(f(o))]$, where o ranges over occasions and $f(o)$ is the group of men that walked in at o

But on our second story, we can maintain that (104) is not a possible meaning for (103a), precisely because the pronoun he_1 is singular and calls for a singular reference. At the same time (104) is, of course, a possible reading for (103b).

Our first story, which is committed to the assumption that E-type pronouns are semantically unmarked for plurality, seems to be in worse shape in ruling (103a) out. But I feel that our current understanding of the contrast in (103) is just too limited to warrant jumping to conclusions. For example, quite clearly the contrast in (103) is on a par with the one in (105):

(105) a. *No man$_1$ came. He$_1$ stayed home

b. No man$_1$ came. They$_1$ stayed home

A straightforward alternative to the DR-theoretic strategy outlined above that would cover both (103) and (105) could go as follows. We know that common nouns are associated in a natural way with kinds: the common noun *dog* is associated with dogs, etc. Thus kinds associated with common nouns mentioned in a given context will always be salient in that context and can be referred to, just like ordinary individuals can. Accordingly, the type of anaphora in (103)–(105) needn't resort to the E-type strategy. It is, rather, parallel to:

(106) John walked in. He was wearing a hat

This type of referential pronouns, unlike genuine E-type pronouns are clearly syntactically and semantically marked for plurality. A sentence like:

(107) John and Bill walked in. He was wearing a hat

is odd, and at any rate cannot mean the same as:

(108) John and Bill walked in. They were wearing a hat

There is also good evidence that at least in English, kinds in the technical, semantic sense of this term are plural entities: the canonical way of referring to kinds is by means of bare plurals. But this sufficies to account for the contrasts in (103) and in (105). Something like (105a) would be interpreted as Carlson [2] suggested that (109) is interpreted (or as per some update/refinement of Carlson's approach):

(109) a. Dogs are barking in the court-yard. I hate them.

b. Dogs are dangerous. They stole my roastbeef.

I am suggesting that (103) and (105) could be analyzed as reference to kinds. This type of anaphora doesn't involve E-type pronouns but direct reference to a contextually salient individual, an option which, one can assume, is always available and takes precedence over the E-type strategy (for referring to a contextually salient individual arguably requires less effort that reconstructing a function from contextual clues). This approach is consistent with our first story and accounts for the facts at least as well (if not better) than the DR-theoretic strategy.

In light of these considerations, I think that we are entitled to think that the strategy of deriving the strong reading of donkey sentences via E-type pronouns is on the right track. The overall view of anaphora that emerges is quite pleasing.

Dynamic determiners are all uniformely defined in terms of a mathematically simple schema (our (89) above). This yields a notion of semantic scope ('accessibility') that appears to be reasonably well-supported by the facts. Besides their use as bound variables, pronouns can also act as descriptions in disguise, cast as functions from individuals into individuals. By and large, we resort to the E-type strategy to reach out for anaphoric links that are inaccessible to the bound variable strategy, or to get at readings which we cannot get with the bound-variable strategy. Determiners are not ambiguous between a strong and a weak meaning. The complicated and not general schema in (85b) can be dispensed with.

8 Some comparisons

The topics I have dealt with in the present paper are at the hart of an intense ongoing debate. Even if I were to limit myself to a consideration of the most influential positions that have been advocated, there is no hope that I will be able to draw comprehensive comparisons between them and the approach I have presented here. There are, however, two recent papers (Heim [16] and Kratzer [21]) which I find particularly insightful and that have a particularly substantial overlap with the concerns of the present work. Even though I will not be able to do full justice to them, I think it is appropriate to indicate where the main substantive differences between those theories and mine are to be found.

8.1 Heim

In her paper, Heim explores and defends a theory of donkey anaphora which doesn't exploit dynamic binding, but relies solely on the E-type strategy. In her previous work, Heim had been one of the most articulate critics of the E-type approach. The bulk of her criticisms was twofold:

(i) The E-type strategy relies on a purely pragmatic link between pronouns and their antecedent, which leads to inadequacies.

(ii) Such a strategy also leads to exceedingly strong uniqueness conditions on pronouns.

Problem (i) is exemplified by examples such as (110), mentioned above and repeated here:

(110) a. Every man who has a donkey beats it

b. *Every donkey-owner beats it

Problem (ii) is exemplified by 'sage plant' sentences like:

(111) Every man who bought a sage plant bought five others with it

Heim tries to obviate to these shortcomings of the E-type approach in two ways:

(i) by establishing a formal link between E-type pronouns and their antecedents,

(ii) by introducing quantification over situations.

Heim's approach to (i) bears analogies with some current proposals on VP-anaphora. It is based on a transformation (part of the map from Surface Structure into LF) that adjoins to a pronoun its antecedent as follows:

$$\begin{array}{lllllllllllll} & \text{X} & \text{S} & \text{Y} & \text{NP}_i & \text{Z} & \Rightarrow & 1 & 2 & 3 & 4+2 & 5 \\ (112) & 1 & 2 & 3 & 4 & 5 \end{array}$$

conditions: 4 is a pronoun and 2 is of the form $[_S\ \text{NP}_i\ \text{S}]$

Let's illustrate its workings by means of an example. Take a classic donkey-sentence, like (113a). Its structure, after QR, will be something like (113b).

(113) a. Every man that owns a donkey beats it

b. [every man$_1$ that **[a donkey$_2$ that [t$_1$ own t$_2$]]]]**[t$_1$ beats it$_2$]]

(112) applies to (113b) (where term 2 has been marked in boldface) and yields:

(114) [every man$_1$ that [a donkey$_2$ that [t$_1$ own t$_2$]]]][t$_1$ beats **[it$_2$ [a donkey$_2$ that [t$_1$ own t$_2$]]]]]**

The structures so generated are then interpreted as definite descriptions. In particular the constituent in boldface in (114) is interpreted a shown in (115a), using the general rule given in (115b).

(115) a. [it$_2$ [a donkey$_2$ that [t$_1$ own t$_2$]]] $\Rightarrow \iota x_2[\mathtt{donkey}(x_2) \wedge \mathtt{own}(x_1, x_2)]$

b. $[\![[\text{it}[\text{DET}\alpha]\beta]]\!]_g$ = the unique a such that $a \in [\![\alpha]\!]_g$ and $[\![\beta]\!]_{g[a/u]} = 1$ (undefined if there is no such a)

The point of this is to provide an explicit way to reconstruct the relevant descriptive content that enables one to interpret pronouns. Examples like (96b) are ruled out on this approach simply because they do not meet the structural description for the transformation in (112).

