TOPICS IN DYNAMIC SEMANTICS

Gerhard Jäger

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Chapter One:
Introduction

This dissertation deals with several phenomena usually subsumed under the category of (in)definiteness. There are nearly as many proposals on how to describe this category semantically as there are semantic frameworks. In traditional truth-conditional semantics from Russell to Montague, it is assumed that indefinites express an existential statement, while definites carry additionally some uniqueness requirement. More recent approaches like Discourse Representation Theory (Kamp['81], Kamp & Reyle['93]) or File Change Semantics (Heim['82]) prefer to assume that definites and indefinites perform different actions on some discourse model. As a common integrator, most influential semantic frameworks consider definiteness to be a central issue of semantic theory.

One might wonder whether this dichotomy is really that important after all. There are a considerable number of languages that do well without any marking of definiteness, and even in languages such as English and German, where the contrast is expressed morphologically, it is highly redundant. (I was once told a very illuminating story[1]about a Japanese woman living in Germany who knew German superficially very well. She never used any articles. Her German colleagues not only failed to miss them, they even failed to notice it at all.)

Of course the communicative redundancy of definiteness does not suffice to prove its theoretical marginality. There are quite many widespread phenomena in different languages that are *prima facie* related to definiteness. They are usually covered with the notion of "Definiteness Effect". We do not intend to investigate these systematically here, but it is questionable whether this term is really appropriate. As an example, the most prominent instance, English *there*-constructions, is obviously not related to definiteness at all.

(1) a. There is only John in the garden.
 b. There was the biggest car I've ever seen in front of his house. (Chris Wilder, p.c.)

I am not aware of any definition of indefiniteness that covers *only John* or *the biggest car I've ever seen*. Whatever the category is the coda of *there*-sentences is sensitive for, it is not definiteness.

Similar considrations arise when we consider scrambling in German[2], another alleged

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[1]by Manfred Pinkal (p.c.)

[2]To be precise, there are (at least) two kinds of scrambling in German. One is very similar to I-topicalization, i.e. the scrambled item receives a heavy rising accent, and if scope-bearing items are involved, we have an inverted interpretation. All kinds of maximal projections, including remnant VPs can be affected by

(continued...)

instance of the Definiteness Effect. Several authors (Lenerz['77], Reis['87], and, more recently, Büring['94]) have proposed that in German, the surface position of arguments inside or outside VP is largely determined by definiteness. Provided that no focus- or animacy-effects intervene, definite subjects and objects have to occur in a VP-external position, while indefinites remain *in situ*. Most data support this view.

(2) a. Peter hat gestern ein Buch gekauft.
Peter has yesterday a book bought
b. ???Peter hat ein Buch gestern gekauft
Peter has a book yesterday bought
'Yesterday, Peter bought a book'
(3) a. ???Peter hat gestern das Buch gekauft.
Peter has yesterday the book bought
b. Peter hat das Buch gestern gekauft
Peter has the book yesterday bought
'Peter bought the book yesterday'

If we assume that the adverb *gestern* 'yesterday' marks the VP-boundary, the indefinite object is preferred in the VP-internal position and the definite one in the VP-external position. Nevertheless, there are counterexamples. Name-like definites like *die Bibel* 'the Bible' are allowed in both positions equally well, and specific indefinites occur in scrambled positions.

(4) a. Peter hat gestern die Bibel gekauft.
Peter has yesterday the Bible bought
b. Peter hat die Bibel gestern gekauft
Peter has the Bible yesterday bought
'Yesterday, Peter bought the Bible'
(5) a. Hans hat einen bestimmten Studenten noch nie gesehen.

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[2](...continued)
this process.

(i) (weil) das [$_{AP}$ FREIwillig]$_i$ / NIEmand \ t$_i$ tun würde
(since) this voluntarily nobody do would
'Since nobody would do this voluntarily'
(ii) weil mit SIcherheit$_i$ / NIEmand \ t$_i$ die Wahrheit kennt
since with security nobody the truth knows
'Since nobody knows the truth for sure'

We are only interested in the second kind of scrambling which is restricted to DPs and some PPs, involves only deaccentuation of the scrambled item and does not give rise to scope inversion.

Hans has a certain student still never seen

b. *Hans hat noch nie einen bestimmten Studenten gesehen.

Hans has still never a certain student seen

'There is a certain student that Hans never saw'

As it turns out, there are other factors scrambling is sensitive to that usually coincide with definiteness, but sometimes the distinctions are orthogonal to each other. There is a lot of recent crosslinguistic work that shows that this property of scrambling is not a pure idiosyncrasy of German. Comparable observations can be made for Dutch (de Hoop['93]) and - more unexpectedly - Cashmerese (Rajesh Bhatt, p.c.). Meinunger['95] shows convincingly that for instance case alternation phenomena in Finnish and Russian and clitic doubling in Romance and Bantu-languages should be treated on a par with scrambling. This enables us to assume that there is another dichotomy besides (in)definiteness that is responsible for the mentioned contrasts. I decided to call those items that are marked by scrambling/ structural case/ clitic doubling **Topic**, but the nomenclature is of minor importance. Probably, there is a kind of feature specification default that requires definites to be Topics and indefinites to be non-Topics, but there are exceptions in both directions. It is very likely that the category Topic is universally present, while there is no need to assume that languages that do not express definiteness morphologically have that category at all.

The aim of this dissertation is to give an explicit formal specification of the semantic impact of the category "Topic". In order to do so, we review three representative semantic frameworks in chapter two. We start with a brief overview on basic ideas of Montague Semantics, pointing out in particular its shortcomings in connection with anaphora phenomena. Subsequently, the main ideas of Irene Heim's['82] File Change Semantics are presented in more detail, and that model is compared with Montague Semantics both w.r.t. the empirical predictions and the methodology. We will come to the conclusion that File Change Semantics is very successful as far as the empirical coverage is concerned, but that Montague Semantics is much more restrictive methodologically. Therefore, finally, a synthesis of both, called **Dynamic Extensional Type Theory** (DETT), is developed that owes its design to Groenendijk & Stokhof's['91a] Dynamic Montague Grammar. Apart from the frameworks mentioned, DETT borrows important features from Dekker's['93] Extensional Dynamic Predicate Logic.