The second main aspect of Heim's proposal is to relativize the descriptive content reconstructed by (112) to appropriate situations so as to avoid too strong uniqueness presuppositions. The notion of situation Heim uses is borrowed from Kratzer's work ([22]) on conditionals: a situation is simply part of a world. Situations are primitive objects partially ordered by a part-of relation ($\leq$), where worlds are maximal elements with respect to $\leq$. Predicates have an extra argument ranging over situations. For example:

(116) a. $\mathtt{man}(s, x)$

b. $\mathtt{beat}(s, x, y)$

(116a) says that x is a man in s and (116b) that x beats y in s. Within this set of assumptions, one can maintain that indefinites are existentially quantified NPs and that adverbs of quantifications quantify over situations. Let us flesh Heim's proposal out a bit more, by considering first how conditionals are treated. Then we will turn briefly to relative clause variants of donkey sentences.

A conditional like (117a) is assigned the truth conditions in (117b).

(117) a. If a man owns a donkey, he is happy

b. every minimal situation s in which there is a man and a donkey owned by that man is part of a situation s' where the man in s is happy.

It may be useful to reconstruct how the truth-conditions in (117b) are arrived at. Sentence (117a) is mapped onto the following LF:

(118) always$_s$ if [a man$_{s,1}$ [a donkey$_{s,2}$ [t$_1$ owns$_s$ t$_2$]]]$_{s'}$ [he$_1$ is happy$_{s'}$]

This is then transformed by (112) into (119a), which is interpreted as shown in (119b).

(119) a. always$_s$ if [a man$_{s,1}$ [a donkey$_{s,2}$ [t$_1$ owns$_s$ t$_2$]]]$_{s'}$ [he$_1$ **[a man$_{s,1}$ [a donkey$_{s,2}$ [t$_1$ owns$_s$ t$_2$]]]** is happy$_{s'}$]

b. $\forall s[\exists x_1 \mathtt{man}(s, x_1) \wedge \exists x_2[\mathtt{donkey}(s, x_2) \wedge \mathtt{own}(s, x_1, x_2)]] \rightarrow \exists s'[s \leq s' \wedge \mathtt{happy}(s', \iota x_1[\mathtt{man}(s, x_1) \wedge \exists x_2[\mathtt{donkey}(s, x_2) \wedge \mathtt{own}(s, x_1, x_2)]])]]$

The quantifiers over situations in (119b) are understood as ranging over *minimal* situations, which is what enables us to achieve the effects of quantifying over n-tuples. Descriptions are relativized to situations and thus we are never going to get overly strong uniqueness conditions. In particular, the sage-plant example will work fine: we quantify over minimal situations in which a person buys a sage plant; each such situation must be part of a larger one in which the person buys five more.

What about asymmetric readings of conditionals? To make a long story short, the strategy that Heim pursues is roughly the following. Instead of quantifying over minimal situations in which, say, a man owns a donkey, one can quantify over smaller situations. For example, one can quantify over situations in which there is a man that are part of situations in which that man owns a donkey. This will get us the effects of quantifying over donkey-owning men and thus will get us the subject asymmetric reading. Or we can quantify over minimal situations in which there is a donkey that can be extended to situations in which the donkey is owned by a man. This amounts to quantifying over donkeys owned by men and will get us the object-asymmetric reading. I give a sketchy illustration of the object-asymmetric reading of (120a) in (120b-c).

(120) a. If A MAN owns a donkey, it gets beaten

b. LF: always$_s$ [a donkey$_{s,1}$ $_{\underline{s}}$[a man$_{s,2}$ [t$_2$ owns t$_1$]]] $_{s'}$[it$_1$ gets beaten]

c. Truth-conditions:
$\forall s[\exists x_1[\mathbf{donkey}(s,x_1) \wedge \exists s''[s \leq s'' \wedge \exists x_2[\mathbf{man}(s'',x_2) \wedge \mathbf{own}(s'',x_2,x_1)]]] \rightarrow$
$\exists s'[s \leq s' \wedge \mathbf{beaten}(s', \iota x_1[\mathbf{donkey}(s,x_1)])]]$

(120c) says that every situation s with a donkey in it that is part of a situation where that donkey is owned by a man is also part of a situation where the donkey in s gets beaten. The key step in the derivation of this reading is to allow for S-nodes to be indexed by situations (cf., the underlined s in (120b)) and to set up an interpretive procedure whose effect is to map structures like (120a) into formulae like (120c) (see Heim's paper for relevant deteails).

Let me now turn briefly to Heim's treatment of relative clause cases of donkey anaphora. Here too we face the task of avoiding too strong uniqueness presuppositions in sage-plant sentences. The strategy that Heim adopts is common to much work on this topic, the same that I also followed in the schema (78b) above. The idea is that sentences such as those in (121a) involve in fact two nested quantifications:

(121) From Heim (1990)

a. Most people that owned a slave also owned his offspring
$\approx$ for most people that owned a slave: for every slave they owned they owned also his offspring

b. No parent with a teenage son will lend him the car
$\approx$ for no parent with a teenage son: there is a teenage son to which he or she lends the car

The main quantificational force is the one standardly associated with the determiner that heads the NP containing the relative clause. Each indefinite inside a relative clause is either universally or existentially quantified over (depending, on the determiner heading the NP containing the relative clause). Heim provides a version of this approach using again quantification over situations. I give here only informally an example of her implementation:

(122) Most people that owned a slave also owned his offspring
$\approx$ for most people that owned a slave: every minimal situation s where they owned a slave is part of a situation s' where they also owned the offspring of the slave they owned in s.

Here uniqueness presuppositions are again relativized to suitably constructed minimal situations and hence they do not yield any counterintuive result.

Heim argues that if one compares classical *DRT* (which has to make heavy use of accomodation) with her version of the E-type only approach, the E-type approach comes out better. In fact, Heim's theory constitutes the most thoroughly worked out attempt to dispense with dynamic binding. I now turn to discuss the main areas where her theory and mine differ and point out some reasons why I find preferable the mixed approach developed in the present paper. I will begin with empirical differences and then I'll turn very briefly to more conceptual ones.

A first thing to notice is that Heim doesn't discuss at all weak readings of donkey sentences. If, as I have argued, such readings are there, it remains to be seen how they could be analyzed in terms of the E-type strategy. Prima facie, it is not obvious how to proceed.

A second thing to notice is that Heim, as she explicitly admits, has no account for symmetric predicates in conditionals, such as (61) above repeated here:

(123) a. If a cardinal meets someone he blesses him

b. If a man shares an apartment with another man, he shares the housework with him.

The problem here for Heim's theory is that the minimal situation we have to consider is one with two cardinals for (123a) and one with two men for (123b). Thus we don't have at our disposal any suitable description to identify the referents of the pronouns in the consequent. The theory developed in the present paper, per contrast, makes the right predictions in this connection.

A third interesting empirical difference between Heim's theory and mine has to do with the asymetric readings of conditionals. Heim is committed to claiming that asymmetric readings of conditionals always trigger certain uniqueness presupposition (following on this Kadmon [18]). To see why, consider sentence (9) again, repeated here:

(124) If Mary lends a book to a student, he usually returns it with insightful comments.

Consider, say, the direct object asymmetric reading of (124), i.e., the one where we quantify over books. In order to get such reading in Heim's theory, we must quantify over minimal situations in which there is a book of Mary's. Think now what description can we use to pick the reference of the pronoun he in the the consequent. It can only be something like for each book the student to which Mary lent that book. So students have to be unique with respect to books. My intuitions do not sustain this claim. I don't get such uniqueness effect, or at least not always. Let me try to substantiate my intuitions a bit. Imagine uttering (124) with the focal stress on the indirect object in the situation described below:

(125) Mary's books (3): A, B, C
Mary's students (5) : a, b, c, d, e
Lendings(15) : each book is lent once to each student
Insightful comments (7): twice from a, twice from b, twice from c, and once from d

I think that (124) can be true in the scenario in (125). Yet on the symmetric reading (124) would be false in it, as the reader can easily check. So (124) must be interpreted on one of its asymmetric readings. But neither the books are each uniquely lent to a single student, nor does each student borrow a unique book. So on Heim's theory, (9) is predicted to be false (or perhaps uninterpretable, due to failure of uniqueness presuppositions) relative to (125).

To reinforce these conclusions, consider next the discourse in (126):

(126) In Italy, most donkey owners own more than one donkey. The most famous donkey owner is the avvocato Gianni Asinelli: he owns the largest number of donkeys in the country and treats them well. Yet, in spite of his good

example, usually in Italy, if someone owns a donkey, he beats it.

I think that the underlined sentence makes perfect sense and in fact describes a possible state of affairs. I believe that Heim's theory would predict it to be necessarily false or uninterpretable. For the presence of Gianni Asinelli makes the sentence false on the symmetric reading. The majority of pairs that satisfies the antecedent doesn't satisfy the consequent. The sentence is only true in one of its asymmetric readings. But this would force either each man to own just one donkey or each donkey to be owned by just one man. But of course neither of these need to obtain for (126) to be true.[15] On this basis, I conclude that Heim's approach does not quite succeed in getting rid of all the overly strong uniqueness presuppositions that an E-type only approach to donkey anaphora gives raise to.

There are also a number of less immediately data driven differences between the two theories. I will briefly mention three of them. The first concerns the treatment of NP's, which doesn't seem to be uniform in Heim's theory. Indefinites are treated as ordinary existential quantifiers. Quantifiers like *most* and *every* instead appear to be binary quantifiers over individuals and situations. This suggests that indefinites and quantifiers like *every* will be of different types. I think that this may lead to problems in connection with sentences like:

(127) [a thief who was carrying a gun] and [every policemen who wanted to take it away from him] rushed into the room

If the NP's in (127) are of different types it is not clear how they could be conjoined. On the approach developed in this paper, we can instead stick to the simple theory of cross-categorial conjunction developed in Partee and Rooth [26]. NP's belong uniformely to the same type and that type is a conjoinable one. In fact, it would be interesting to study what happens when we consider anaphoric interactions involving coordinate structures. But this must be deferred to another occasion. The fact remains, however, that assigning to NP's different logical types generally spells trouble when it comes to dealing with coordination.

A second thing to note is that Heim is forced to adopt a complicated schema to give the semantics for closed quantifiers (a schema which corresponds to our (78b) above) while our theory enables us to adopt the formally simpler (conservative) schema in (78a). And finally, while Heim's theory does away with accomodation, it adopts something which is closely related to it, namely a transformation on logical form such as (112). If the line on E-type pronouns I have sketched above turns out to be tenable, such a transformation on logical form can be dispensed with. These are the main reason that make me hope and believe that the line explored in the present paper is more on the right track than Heim's.

8.2 Kratzer

Kratzer argues that stage-level and individual-level predicates differ in argument structure and that this difference has far reaching consequences for a theory of anaphora. In particular, she claims that this difference in argument-structure sheds light on the proportion problem. I will not be able to discuss here every aspect of Kratzer's proposal. I will try, however, to indicate where the main empirical differences between my approach and hers lie. I will begin by summarizing the aspects of Kratzer's proposal that are most directly relevant to the problems we are concerned with in the present paper. In doing so, I will have to presuppose some familiarity with the government and binding framework, that Kratzer adopts.

The difference between individual-level and stage-level predicates was systematically studied in Carlson [2] and has to do with contrasts such as those in (128) and (129).

[15] Similar objections I would level against [18].

(128) a. There is a fireman available

b. *There is a fireman altruistic

(129) a. Firemen are available

b. Firemen are altruistic

As (128) illustrates, in there-sentences only certain adjectives can occur felicitously. Intuitively, those are adjectives that express a transient or episodic property of entities. These adjectives are an instance of stage-level predicates. Adjectives like *altruistic* express instead a more or less stable or tendentially permanent property of entities and are accordingly classified as individual-level predicates. This difference manifests itself in a different manner in the sentences in (129). (129) has a reading where the bare plural subject is understood as being existentially quantified. On such a reading (129a) is roughly equivalent to 'some firemen are available'. This is the most prominent (though not the only) reading of (129a). In contrast, (129b) cannot be interpreted in a parallel fashion. It cannot mean something like 'some firemen are altruistic'. (129b) has only a quasi-universal reading, roughly paraphrasable as 'most firemen are altruistic' or 'typically, firemen are altruistic'. So individual-level predicates select the quasi-universal or generic reading of bare plurals.

This distinction doesn't apply just to adjectives but to all predicates. For example, *beat* is a stage-level predicate. This can be seen from the fact that (130) has an episodic reading:

(130) Italian hooligans beated us up

Accordingly the bare plural subject in (130) is understood existentially. Per contrast, *love* is individual-level. The only reading of (131) is generic:

(131) Italian hooligans loved to attack old ladies

The bare plural subject here is understood quasi-universally. I refer to Carlson [2] for further discussion.