In chapter three, we seek to extend the coverage of DETT to definite descriptions. It is argued that this is impossible without taking the category Topic into account. To describe the semantics of Topics, a formalism more powerful than DETT is needed. In particular, the twofold distinction between novel and familiar discourse referents proves to be not finegrained enough. Intuitively, we have to distinguish (at least) two layers of discourse referents. Similar ideas - figuring under the headers "Centering" or "Focus" - are already quite common in computational linguistics (cf. Grosz/Joshi/Weinstein['83], Grosz & Sidner['86], Bosch['88] among many others). Nevertheless, this dissertation is to my knowledge the first attempt to elaborate on these insights in a compositional model of natural language semantics. As starting point, Groenendijk/Stokhof/Veltman's['93, '94] Dynamic Modal Predicate Logic is used. Its main features are incorporated into the overall architecture of DETT. The resulting system is called **Dynamic Intensional Type Theory** (DITT). DITT provides an adequate formal tool to define a template that shifts the meanings of determiners heading non-Topic DPs to the meanings of the corresponding Topics. This allows us to give a unique semantics of the definite determiner that covers a wide variety of apparently unrelated readings of this item.

In chapter four, the influence of the Topic-template on indefinite DPs is investigated. It is shown that it offers a basis for a unified account of widely discussed phenomena like the partitive readings of weak quantifiers and the proportion problem in connection with donkey conditionals.

Chapter Two:
The Dynamic Framework

2.1 Donkey Sentences and Cross-sentential Anaphora

In the early 1980's, the Montagovian approach to natural language semantics was challenged by two observations concerning anaphora. The first - and in fact the crucial one - concerns the so-called donkey sentences[1]:

(1) Every farmer who owns a donkey$_i$ beats it$_i$.
(2) If a farmer$_i$ owns a donkey$_j$, he$_i$ beats it$_j$.

The compositional translation of these sentences into Predicate Logic in the spirit of Montague gives us (ignoring intensionality for the moment)

(3) $\forall x[\mathbf{farmer'}(x) \wedge \exists y[\mathbf{donkey'}(y) \wedge \mathbf{own'}(x,y)] \rightarrow \mathbf{beat'}(x,y)]$
(4) $\exists x[\mathbf{farmer'}(x) \wedge \exists y[\mathbf{donkey'}(y) \wedge \mathbf{own'}(x,y)]] \rightarrow \mathbf{beat'}(x,y)$

which is obviously not the desired result. The important features which matter for our purposes are that the indefinite determiner is translated as an existential quantifier and that the anaphoric pronouns are translated as variables. The problem in both cases is that the variable "y" in the consequence of the implication is free. Hence, according to a standard first order equivalence, we can rename the bound occurrences of "y" with "z" leaving the free occurrences unaffected, without changing the meaning of the entire formula:

(5) $\forall x[\mathbf{farmer'}(x) \wedge \exists z[\mathbf{donkey'}(z) \wedge \mathbf{own'}(x,z)] \rightarrow \mathbf{beat'}(x,y)]$
(6) $\exists x[\mathbf{farmer'}(x) \wedge \exists z[\mathbf{donkey'}(z) \wedge \mathbf{own'}(x,z)]] \rightarrow \mathbf{beat'}(x,y)$

Neither of these formulae allow the conclusion that there is a donkey which is beaten if a farmer owns it.

(7) $\forall x[\mathbf{farmer'}(x) \wedge \exists z[\mathbf{donkey'}(z) \wedge \mathbf{own'}(x,z)] \rightarrow \mathbf{beat'}(x,y)] \not\models$
$\forall x[\mathbf{farmer'}(x) \wedge \exists y[\mathbf{donkey'}(y) \wedge \mathbf{own'}(x,y)] \rightarrow \mathbf{beat'}(x,y) \wedge \mathbf{donkey'}(y)]$
(8) $\exists x[\mathbf{farmer'}(x) \wedge \exists z[\mathbf{donkey'}(z) \wedge \mathbf{own'}(x,z)]] \rightarrow \mathbf{beat'}(x,y) \not\models$

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[1]Donkey sentences were discussed already in Geach['62], and the discussion about this kind of construction may be traced back even to ancient philosophy, but they only became a central point of semantic theory in the last 15 years.

$$\exists x[\mathbf{farmer'}(x) \wedge \exists z[\mathbf{donkey'}(z) \wedge \mathbf{own'}(x,z)]] \rightarrow \mathbf{beat'}(x,y) \wedge \mathbf{donkey'}(y)$$

An intuitively correct translation of both (1) and (2) would be

(9) $\forall x \forall y[\mathbf{farmer'}(x) \wedge \mathbf{donkey'}(y) \wedge \mathbf{own'}(x,y) \rightarrow \mathbf{beat'}(x,y)]$

at least for one reading of the examples. The crucial problem here is that the indefinites *a donkey* in (1) and both *a farmer* and *a donkey* in (2), which have syntactically narrow scope, seem to have universal force and global scope, i.e. they appear as universal quantifiers with scope over the entire formula in (9). That these occurrences of indefinites are somehow "ill-behaved", and that the Russellian treatment of the indefinite determiner as an existential quantifier is descriptively adequate in the "well-behaved" cases, is beyond any reasonable doubt.

(10) A man is in the park

correctly translates to

(11) $\exists x[\mathbf{man'}(x) \wedge \mathbf{in\_the\_park'}(x)]$

The enlargement of the scope of indefinites is not bound to the ill-behaved constructions just discussed. This leads us to the second weakness of the Montagovian treatment of anaphora.

(12) A man_i is in the park and he_i whistles
(13) $\exists x[\mathbf{man'}(x) \wedge \mathbf{in\_the\_park'}(x)] \wedge \mathbf{whistle'}(x)$

Here again the coreference between the indefinite *a man* and the pronoun *he* is not expressed since the pronoun *he* is outside the c-command domain of the indefinite *a man* and hence outside of the scope of the corresponding existential quantifier. While this problem can be solved by means of quantifying in, things become hopeless when we take a two-sentence discourse instead of a conjunction.

(14) A man_i is in the park. He_i whistles

The translation of (14) we are looking for should be equivalent to

(15) $\exists x[\mathbf{man'}(x) \wedge \mathbf{in\_the\_park'}(x) \wedge \mathbf{whistle'}(x)]$[2]

[2]Kadmon['87] objects that this way of interpreting cross-sentential anaphora makes wrong predictions:
(i) John owns sheep_i. Harry vaccinates them_i.

(continued...)

To see how different semantic approaches overcome this problem, we have to look at the overall architecture of Montagovian semantics.

2.2 Montague Semantics and File Change Semantics: A Comparison

2.2.1 Montague Semantics: The General Picture

In his paper "The Proper Treatment of Quantification in Ordinary English", Richard Montague proposes a three-step model theoretic interpretation of English sentences. In a first step, an English sentence is mapped to an expression of an artificial language called "Disambiguated English" (DE). Roughly, an expression of that language is a syntactic tree where quantifier scope and coreference are encoded. In terms of GB-syntax, an expression of DE is something halfway between S-structure and LF. We will return to that point later.