The main novelty of Kratzer's proposal consists of the claim that this distinction is reflected in argument structure. Stage-level predicates have an extra argument for spatio-temporal locations, individual-level ones don't. So, for example, (132a) has the function-argument structure in (132b):

(132) a. John is available

b. $\mathtt{available}(j, l)$

l is a variable ranging over space-time locations. (132b) says roughly that John is available at l. A sentence involving individual-level predicates like (133a) has, according to Kratzer's proposal, the function-argument structure given in (133b):

(133) a. John is altruistic

b. $\mathtt{altruistic}(j)$

Kratzer's proposal is in the same spirit as Davidson's approach ([4]) to action-sentences. But Kratzer claims that only stage-level predicates have an extra Davidsonian argument.

One of the main argument in support of this claim is based on the paradigm in (134)–(135):

(134) a. When John is happy, he sings

b. When a fireman is happy, he sings

(135) a. *When John is altruistic, he is a good fireman

b. When a fireman is altruistic, he is a good fireman

Kratzer sticks to the main assumptions of classical *DRT*, concerning these sentences. So she assumes that indefinites are free variables and that in (134)–(135) there is an implicit adverb of quantification. Putting this together with the hypothesis that predicates differ in argument structure along the lines just indicated, (134a) is assigned the logical form given in (136a) and (135a) the one given in (136b):

(136) a. $\mathtt{always}_l[\mathtt{happy}(j,l)][\mathtt{sing}(j,l)]$

b. $\mathtt{always}[\mathtt{altruistic}(j)][\mathtt{good\_fireman}(j)]$

This suggests a natural explanation for the contrast in (134)–(135). In (134a) the space-time location provides a variable for the adverb of quantification to bind. But in (135a) there is nothing for such an adverb to bind. The quantification in (135a) is vacuous, whence its deviance. Per contra, in (135b) the indefinite subject provides a variable for the adverb of quantification to bind, and this is why (135b) is grammatical.

In order to explain why individual-level predicates select the universal reading of bare plurals, Kratzer (building on work by Diesing [6]) adopts the following widely shared assumption from the syntactic literature. Predicates have at most one external argument (cf., Williams [34]), i.e., at most one of their arguments can be realized outside of their maximal projection. For verbs, this means that only one of their arguments is realized outside of V_{max}. Kratzer then conjectures that the space-time argument of stage-level predicates is always the external one. This entails that the surface subject of these verbs must be generated inside the VP. In languages like English, the VP-internal subject is then moved to its S-structure position (that is, Spec of IP). Individual-level predicates lack this extra argument and thus have the option of selecting one of their other arguments as the external one.[16] This means that in English stage-level predicates and individual-level predicates will have different S-structures. Stage-level predicates will have in the VP a trace coindexed with the subject in Spec of IP. Individual-level predicates in general won't. Kratzer then assumes that there is a rule that closes existentially material in the VP. This rule is meant to replace the rule of existential closure of classical *DRT* which applies at the discourse level and guarantees that all indefinites not in the scope of a suitable binder are interpreted as being existentially quantified.

To see what consequences these assumptions have, let us consider a specific example. Consider a sentence with a stage-level predicate such as:

(137) Firemen are available

Such a sentence will have roughly the structure in (138):

(138) $[_{\mathrm{IP}}$ firemen$_3$ are $[_{A''}$ t_3 available$]]$

How are these structures interpreted? There is evidence coming from raising (cf., May [25]) which suggests that in cases like these, NP's can either be interpreted in situ or reconstructed back into the position of the trace. If it is reconstructed back into the trace-position, the variable associated with firemen (which is taken to be just an indefinite) will be caught by the VP-level rule of existential closure. This will yield the existential reading of (137). If it is left in situ, it becomes possible to bind the variable associated with firemen with a generic operator. This will result in the generic interpretation of (137). The interesting point in this connection is that individual-level predicates don't have this option, for they originate outside of the VP and thus there is no position within the VP into which they can be reconstructed. Consequently, they can only get a generic interpretation. This accounts for the

[16] As Kratzer discusses at length, individual-level predicates that are unaccusative will lack an external argument altogether. Here I will limit myself to a consideration of individual-level predicates that are not unaccusative.

difference in quantificational force associated with stage-level vs. individual-level predicates.

The assumption that VP's are always existentially closed has far reaching consequences. It entails that no indefinite within the VP can, in the terminology of the present paper, act as a dynamic binder. Consider for example the following discourse.

(139) Mary knows a fireman. He is blond

Unlike what happens in classical *DRT*, the pronoun *he* here cannot be understood as being bound by the indefinite *a fireman*, for the variable associated with the latter will be existentially closed within the minimal VP containing it. Thus a different pronominalization strategy is called for. Kratzer assumes that in cases such as these one falls back on a version of the E-type strategy. The pronoun is understood as a description of some sort. The theory of definite descriptions that Kratzer adopts is the one developed in Heim [13]. According to it, a definite is assimilated to a free variable that in the given context must be old or familiar. The descriptive content of the definite, if any, must be accomodated in the sense of Lewis [24] and Heim [13, 14].[17]

Kratzer notices, further, the contrast in (140):

(140) a. *When Pedro has a donkey, he beats it

b. When Mary knows a foreign langugage, she knows it well

The ungrammaticality of (140a) is predicted by Kratzer's theory. The indefinite in (140a) occurs within the VP and thus it is existentially closed. Since the predicate is individual-level, there is no variable for the implicit quantificational adverb to bind. This is a welcome result. But why is then the structurally parallel sentence (140b) grammatical? Something must allow the object of know (but not the object of have) to escape existential closure. That something, Kratzer proposes, is scrambling. Scrambling is a process that moves an NP and adjoins it to IP. In languages like German such a process occurs at S-structure, while in languages like English it occurs, according to Kratzer, at Logical Form (and thus is 'invisible'). The factors that influence scrambling are still poorly understood. But Kratzer argues that the verbs that allow overt scrambling of their objects in German are the same that pattern like know in structures like (140b). This provides an interesting empirical support in favour of her hypothesis. So the possibility for an indefinite within a VP to bind something outside of its S-structure scope is tied to its scrambability.

Kratzer argues for the hypotheses I have sketchily summarized on the basis of a rich set of facts from English and German, that I cannot discuss here in detail. Before getting into a discussion of where her approach diverges from mine, I would like to indicate some areas of agreement. As in the proposal articulated in the present paper, Kratzer advocates a mixed approach to anaphora where some pronouns are treated as bound variables, while others as E-type. She assumes furthermore, as I have, that the E-type strategy takes over whenever direct semantic binding is not available. With regard to space-time locations, while I never referred to them in my approach, it is nevertheless straightforward to incorporate a Davidsonian treatment of them within my theory. In fact, this move represents the most natural way to treat examples like:

(141) a. When John is in the bathtub, he always sings

[17] Thus accomodation carries a heavy burden in determining the distribution of readings involving definites. From the discussion of examples (79) and (80) in Kratzer's paper, she seems to be assuming that the descriptive content of definites is accomodated in the restrictive part of the clause where the definite occurs. How general this is (and how it extends to definites with overt descriptive content) remains to be seen.

b. $\mathbf{every}'(\lambda p\exists o[\mathbf{in\_the\_bathtub}(o)(j) \wedge {}^{\vee}p])(\lambda p\exists o'[R(o)(o') \wedge \mathbf{sing}(o')(j) \wedge {}^{\vee}p])$

c. $\forall o[\mathbf{in\_the\_bathtub}(o)(j) \rightarrow \exists o'[R(o)(o') \wedge \mathbf{sing}(o')(j)]]$

Assuming that there are (existentially quantified) variables over occasions in (141a), its meaning would be as given in (141b). This is equivalent to (141c). I assume that R in (141c) is a context-dependent relation between occasions in terms of which their sequencing is specified. In the case at hand $R(o)(o')$ is understood as something like 'o' overlaps with o'. So (141c) says that every occasion in which John is in the bathtub overlaps with an occasion in which he sings.

So to integrate the present theory with a Davidsonian treatment of space-time locations is straightforward and perhaps desirable. The question now arises as to whether one regards space-time locations uniformely as arguments of every kind of predicate or whether one follows Kratzer in the assumption that stage-level and individual level predicates differ in that respect. In the latter case, one could use the present framework to recast Kratzer's theory. This could lead to an approach that mirrors Kratzer's solutions but where a uniform treatment of NP's would be possible. There are reasons, however, to doubt the ultimate viability of the main aspects of Kratzer's proposals. I will now try to flesh out what they are.

Let us begin by considering Kratzer's treatment of conditionals. It will suffice for my purposes to discuss two cases involving individual-level predicates. Consider the following example (based on Kratzer's (78)):

(142) Usually when a house has a barn, it has another one next to it

This is a sage-plant sentence. The object of the *when*-clause is existentially closed, so we quantify over houses with a barn. The problem is how the second *it* in the main clause is going to be interpreted. As dynamic binding is not available, we have to resort to the E-type strategy. The problem is to do so without imposing too strict uniqueness requirements. We can't resort to quantification over situations as Heim does, for we are dealing with an individual-level predicate. Kratzer proposes that the second it in the main clause is interpreted as a variable and that the relevant descriptive content associated with it is accomodated within the nuclear scope of *usually.* The result of this process will be something like:

(143) $\mathbf{usually}_x[\mathbf{house}(x) \wedge \exists y[\mathbf{barn}(y) \wedge \mathbf{has}(x,y)]]\exists y,z[\mathbf{barn}(z) \wedge \underline{\mathbf{barn}(y) \wedge \mathbf{has}(x,y)} \wedge y \neq z \wedge \mathbf{has}(x,z) \wedge \mathbf{next\_to}(z,y)]]$

The accomodated part is underlined. The result of accomodation is to bring the variable associated with the second occurrence of *it* inside the scope of $\exists$ which existentially closes the VP of the main clause. Thus, y in the nuclear scope will be caught by $\exists$. The truth-conditions one gets as a consequence of this are the weak ones.

There is a question as to how this form of accomodation fits within a general theory of definites. Be that as it may, the point is that (142) is predicted not to have a symmetric reading, for the object of have cannot be scrambled, acording to Kratzer. I believe that this prediction is wrong. While this may be difficult to detect for (142), there are fully parallel examples where this is quite clear. The following illustrates:

(144) If a father has a teenager son, he usually lends him the car on the week-end.

Here quite clearly every pair $\langle x, y\rangle$ where x is a father and y one of x's sons counts for the truth of (141). The logical form that Kratzer's approach would get us is:

(145) $\mathbf{usually}_x[\mathbf{father}(x) \wedge \exists y[\mathbf{teenage\_son}(y) \wedge \mathbf{has}(x,y)]]$
$\exists y[\underline{\mathbf{teenage\_son}(y) \wedge \mathbf{has}(x,y)} \wedge \mathbf{lend\_the\_car\_etc}(x,y)]]$

The underlined part is accomodated as in example (143). The point is that the truth-conditions we get in this case are too weak. According to them, we are comparing the number of fathers with a teenage son, with the number of fathers which lend a car to one of their teenage sons. But this is not right for (144). Imagine a situation with 100 fathers who have three teenage son each. The fathers lend the car only to the major of their sons, never to the unfortunate younger teenagers. In this situation, (144) is intuitively false, while Kratzer's analysis would predict it to be true.

There is a parallel prediction that Kratzer makes which is also, in my opinion, not quite borne out by the facts. When-clauses with verbs like know (which allow for scrambling of their objects) are expected to allow for a subject asymmetric reading (if the object is not scrambled) and for a symmetric reading (if the object is scrambled) but to disallow an object asymmetric reading, for there is no way to lower the subject inside the scope of existential closure. I do not think that this is true in general. Consider the following discourse.

(146) I teach in a department of linguistics where there are students who speak so many foreign languages. And the interesting thing is that when a student of mine speaks a language other than English, rarely he or she learned it in high-school.

I think that the last sentence of the discourse in (146) would be true in the following circumstances. I have 50 students. 30 are native speakers of (or have near native fluence in) languages other than English or French (i.e. one is a native speaker of Yoruba, one of Icelandic, etc.). They all learned French (and only French) in highschool. What makes the relevant sentence of (146) true in this context is that few languages that a student of mine knows where learned in highschool. But this is precisely the object asymmetric reading, which Kratzer claims to be absent. On the other possible readings, it is easy to see that the sentence in question would be false.