English

$\Downarrow$ ***Disambiguation*** $\Downarrow$

Disambiguated English

$\Downarrow$ ***Translation*** $\Downarrow$

Intensional Logic

$\Downarrow$ ***(model theoretic) Interpretation*** $\Downarrow$

Meaning

In a second step, DE-expressions are translated into formulae of a type-theoretic calculus

[2](...continued)
(ii) $\exists x[\mathbf{sheep'}(x) \wedge \mathbf{own'}(\mathbf{j},x) \wedge \mathbf{vaccinate'}(\mathbf{h},x)]$
Imagine a situation where John owns ten sheep and Harry vaccinates five of them. In this situation, (ii) would be true while (i) is false or at least infelicitous. In Dekker['90], a possible solution to this puzzle in a dynamic bound-variable approach is sketched.

called "Intensional Logic" (IL). This translation function is subject to a very rigid compositionality requirement. It can be formulated as the

Principle of Compositionality of Translation

A compositional translation L_1 to L_2 must meet the following conditions:

i) Every basic expression of L_1 has a unique translation in L_2 (which need not be basic).
ii) For every syntactic category c_1 of L_1, there is a unique syntactic category c_2 from L_2 such that all L_1-expressions of the category c_1 are translated to L_2-expressions of the category c_2.
iii) For every syntactic rule of L_1 there is a unique translation rule which specifies the translation of the output of the syntactic rule solely in terms of the translations of the input(s) to it.

The underlying idea of this principle is that the translation of a complex expression is completely determined by the translations of its parts and the way they are combined.

Turning back to the phenomena we discussed above, we are especially interested in the translations of the indefinite determiner, of the determiner *every*, of pronouns and of the conditional construction. As already mentioned, the core of the analysis of indefinites is the Russellian existential quantifier, while *every* becomes a universal quantifier. Since determiners are generally translated as two-place second-order predicates, we have:

(16) a ==> $\lambda P \lambda Q.\exists x[P(x) \wedge Q(x)]$[3]
every ==> $\lambda P \lambda Q.\forall x[P(x) \rightarrow Q(x)]$

The translation of a pronoun is simply a variable. For technical reasons, it is shifted to a Generalized Quantifier, which practically makes no difference.

(17) he ==> $\lambda P.P(x)$

Finally, *if*-conditionals are translated as material implication:

(18) If p, q ==> $p' \rightarrow q'$ (where p' and q' are the translations of p and q respectively)

The final step, the interpretation of IL formulae, follows an equally strong compositionality requirement.

[3]For our purposes here, an extensionalized version of IL suffices.

Principle of Compositionality of Interpretation

Given a language L, a compositional interpretation function $\|.\|$ for L must meet the following conditions:

i) $\|.\|$ assigns a unique value to every basic expression of L (the nonlogical vocabulary in the case of a formal language of logic)

ii) For every syntactic rule of L, there is a unique corresponding semantic rule which determines the interpretation of the output of the syntactic rule solely in terms of its input.

iii) For any two expressions a and b of L which belong to the same syntactic category, $\|a\|$ and $\|b\|$ belong to the same class of semantic objects.

This principle is a specification of the well-known Fregean principle: "The interpretation of a complex expression is exclusively determined by the interpretation of its parts and the way they are combined". "Classes of semantic objects" in the sense of (iii) are for instance sets, 1-place functions, 3-place relations etc.

Of course, we are primarily interested in natural language semantics and not in the semantics of IL or any other formal language. The motivation behind the system described is the fact that translation and interpretation can be combined. If we call the translation function from DE to IL F, we can construct a composed function $[\![.]\!]$ which assigns a model-theoretic interpretation to any DE-expression S such that $[\![S]\!] = \|F(S)\|$. It can be shown that the compositionality of the translation function F and of the IL-interpretation function $\|.\|$ suffice to ensure that the DE-interpretation function $[\![.]\!]$ is compositional too. IL in fact plays only an auxiliary role in the PTQ-system. It is introduced just for convenience since it is easier to deal with logical formulae than with complex model-theoretic entities.

The interpretations of the English items we are interested in can now be identified with the interpretation of the extensionalized IL-expressions given above. But there is an apparent problem. $\|.\|$, the interpretation function of IL, is relativized to an assignment function g which is a total function from the set of IL-variables to the individual domain E of the model. Since variables are IL-artifacts, we cannot use such a function for the direct interpretation of DE. One way to overcome this difficulty, which makes the comparison of the described system with File Change Semantics easier, runs as follows. In the input to the interpretation, namely DE, we need some representation of coreference relations between DPs, including pronouns. In the syntactic literature, referential indices usually do that job. We adopt this technique and annotate each DP with some natural number subscript. In the course of IL-translation, indices control the choice of IL-variables (this can be done by an easily formulated algorithm). Similarly to assignment functions, we now define:

Definition 2.1 Sequences
A **sequence** a_N is a total function from the set of natural numbers into the individual domain A. A^N is the set of all sequences based on the Domain A.
$a_i =_{def} a_N(i)$

For typographic reasons, I sometimes only write "a" instead of "a_N" in cases where no confusion can arise. So we can relativize the direct interpretation of DE to sequences. Under this perspective, the interpretations of the relevant items are:

(19) a. $[\![a]\!]_a = \{<A,B>|\ A,B \subseteq E \wedge A \cap B \neq \emptyset\}$
b. $[\![every]\!]_a = \{<A,B>|\ A,B \subseteq E \wedge A \subseteq B\}$
c. $[\![he_i]\!]_a = \{A \subseteq E|\ a_i \in A\}$
d. $[\![\text{ If p, q}]\!]_a = \max((1-[\![p]\!]_a),[\![q]\!]_a)$

The d-clause is simply the meaning of material implication if we take the truth values 0 and 1 as the possible meanings of sentences. We may even go a step further and identify the meaning of a sentence with the set of sequences under which it has the value 1. Instead of (19d), we have:

(20) $[\![\text{ If p, q}]\!] = A^N \backslash ([\![p]\!] \backslash [\![q]\!])$

Let us briefly illustrate this with some examples.

(21) $[\![$A man$_1$ walks$]\!] = A^N$ iff there is some individual in E which falls both under the extension of *man* and *walk*, else Ø

(22) $[\![$Every man$_1$ walks$]\!] = A^N$ iff the extension of *man* is an improper subset of the extension of *walk*, else Ø

(23) $[\![$He$_1$ is a man$]\!] = \{a_N|\ a_1$ falls under the extension of *man*$\}$

As can be seen from these examples, the interpretation of a sentence depends on the sequence only if the sentence contains a "free" occurrence of a pronoun, i.e. a pronoun which is not bound by any quantificational expression. Otherwise the sentence is interpreted either as the whole set of possible sequences (i.e. the sentence is true) or the empty set (i.e. it is false).

With this background, we are able to concretize the shortcomings of this approach to interpretation w.r.t. donkey anaphora.