This seems to show that Kratzer's treatment of conditionals runs into empirical difficulties. The situation is not any better if we look at relative clause versions. Consider for example:

(147) a. Most men that have a donkey beat it

b. Most men who had a slave also owned its offsprings

In these examples, the donkey-pronouns must be treated as E-type ones, for the possible antecedents are existentially closed. If we accomodate the relevant descriptive content in the nuclear scope of *most* in a way which parallels Kratzer's treatment of example (142), we would only get the weak truth-conditions for (147a,b). The question then is how to get the strong reading that these sentences have. And if we don't resort to accomodation, the question is how to avoid overly strong uniqueness restrictions.

A further problem is created by sentences like the following:

(148) Most women that a fireman loves are blond

Here, the indefinite object of *love* has been extracted. At S-structure, it is ouside of the scope of $\exists$. So this sentence should have at least a reading where *a fireman* stays as a free variable. If *most* is an unselective binder, as in classical *DRT*, then the variable associated with *a fireman* should be caught by *most*, which is the next available operator. So (145) is expected to have a symmetric reading, one which amounts to quantifying over women-firemen pairs, contrary to fact. One can try several ways out. But I see none which is not ad hoc.

There are two further difficulties with Kratzer's approach, which were noticed and discussed by de Hoop and de Swart [17]. The first has to do with sentences like:

(149) a. A fireman I know is altruistic

b. Some firemen are altruistic

These sentences involve indefinites like *a* and *some* (which also supports donkey anaphora —see Heim [13, 73]) in the subject position of an individual-level predicate, where they are clearly interpreted existentially. How is this interpretation going to come about on Kratzer's theory? Since a and some support donkey anaphora (for some, cf., e.g., Heim [13, 73] they must be treated as free variables. But being in the subject position of an individual-level predicate, they are not in the scope of the VP-level existential closure operation. And it is crucial to Kratzer's analysis that there is no discourse-level existential closure. So there seems to be no way on Kratzer's analysis for (149) to get the interpretation they have. Perhaps one could try to argue that *a* and *some* are ambiguous between a free-variable interpretation and one where they are true existentially quantified NP's. But the point is that a theory that can cover the same data without positing such an ambiguity (like the one in the present paper) would appear to be preferable.

The final difficulty for Kratzer's approach I would like to discuss has to do with the following sentences (borrowed from de Hoop and de Swart [17])

(150) a. *When John dies, he is unhappy

b. *When John destroys this house, he destroys it thoroughly

c. *When John kills this rabbit, he kills it cruelly

These sentences are all ungrammatical, just like Kratzer's examples involving individual-level predicates, like:

(151) *When John knows French, he knows it well

Yet all of the predicates in (150) are stage-level. Thus, according to Kratzer they will contain a variable ranging over space-time locations. Hence, the ungrammaticality of (150) cannot be blamed on a constraint against vacuous binding.

Various hypotheses come to mind in this connection. What is it that (150) and (151) have in common? They all characterize situations which in a sense cannot be naturally iterated. This can be seen by the oddity of (152a–d) contrasted with the naturalness of (152e-f):

(152) a. ??John died twice

b. ?? John destroyed this house twice

c. ?? John killed this rabbit twice

d. ?? John knew French twice

e. John was in New York twice

f. John kissed Mary twice

This suggests, as de Hoop and de Swart point out, that *when*-clauses (when they are in construction with adverbs of quantification) dislike eventualities that are not naturally iterable. It can be viewed as a kind of plurality presupposition: for a *when*-clause to be felicitous it must be possible for there to be more than one eventuality of the relevant type satisfying the *when*-clause.

Whether something along these line ultimately works out or not, it is likely to be the case that whatever account for the ungrammaticality of the sentences in (150) will also account for the ungrammaticality of Kratzer's (151). This seems to undermine one of the main argument for treating the stage-level vs. individual-level contrast as a difference in argument structure.

To summarize, it emerges from these considerations that Kratzer's proposal is at the same time too innovative and too conservative with respect to classical *DRT*. It is too innovative in that the existential closure at the VP level undermines too much of the accessibility relation. It leaves too little to dynamic binding and it puts on the E-type strategy a burden that it can't carry without giving rise to serious empirical problems (at least, at our present level of understanding of the E-type strategy). Kratzer's proposal is also too conservative, in that it adheres too closely to the classical DR-theoretic principle that indefinites are free variables, which, as I have tried to argue, is the ultimate source of the proportion problem. As far as I can see, all of the problems considered in this section are handled adequately by the theory presented in this paper.

9 Conclusions

In this paper I have argued for an approach to donkey sentences that assigns them weaker truth-conditions than those that standard *DRT* assigns them. I have also provided some arguments in favour of an approach to anaphora that integrates dynamic binding with the E-type strategy. I have suggested that the stronger truth-conditions that donkey sentences also have are due to the latter pronominalization strategy. Using an extensional version of the dynamic logic investigated by Groenendijk and Stokhof, I have developed a theory of adverbs of quantification which accomodates symmetric and asymmetric readings of *if/when*-clauses. I have also provided a general way to define dynamic determiners in terms of their static counterparts that preserves the conservative character of the latter. Determiners and adverbs of quantification turn out to be closely related, and in fact can be viewed as different instantiations of the same functions. I have argued that this provides an enlightening approach to proportions in quantificational statements. Finally, I have tried to chart out some of the empirical differences with other approaches and indicate where I think the present proposal appears to be more on the right track. All this has been carried through in a set up that limits severely appeals to accomodation or to operations on logical forms that are not independently motivated.

Appendix

I

We want to show the equivalence of (49c) and (50), repeated here:

(49c) $\forall c[\exists x[\mathbf{man}(x) \wedge \mathbf{in\_the\_bathtub}(x) \wedge {}^{\vee}c] \rightarrow \exists x[\mathbf{man}(x) \wedge \mathbf{in\_the\_bathtub}(x) \wedge \mathbf{sing}(x) \wedge {}^{\vee}c]]$

(50) $\forall x[[\mathbf{man}(x) \wedge \mathbf{in\_the\_bathtub}(x)] \rightarrow \mathbf{sing}(x)]$

We do this by computing the truth-conditions of (49c) and showing that they are the same as the truth-conditions of (50). In the computation, I take the liberty of switching from characteristic functions to the corresponding sets, whenever it may facilitate things.