(24) $[\![$Every farmer$_1$ who owns a donkey$_2$ beats it$_2]\!] = \{a_N|\ a_2$ is beaten by every

donkey-owning farmer}

(25) ⟦If a farmer$_1$ owns a donkey$_2$, he$_1$ beats it$_1$⟧ = A^N iff there is no farmer who owns a donkey, {a_N| a_1 stands in the beating-relation to a_2} else

These interpretations are obviously nonsense. At least they have nothing in common with the intuitive interpretation of the sentences: rather, they are the interpretations we would wish to obtain for (26) and (27):

(26) Every farmer$_3$ who owns a donkey$_4$ beats it$_2$.
(27) If a farmer$_3$ owns a donkey$_4$, he$_1$ beats it$_2$.

There is no way to link the indices of the anaphoric pronouns in the examples to those of preceding quantificational expressions.

2.2.2 File Change Semantics: An Overview

2.2.2.1 The Strategy

There are several ways to deal with phenomena of this kind. Hans Kamp['81] developed a completely new framework for natural language interpretation called **Discourse Representation Theory** (DRT). It is difficult to compare DRT with Montague semantics (MS) since it does away with compositionality in the sense described. Certain linguistic items above, such as determiners, do not have a meaning of their own. Rather, they govern the application of certain construction rules. Roughly at the same time, Irene Heim['82] developed her **File Change Semantics** (FCS), which is very similar to DRT as far as the underlying strategy is concerned, but which is closer to MS and preserves some notion of compositionality.

In principle, there are three options for revising Montague's system. It is possible (a) to modify the mapping from English sentences to disambiguated expressions, (b) to change the translation procedure from the disambiguated expressions to a logical formalism or (c) to give another interpretation to Montague's IL-language. In a sense, Heim exploits all three options simultaneously. As far as the constructions discussed above are concerned, disambiguation only means to give a syntactic structure to the sentence and to index DPs. For all practical purposes, the disambiguated sentence can be identified with the S-structure in terms of GB-theory. Heim assumes that the input to interpretation differs substantially from S-structure, and in fact a great deal of her theory concerns disambiguation rather than interpretation. She borrows the term "Logical Form" (LF) for her version of Disambiguated English from the GB-literature, but it is actually a hybrid between a syntactic structure and a logical language. To put it another way round, Montague's disambiguation is enriched with devices which are part of the translation function in the original system. Heim's LF representations are interpreted directly, without a further mediating level. This interpretation is compositional in the weak sense of the Fregean Principle ("The meaning of a complex expression is a function of the meaning of its parts and the way they are combined"), but it is hard to say whether or not it follows the stronger Principle of Compositionality of Interpretation. We will address this question below.

Besides collapsing Montague's Disambiguated English and the logical language into one level (LF), Heim makes another move away from traditional approaches, which is probably the most important aspect of her work. Instead of defining the meaning of an English sentence in terms of its truth-conditions, she takes it to be something like a program, an instruction to perform some action. Such a program is called a **File Change Potential** (FCP). The basic idea is that the conversational background of the conversants can be seen as a kind of file. Such a file contains a file card for every individual that was mentioned in the discourse or can be assumed to be in the attention of all participants of a conversation. On a file card, the information about the individual it represents is written down. An FCP is (or defines) a modification of a file, namely th addition of new file cards or of entries on the cards. Truth and falsehood are basically properties of files, and truth of an FCP can be defined as the ability to turn a true file into another true file. Let us take an example:

(28) A dog is barking.

Interpreting this sentence means to perform three steps:

a) Add a new card to your file,
b) write "is a dog" on that card
c) write "is barking" on that card.

2.2.2.2 Files

Now let us start implementing this idea. Of course, talking about files can only be meant metaphorically. The ontology of FCS is basically the same as in traditional "static" approaches, namely it contains truth values, possible worlds and individuals as primitive entities. As we did in the discussion of MS, we ignore possible worlds for the moment. The file cards in the metaphor are defined as natural numbers. Hence the definition of a file must contain a finite set of natural numbers, which is called the **domain of a file**. The entries of the cards do not have a straightforward counterpart in the formal definition, since *is a dog* or *is barking* in the example are linguistic entities which cannot enter the model theoretic construction which the metaphor "file" stands for.

A file is something which can be true or false. It shares this property with the meaning of a sentence in Montague's system. Hence files contain the same kind of semantic objects which are the "static" meaning of a sentence. In the modified version which was presented above, this was identified with a set of sequences, the **satisfaction set of a file** in the FCS-terminology. This leads us to the

Definition 2.2 Files

i) A **file** F is an ordered pair <D,S>, where D is a finite set of natural numbers and S is a set of sequences, such that for every natural number $n \notin D$:
if a_N and b_N are two sequences that are alike except insofar as $a_n \neq b_n$,
then $a_N \in S$ iff $b_N \in S$.

ii) Dom(<D,S>) $=_{def}$ D

iii) Sat(<D,S>) $=_{def}$ S

This definition ensures that F contains only information about the indices in its domain.

2.2.2.3 LF-Construal

Before we can start to define FCPs recursively, we have to consider the way an S-structure is mapped to an LF. There are four operations called

(29) **LF-Construal Rules**:

i) DP-Indexing[4]:
Assign every DP a referential index

ii) DP-Prefixing:
Adjoin every non-pronominal DP to S

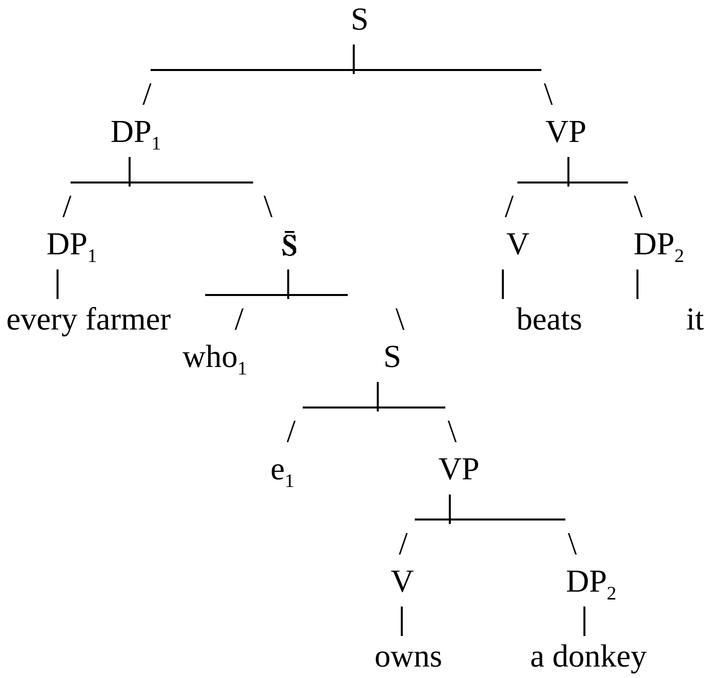
iii) Operator Construal:
Attach every operator as a leftmost immediate constituent of S

iv) □-Construal:
Attach □ as a leftmost immediate constituent of the matrix-S of a bare *If*-conditional

The fourth rule is not stated explicitly in Heim's thesis, but something like that is implicitly assumed. Let me illustrate the effects of these rules with the notorious donkey sentences. Input to the rules is S-structure. Since under standard assumptions this level of representation already provides referential indices, DP-Indexing is superfluous. Hence we start with the structure

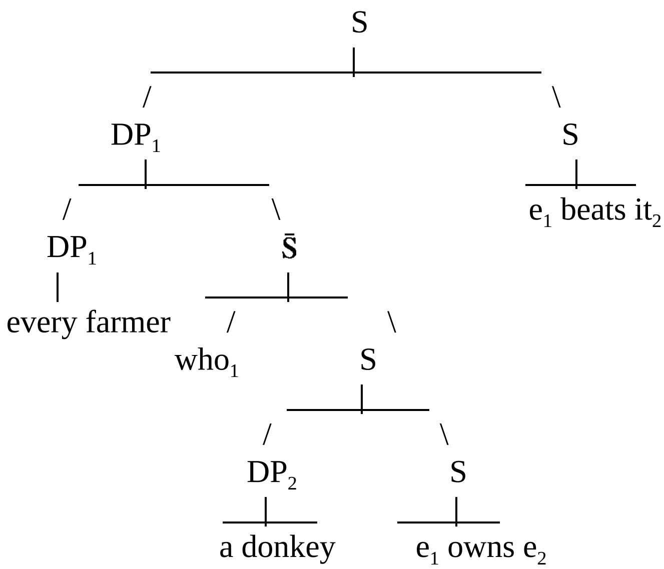
[4]"NP-Indexing" in Heim['82]. I update the terminology to current linguistic jargon.

(30)



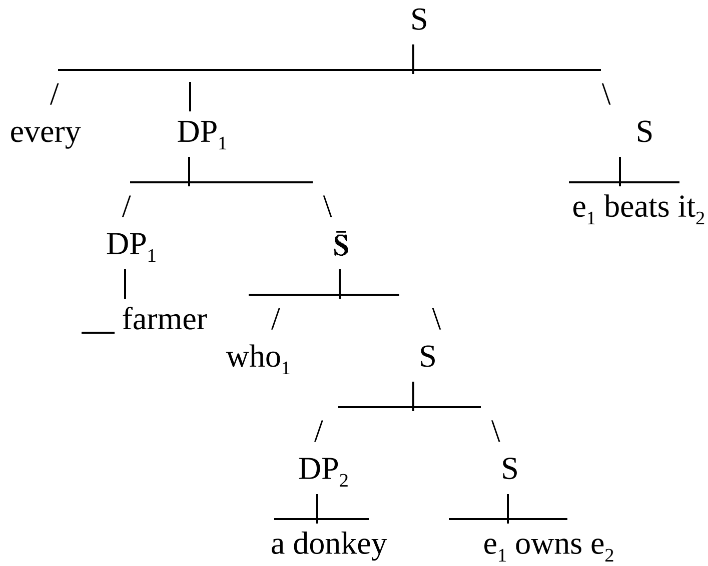
The reader should not be confused by the old-fashioned labelling of the nodes; you may replace "S" by "IP" or "AgrP" and "S̄" by "CP" if you want. After performing DP-Prefixing, we have

(31)



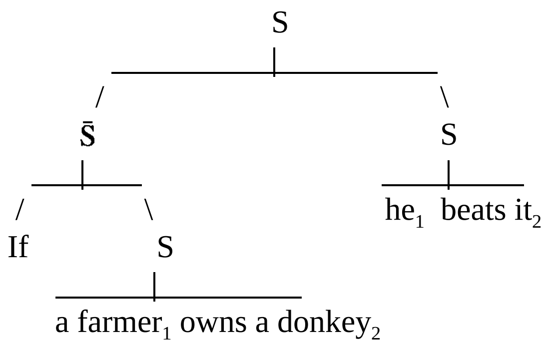
Both DP$_1$ and DP$_2$ are raised and adjoined to the S-node they were dominated by. I do not spell out the internal structure of the remnant S, since it does not matter for the further discussion. Finally, Operator-Construal applies. The only operator is *every* in DP$_1$.

(32)

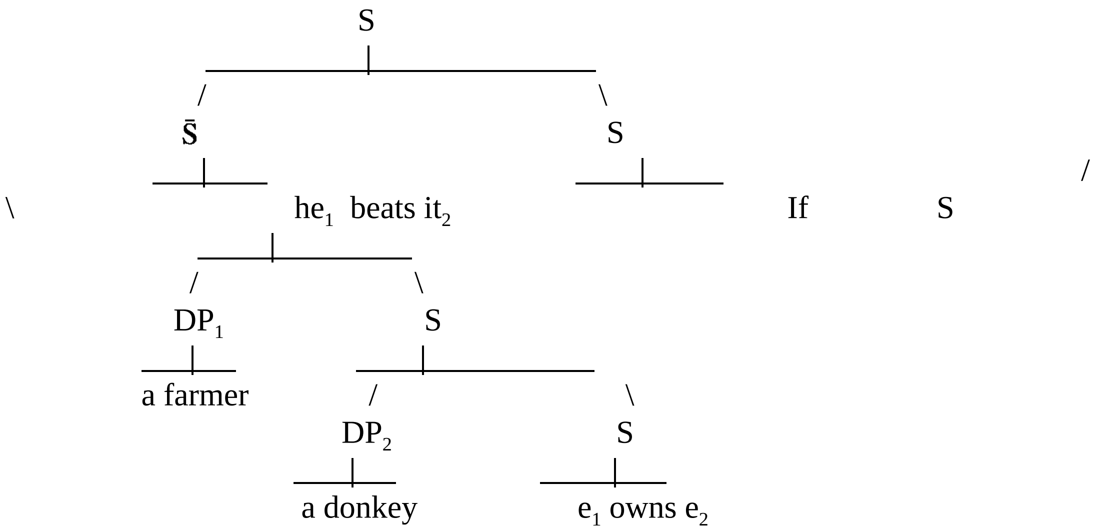


The LF-Construal of *If a farmer owns a donkey, he beats it* goes as follows:

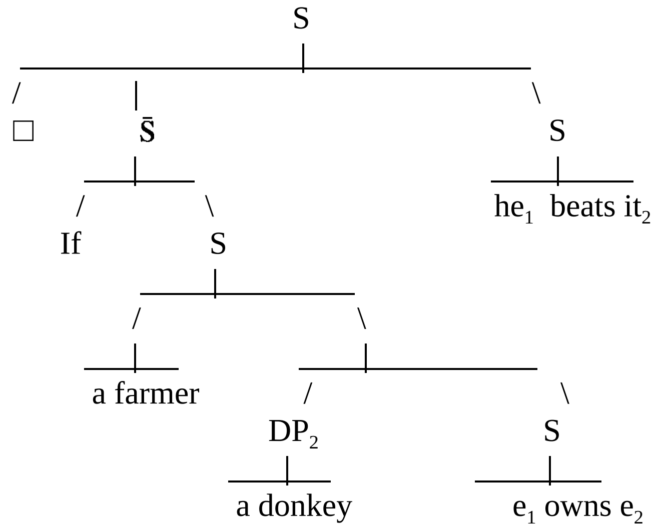
(33)



(34) <u>DP-Prefixing:</u>



(35) □-<u>Construal</u>

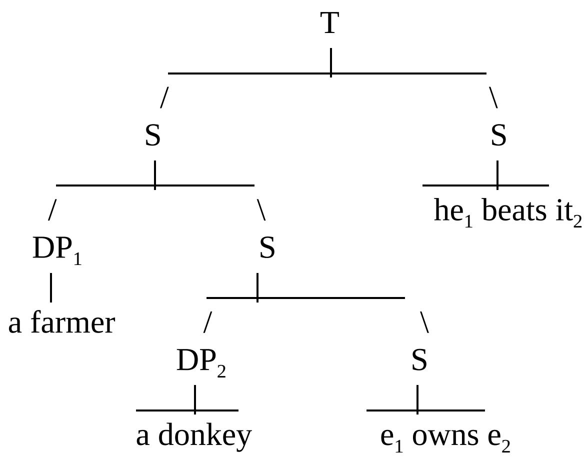


To deal with cross-sentential anaphora, Heim assumes that all the matrix S-nodes of a discourse are daughters of a hypothetical text-node T.

(36) A farmer owns a donkey. He beats it.

is mapped to the LF:

(37)



Before defining the interpretation of LFs, some further terminology has to be introduced. Both NPs and verbs are called **predicates**, as it is standard in logical semantics. An NP or an intransitive verb is a **1-place predicate**, transitive verbs are **2-place predicates** etc. Pronouns and DP-traces are **variables**, which bear a unique index. In the following definition, I slightly depart from Heim's original proposal, but the general line remains the same. Firstly, I assume that quantificational determiners like *every* leave a trace when they are moved by operator construal. The index of this trace is simply identical to the index of the dominating

DP-node. Secondly, definite and indefinite determiners should inherit the index of the DP they are the head of. Quantifier traces and (in-)definite determiners are variables, too. These modifications ensure that both DPs and Ss include nothing more than a predicate and some variables (remember that "inclusion by X" means "domination by every segment of X", cf. Chomsky['86]). This configuration is called an **atomic formula**. If a DP-node, an S-node or a T-node dominates more than one formula and does not dominate an operator, the whole S or DP is called a **cumulative molecular formula**. $\bar{S}$-nodes and their non-S-daughters are invisible for the interpretative component; hence $\bar{S}$s are the same formulae as their S-daughters. Adnominal quantifiers like *every*, negation, invisible "□" and adverbs of quantification are called **operators**. Finally, operators except negation induce a **tripartite Logical Form**. This means that an S with a non-negating operator as leftmost daughter must have two further daughters which are formulae to be well-formed or interpretable. The leftmost sister of the operator is called the **restrictive clause** and the rightmost sister the **nuclear scope**.

It should be mentioned that in chapter two of her thesis, Heim introduces an additional LF-construal called **existential closure**, which has become fairly popular in the subsequent literature (cf. Kratzer['89b], Diesing['92] among others). Existential closure requires that an existential quantifier is adjoined to the nuclear scope of an operator and to the T-node of a multi-sentential LF. This addition is necessary at this stage of her argumentation, where she takes truth-conditions to be the primary aspects of the meaning of a sentence (or discourse) and the FCP as a secondary aspect. In the final version of FCS, where things are reversed, this operation proves to be superfluous. Its effect is taken over by the interpretation function itself.

2.2.2.4 The Interpretation of LF

As mentioned above, the interpretation of a sentence or discourse or, more generally, of a formula, is a File Change Potential, a function which maps an **input file** to an **output file**. Since a file F consists of its domain Dom(F) and its satisfaction set Sat(F), the interpretation of a formula has to specify how these components are affected. Hence an FCP has to specify how these components of the input file are modified to yield the output file. Besides this, an FCP may bear certain requirements on the input file, or, technically speaking, a formula may be mapped to a partial function over files. The intuitive content of this requirement is that an indefinite DP introduces a new file card, while definites pick up old ones, and that the descriptive content of a definite full DP is already present in the file card it picks up. Formally, this is stated by the

(38) Novelty-Familiarity-Condition (NFC):

For a formula ϕ to be felicitous w.r.t. a file F it is required for every DP_i in ϕ that

(i) if DP_i is [-definite], then $i \notin Dom(F)$:

(ii) if DP_i is [+definite], then

(a) $i \in Dom(F)$, and

(b) if DP_i is a formula, F entails DP_i

The semantics or pragmatics of full definite DPs is not at issue for the moment, so that clause (iib) may be ignored.

Now we are in a position to start with the recursive definition of the semantics of (a fragment of) English (of English LFs, to be precise). With "F+ϕ" we refer to the output file which results by application of the formula ϕ to the input file F.

Model

A **model** $\mathscr{M}$ for English is an ordered pair <A,Ext> such that

i) A is a non-empty set, the individual domain and

ii) Ext is a function which maps every predicate to an extension of the appropriate type (i.e. every n-place-predicate to a subset of A^n)

Interpretation Rules:

Let a model <A,Ext> for English be given.