$[\![\forall c[\exists x[\mathbf{man}(x) \wedge \mathbf{in\_the\_bathtub}(x) \wedge {}^{\vee}c] \rightarrow \exists x[\mathbf{man}(x) \wedge \mathbf{in\_the\_bathtub}(x) \wedge \mathbf{sing}(x) \wedge {}^{\vee}c]]]\!]_{g,\omega} = 1$ iff for every singleton $\mathbf{c} \in D_{\langle s,t\rangle}$, $[\![\exists x[\mathbf{man}(x) \wedge \mathbf{in\_the\_bathtub}(x) \wedge {}^{\vee}c] \rightarrow \exists x[\mathbf{man}(x) \wedge \mathbf{in\_the\_bathtub}(x) \wedge \mathbf{sing}(x) \wedge {}^{\vee}c]]\!]_{g[\mathbf{c}/c],\omega} = 1$ (semantics of $\forall$)

iff for every singleton $\mathbf{c} \in D_{\langle s,t\rangle}$, if $[\![\exists x[\mathbf{man}(x) \wedge \mathbf{in\_the\_bathtub}(x) \wedge {}^{\vee}c]]\!]_{g[c/c],\omega} = 1$ then $[\![\exists x[\mathbf{man}(x) \wedge \mathbf{in\_the\_bathtub}(x) \wedge \mathbf{sing}(x) \wedge {}^{\vee}c]]\!]_{g[\mathbf{c}/c],\omega} = 1$ (semantics of $\rightarrow$)

iff for every singleton $\mathbf{c} \in D_{\langle s,t\rangle}$, if for some $u \in U$, $[\![[\mathbf{man}(x) \wedge \mathbf{in\_the\_bathtub}(x) \wedge {}^{\vee}c]]\!]_{g[\mathbf{c}/c],\omega[u/x]} = 1$ then for some $u' \in U[\![[\mathbf{man}(x) \wedge \mathbf{in\_the\_bathtub}(x) \wedge \mathbf{sing}(x) \wedge {}^{\vee}c]]\!]_{g[\mathbf{c}/c],\omega[u'/x]} = 1$ (semantics of $\exists$)

iff for every singleton $\mathbf{c} \in D_{\langle s,t\rangle}$, if for some $u \in U, F(\mathbf{man})(u) = 1$ and

$F(\texttt{in\_the\_bathtub})(u) = 1$ and $\mathbf{c} = \omega[u/x]$, then for some $u' \in U, F(\texttt{man})(u') = 1$ and $F(\texttt{in\_the\_bathtub})(u') = 1$ and $F(\texttt{sing})(u') = 1$ and $\mathbf{c} = \omega[u'/x]$ (semantics of $\wedge$, and semantics of $^\vee$). But this is possible only if $u = u'$. So:

iff for every singleton $\mathbf{c} \in D_{\langle s,t\rangle}$, if for some $u \in U, F(\texttt{man})(u) = 1$ and $F(\texttt{in\_the\_bathtub})(u) = 1$ and $\mathbf{c} = \omega[u/x]$, then for that $u, F(\texttt{man})(u) = 1$ and $F(\texttt{in\_the\_bathtub})(u) = 1$ and $F(\texttt{sing})(u) = 1$ and $c = \omega[u/x]$. But these are essentially the truth-conditions for (50).

II

We compute the translation of

(i) Most men that have a donkey beat it

using the following characterization of the meaning of *most*:

$$\texttt{most}^\circ(A)(B) = \texttt{most}(\lambda u{\downarrow}A(u))(\lambda u[\texttt{every}'(A(u))(B(u))])$$

a. men that have a donkey $\rightsquigarrow \lambda v[\uparrow\texttt{man}(v)\,;\mathcal{E}x[\uparrow\texttt{donkey}(x)\,;\uparrow\texttt{has}(x)(v)]]$

b. beat it $\rightsquigarrow \lambda v[\uparrow\texttt{beat}(x)(v)]$

c. (i) $\rightsquigarrow \texttt{most}^\circ(\lambda v[\uparrow\texttt{man}(v)\,;\mathcal{E}x[\uparrow\texttt{donkey}(x)\,;\uparrow\texttt{has}(x)(v)]])(\lambda v[\uparrow\texttt{beat}(x)(v)])$

reductions:

d. $\texttt{most}(\lambda u{\downarrow}[\lambda v[\uparrow\texttt{man}(v)\,;\mathcal{E}x[\uparrow\texttt{donkey}(x)\,;\uparrow\texttt{has}(x)(v)]](u)])(\lambda u[\texttt{every}'(\lambda v[\uparrow\texttt{man}(v);\mathcal{E}x[\uparrow\texttt{donkey}(x);\uparrow\texttt{has}(x)(v)]](u))(\lambda v[\uparrow\texttt{beat}(x)(v)](u))])$, def. of $\texttt{most}^\circ$

e. $\texttt{most}(\lambda u{\downarrow}[\uparrow\texttt{man}(u)\,;\mathcal{E}x[\uparrow\texttt{donkey}(x)\,;\uparrow\texttt{has}(x)(u)]])(\lambda u[\texttt{every}'([\uparrow\texttt{man}(u)\,;\mathcal{E}x[\uparrow\texttt{donkey}(x)\,;\uparrow\texttt{has}(x)(u)]])(\uparrow\texttt{beat}(x)(u)))$, by λ-reduction

f. $\texttt{most}(\lambda u{\downarrow}[\lambda p[\texttt{man}(u) \wedge \exists x[\texttt{donkey}(x) \wedge \texttt{has}(x)(u) \wedge {}^\vee p]]])(\lambda u[\texttt{every}'(\lambda p[\texttt{man}(u) \wedge \exists x[\texttt{donkey}(x) \wedge \texttt{has}(x)(y) \wedge {}^\vee p]])(\lambda p[\texttt{beat}(x)(u) \wedge {}^\vee p])])$, def. of $\uparrow$ and ;

g. $\texttt{most}(\lambda u[\texttt{man}(u) \wedge \exists x[\texttt{donkey}(x) \wedge \texttt{has}(x)(u)]])(\lambda u[\texttt{every}'(\lambda p[\texttt{man}(u) \wedge \exists x[\texttt{donkey}(x) \wedge \texttt{has}(x)(y) \wedge {}^\vee p]])(\lambda p[\texttt{beat}(x)(u) \wedge {}^\vee p])])$, def. of $\downarrow$

h. $\texttt{most}(\lambda u[\texttt{man}(u) \wedge \exists x[\texttt{donkey}(x) \wedge \texttt{has}(x)(u)]])(\lambda u \forall c[[\texttt{man}(u) \wedge \exists x[\texttt{donkey}(x) \wedge \texttt{has}(x)(u) \wedge {}^\vee c]] \rightarrow [\texttt{man}(u) \wedge \exists x[\texttt{donkey}(x) \wedge \texttt{has}(x)(u) \wedge \texttt{beat}(x)(u) \wedge {}^\vee c]]])$, def. of $\texttt{every}'$

i. $\texttt{most}(\lambda u[\texttt{man}(u) \wedge \exists x[\texttt{donkey}(x) \wedge \texttt{has}(x)(u)]])(\lambda u \forall x[[\texttt{man}(u) \wedge \texttt{donkey}(x) \wedge \texttt{has}(x)(u)] \rightarrow \texttt{beat}(x)(u)])$, equivalence in appendix I.