(I) Let ϕ be an atomic formula, consisting of an n-place predicate ζ and an n-tuple of variables $<\alpha^1, ..., \alpha^n>$ whose indices are $i_1, ..., i_n$, respectively. Then:

$$Sat(F+\phi) = \{a_N \in Sat(F): <a_{i,1},...,a_{i,n}> \in Ext(\zeta)\};$$
$$Dom(F+\phi) = Dom(F) \cup \{i_1,...,i_n\}.$$

(II) Let ϕ be a cumulative molecular formula with the immediate constituent formulas $\phi^1,...,\phi^n$ (in that order). Then:

$$Sat(F+\phi) = Sat(...(F+\phi^1)...+\phi^n);$$
$$Dom(F+\phi) = Dom(...(F+\phi^1)...+\phi^n)$$

(III) Let ϕ be a quantified molecular formula, consisting of a universal quantifier and the two formulas ϕ^1 and ϕ^2 (in that order). Then:

$Sat(F+\phi) = \{a_N \in Sat(F)$: for every $b_N \sim_{Dom(F)} a_N$ such that $b_N \in Sat(F+\phi^1)$, there is some $c_N \sim_{Dom(F+\phi 1)} b_N$ such that $c_N \in Sat((F+\phi^1) + \phi^2)\}$;

$\mathrm{Dom}(F+\phi) = \mathrm{Dom}(F)$

(where "$a_N \sim_M b_N$" abbreviates "a_N agrees with b_N on all $i \in M$")

(IV) Let ϕ be an operator-headed molecular formula, consisting of a negator and the formula ψ. Then:

$\mathrm{Sat}(F+\phi) = \{a_N \in \mathrm{Sat}(F)$: there is no $b_N \sim_{\mathrm{Dom}(F)} a_N$ such that $b_N \in \mathrm{sat}(F+\psi)\}$;
$\mathrm{Dom}\ (F+\phi) = \mathrm{Dom}(F)$

Let us start exploring (I). Take the example

(39) $[_S$ She$_1$ loves him$_2]$

Applied to an input file F, we have

(40) $\mathrm{Sat}(F+[_S \text{ She}_1 \text{ loves him}_2]) = \{a_N \in \mathrm{Sat}(F)|\ \langle a_1,a_2\rangle \in \mathrm{Ext(love)}\}$
$\mathrm{Dom}(F+[_S \text{ She}_1 \text{ loves him}_2]) = \mathrm{Dom}(F) \cup \{1,2\}$

According to the NFC, 1 and 2 must already be elements of Dom(F), since *she* and *he* are definite pronouns and therefore require their indices to be in the domain of the input file. Hence $\mathrm{Dom}(F+[_S \text{ She}_1 \text{ loves him}_2]) = \mathrm{Dom}(F)$.

(II) simply says that in cumulative formulae, the input file is updated with the single atomic formulae step by step.

(41) A dog barks
LF: $[_S [_{DP}\ a_1 \text{ dog}]_1 [_S\ e_1 \text{ barks}]]$ (= ϕ)
$[_{DP}\ a_1 \text{ dog}]_1 = \phi^1$
$[_S\ e_1 \text{ barks}] = \phi^2$

In a first step, we update F with ϕ^1.

(42) $\mathrm{Sat}(F+\phi^1) = \{a_N \in \mathrm{Sat}(F)|\ a_1 \in \mathrm{Ext(dog)}\}$
$\mathrm{Dom}(F+\phi^1) = \mathrm{dom}(F) \cup \{1\}$
Felicity Condition: $1 \notin \mathrm{Dom}(F)$

Since *a dog* is [-definite], its index 1 must not be in the domain of F, but it is in the domain of $F+\phi^1$. The resulting file is updated with ϕ^2.

(43) $\mathrm{Sat}(F+\phi) = \mathrm{Sat}((F+\phi^1)+\phi^2) = \{a_N \in \mathrm{Sat}(F)|\ a_1 \in \mathrm{Ext(dog)} \wedge a_1 \in \mathrm{Ext(bark)}\}$

$Dom(F+\phi) = Dom((F+\phi^1)+\phi^2) = dom(F) \cup \{1\} \cup \{1\} = dom(F) \cup \{1\}$
Felicity Condition: $1 \notin Dom(F)$

Traces are neither [+definite] nor [-definite]. Hence the NFC does not restrict the domain of $F+\phi^1$. Since the index of the trace in ϕ^2 is already introduced by ϕ^1, the domain remains unchanged.

Before proceeding to more complex examples, let us see whether the truth conditions that FCS predicts are correct. Truth of a formula is a derived notion in FCS; the basic notion is truth of a file. This is defined in the simplest way one can imagine.

Definition 2.3 Truth of a File
"[A **file**] F is **true** iff there is at least one sequence a_N such that $a_N \in Sat(F)$."
(Heim['82],p. 330)

The next step is to define the notion of the truth of a formula **with respect to a file**.

Definition 2.4 Truth w.r.t. a File
"A formula ϕ is **true w.r.t. a file** F if $F+\phi$ is true, and false w.r.t. F if F is true and $F+\phi$ is false" (p. 330)

Note that $F+\phi$ is defined only if ϕ is felicitous w.r.t. F, i.e. ϕ fulfills the NFC. If the input file already contains a file card that is connected to an indefinite DP, or does not contain a file card that a definite DP or a pronoun needs to be interpreted, the formula is neither true nor false w.r.t. this input file. Hence, implicitly, we have a three-valued logic which fails to assign truth-values in case the presuppositions of a formula are not fulfilled.

Note that the truth of a formula is now relativized to files, not to sequences as in the modified MS above. But it is straightforward to give a sequence-based truth definition in FCS too.

Definition 2.5 Truth w.r.t. a Sequence
A formula ϕ is **true w.r.t. a sequence** a_N iff there is a file F such that $a_N \in Sat(F)$ and there is a sequence b_N such that $b_N \in Sat(F+\phi)$ and $a_N \sim_{Dom(F)} b_N$.

We can now define the **static meaning of a formula** as the set of sequences which make the formula true.

Definition 2.6 Static Meaning of a Formula
$[\![\phi]\!] = \{a_N | \phi \text{ is true w.r.t. } a_N\}$

Now the static meaning of *a dog barks* can easily be computed. First we check whether the sentence (or the corresponding formula) is true w.r.t. the **empty file** F_e, which is $<Ø,A^N>$.

(44) $\phi = [_S [_{DP}\ a_1\ dog]_1\ [_S\ e_1\ barks]]$
$F_e = <Ø,A^N>$
$Sat(F_e+\phi) = \{a_N \in A^N |\ a_1 \in Ext(dog) \wedge a_1 \in Ext(bark)\}$
$Dom(F_e+\phi) = \{1\}$
Felicity Condition: $1 \notin Ø$

The felicity condition is trivially fulfilled. $Sat(F_e+\phi)$ is non-empty just if there is some individual in A which falls both under the extension of *dog* and of *bark*. Since a file is true iff its satisfaction set is non-empty, $F_e+\phi$ is true and ϕ is true w.r.t. F_e under exactly those conditions. Otherwise ϕ is false w.r.t. F_e. Since $Sat(F_e)$ contains all sequences, ϕ is again true w.r.t. any arbitrary sequence under the mentioned conditions. Hence:

(45) $[\![[_S [_{DP}\ a_1\ dog]_1\ [_S\ e_1\ barks]]]\!] = A^N$ iff there is a dog that barks, Ø else.

This is the same result as we would get under the static approach. Another example:

(46) $[\![[_S\ she_1\ loves\ him_2\ ]]\!] = \{a_N |\ <a_1,a_2> \in Ext(love)\}$

This falls together with the meaning of the sentence under MS too. Hence FCS is at least not worse than MS as far as the "clear cases" are concerned. Now let us go on to the examples MS is unable to deal with in a satisfactory way.