III

We compute the denotation of (81) and show that it comes out equivalent to (i).

(81) When Mary lends a book to A STUDENT, he usually returns it with insightful comments (while if she lends them tapes, they don't know what to say)

((i)) Most books that are lent by Mary to a student are returned by him with insightful comments.

a. Mary lends a book to a student $\rightsquigarrow$
$\lambda p \exists x \exists y[\texttt{book}(x) \wedge \texttt{student}(y) \wedge \texttt{lend}(y)(x)(m) \wedge {}^\vee p]$

b. he returns it with insightful comments $\rightsquigarrow$
$\lambda p[\texttt{return\_with}(x)(y) \wedge {}^\vee p]$

c. When Mary lends a book to A STUDENT, he usually returns it with insightful comments $\rightsquigarrow$
$\texttt{most}_x(\lambda p \exists x \exists y[\texttt{book}(x) \wedge \texttt{student}(y) \wedge \texttt{lend}(y)(x)(m) \wedge {}^\vee p])(\lambda p[\texttt{return\_with}(x)(y) \wedge {}^\vee p])$

Reductions:

d. $\mathtt{most}''(\lambda u[_x \lambda p \exists x \exists y[\mathtt{book}(x) \wedge \mathtt{student}(y) \wedge \mathtt{lend}(y)(x)(m) \wedge {}^{\vee}p]])(\lambda u[_x \lambda p[$ $\mathtt{return\_with}(x)(y) \wedge {}^{\vee}p]])$, definition of $\mathtt{most}_n$

e. $\mathtt{most}''(\lambda u[\lambda p \exists x \exists y[\mathtt{book}(x) \wedge \mathtt{student}(y) \wedge \mathtt{lend}(y)(x)(m) \wedge {}^{\vee}p]\,;\uparrow u = x])(\lambda u[$ $\lambda p[\mathtt{return\_with}(x)(y) \wedge {}^{\vee}p]\,;\uparrow u = x])$, def. of $\lambda u[_n A]$

f. $\mathtt{most}''(\lambda u \lambda p \exists x \exists y[\mathtt{book}(x) \wedge \mathtt{student}(y) \wedge \mathtt{lend}(y)(x)(m) \wedge u = x \wedge {}^{\vee}p])(\lambda u$ $\lambda p[\mathtt{return\_with}(x)(y) \wedge u = x \wedge {}^{\vee}p])$, def. of $\uparrow$ and ;

g. $\mathtt{most}''(\lambda u \lambda p \exists y[\mathtt{book}(u) \wedge \mathtt{student}(y) \wedge \mathtt{lend}(y)(u)(m) \wedge {}^{\vee}p])(\lambda u \lambda p[$ $\mathtt{return\_with}(u)(y) \wedge {}^{\vee}p])$, tautological transformations

Let us assume that $\mathtt{most}''$ is set to $\mathtt{most}^{\circ}$. Then we get:

h. $\mathtt{most}^{\circ}(\lambda u \lambda p \exists y[\mathtt{book}(u) \wedge \mathtt{student}(y) \wedge \mathtt{lend}(y)(u)(m) \wedge {}^{\vee}p])(\lambda u \lambda p[$ $\mathtt{return\_with}(u)(y) \wedge {}^{\vee}p])$

i. $\mathtt{most}(\lambda u \exists y[\mathtt{book}(u) \wedge \mathtt{student}(y) \wedge \mathtt{lend}(y)(u)(m)])(\lambda u \forall y[[\mathtt{book}(u) \wedge$ $\mathtt{student}(y) \wedge \mathtt{lend}(y)(u)(m)] \rightarrow \mathtt{return\_with}(u)(y)])$, results in appendix II.

Using instead $\mathtt{most}^{+}$, we would have obtained:

$\mathtt{most}(\lambda v[\mathtt{book}(v) \wedge \exists y[\mathtt{student}(y) \wedge \mathtt{lend}(y)(v)(m)]])(\lambda v[\mathtt{book}(v) \wedge \exists y[$ $\mathtt{student}(y) \wedge \mathtt{lend}(y)(v)(m) \wedge \mathtt{return}(v)(y)]])$

IV

Conservativity. We want to show that if a dynamic determiner D^{+} is defined as follows

(78) a. $D^{+}(A)(B) = D(\lambda u{\downarrow}A(u))(\lambda u{\downarrow}[A(u)\,;B(u)])$

it satisfies dynamic conservativity, where dynamic conservativity is defined as follows

(89) $D'(A)(B) = D'(A)(A\,;B)$, where $A\,;B = \lambda u[A(u)\,;B(u)]$

We assume that the free variables in A are disjoint from the set of active quantifiers in A (see Groenendijk and Stokhof [11] for a general discussion of this restriction).

We start by noticing that if A meets the constraint just mentioned, the following holds:

(i) $A = A\,;A$ (Groenendijk and Stokhof [11]

Given (i), all the following formulae are equivalent

a. $D^{+}(A)(A\,;B)$
b. $D^{+}(A)(\lambda v[A(v)\,;B(v)])$, def. of $A\,;B$ and alphabetic change
c. $D(\lambda u{\downarrow}A(u))(\lambda u{\downarrow}[A(u)\,;\lambda v[A(v)\,;B(v)](u)])$, by (78a)
d. $D(\lambda u{\downarrow}A(u))(\lambda u{\downarrow}[A(u)\,;[A(u)\,;B(u)]])$, λ-reduction
e. $D(\lambda u{\downarrow}A(u))(\lambda u{\downarrow}[A(u)\,;A(u)\,;B(u)]])$, associativity of ;
f. $D(\lambda u{\downarrow}A(u))(\lambda u{\downarrow}[A(u)\,;B(u)])$, by (i)
g. $D^{+}(A)(B)$ by (78a)

This establishes the result.

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