(47) A farmer owns a donkey. He beats it.
$\phi = [_T [_S [_{DP}\ a_1\ farmer]_1\ [_S [_{DP}\ a_2\ donkey]_2\ [_S\ e_1\ owns\ e_2]]]\ [_S\ he_1\ beats\ it_2]]$
$Sat(F+\phi) = \{a_N \in Sat(F) |\ a_1 \in Ext(farmer) \wedge a_2 \in Ext(donkey) \wedge$
$<a_1, a_2> \in Ext(own) \wedge <a_1,a_2> \in Ext(beat)\}$
$Dom(F+\phi) = Dom(F) \cup \{1,2\}$
Felicity Condition: $1,2 \notin Dom(F)$
$[\![\phi]\!] = A^N$ iff there are two individuals x and y in A such that:
$x \in Ext(man) \wedge y \in Ext(donkey) \wedge <x,y> \in Ext(own) \cap Ext(beat)$,
Ø else

(48) Every farmer who owns a donkey beats it.
$\phi = [_S\ every\ [_S [_{DP} [_{DP}\ e_1\ farmer]_1\ [_{\bar{S}}\ who\ [_S [_{DP}\ a_2\ donkey]_2\ [_S\ e_1\ owns\ e_2]]]]_1$
$[_S\ e_1\ beats\ it_2]]]$

We compute the meaning of (48) piecemeal, following the Interpretation Rule (III) on page 18.

$\phi^1 = [_{DP}\ [_{DP}\ e_1\ \text{farmer}]_1\ [_{\bar{S}}\ \text{who}\ [_S\ [_{DP}\ a_2\ \text{donkey}]_2\ [_S\ e_1\ \text{owns}\ e_2]]]]_1$
$\phi^2 = [_S\ e_1\ \text{beats it}_2]$
$Sat(F+\phi^1) = \{a_N \in Sat(F)|\ a_1 \in Ext(farmer) \wedge a_2 \in Ext(donkey) \wedge$
$\quad <a_1,a_2> \in Ext(own)\}$
$Dom(F+\phi^1) = Dom(F) \cup \{1,2\}$
$Sat(F+\phi^1+\phi^2) = \{a_N \in Sat(F)|\ a_1 \in Ext(farmer) \wedge a_2 \in Ext(donkey) \wedge$
$\qquad <a_1,a_2> \in Ext(own) \wedge <a_1,a_2> \in Ext(beat)\}$
$Sat(F+[_s\ \text{every}\ \phi^1,\phi^2]) = \{a_N \in Sat(F)|\ \forall x \forall y\ [x \in Ext(farmer) \wedge$
$\quad y \in Ext(donkey) \wedge <x,y> \in Ext(own) \rightarrow <x,y> \in Ext(beat)]\}$
$Dom(F+[_s\ \text{every}\ \phi^1,\phi^2]) = Dom(F)$
Felicity Condition: $1,2 \notin Dom(F)$

Note that the definition of the satisfaction set of the output does not depend on particular values of the sequences at special indices. Hence it either equals the satisfaction set of the input or it is the empty set, depending only on the model. Accordingly, it holds that

$$[\![\phi]\!] = A^N \text{ iff } \forall x \forall y\ [x \in Ext(farmer) \wedge y \in Ext(donkey) \wedge <x,y> \in Ext(own) \rightarrow <x,y> \in Ext(beat)],$$
$$\emptyset \text{ else.}$$

This is just the meaning of (48) we are looking for.

The interpretation of the conditional donkey-sentence runs in fully parallel fashion.

(49) a. If a farmer owns a donkey, he beats it.
b. $[_S\ \Box\ [_{\bar{S}}\ \text{if}\ [_S\ [_{DP}\ a_1\ \text{farmer}]_1\ [_S\ [_{DP}\ a_2\ \text{donkey}]_2\ [_S\ e_1\ \text{owns}\ e_2\ ]]]]$
$[_S\ \text{he}_1\ \text{beats it}_2\ ]]$

The semantics of the phonetically empty operator "□" which is prefixed to bare if-conditionals makes reference to possible worlds, which play a significant role in the ultimate formulation of FCS. For the time being, we ignore this aspect. In the extensional version of FCS we are considering here, "□" turns out to be synonymous to "every". Since both the restrictive clause and the nuclear scope of (49) are synonymous to those of (48), the whole sentence is synonymous to the previous example.

I refrain from computing the semantics of a negated sentence; it is easy to convince oneself that the static meaning of $[_S$ not $[_S\ \phi]]$ is just the complement set of the meaning of ϕ.

2.2.2.5 Comparing MS and FCS

This overview shows quite convincingly that FCS is superior to MS in its empirical coverage. It is straightforward to show that FCS is able to deal with intensionality equally well. Hence it covers the same range of phenomena as MS. Besides this, it is able to deal with donkey sentences and cross-sentential anaphora. As a further advantage, it offers principled solutions to problems connected with the existential presupposition of definite DPs and the anaphora-licensing potential of indefinite DPs. Heim['83b] even offers an approach to deal with presupposition accommodation formally, which I will not discuss here. Nevertheless, some methodological objections are inevitable.

The first point concerns the status of LF. It is cross-theoretically uncontroversial that a level of representation which is more or less comparable with GB's S-structure is essential for any theory of syntax, i.e. one cannot avoid the usage of indices for DPs and the presence of traces and some other empty categories, though technical implementation may differ greatly. But it is highly controversial whether we need additional levels of syntactic representation. Unification-based approaches to grammar like Lexical-Functional Grammar (Kaplan/Bresnan['82]) or Head-Driven Phrase Structure Grammar (Pollard/Sag['87]) are purely declarative anyway, i.e. they do not use any notion of derivation from one level to another. But even current developments inside the generative framework seem to be incompatible with Heim's notion of LF. In the Minimalist Program (cf. Chomsky['93, '94]), LF merely serves to level out cross-linguistic variation or, in other words, its main purpose is to rescue certain constraints which are held to be universally valid but are almost always violated at the surface. LF does not contain specifically semantic information in this setup. Other authors who take the principles-and-parameters theory as their starting point insist that D-structure and S-structure are the only syntactic levels (cf. Jackendoff['94], Ouhalla['94]) or that even S-structure suffices (Grimshaw['94]). Hence a semantic theory which takes S-structure as the input for interpretation makes fewer assumptions about syntactic theory and is *ceteris paribus* to be preferred. An apologist of FCS might answer that MS needs something like Quantifier Raising too, but Cooper['83] shows that an *in-situ* theory for quantifiers is possible. One could contrast **S-compositionality** of MS (since MS in the version of Cooper['83] interprets S-structure compositionally) with the **LF-compositionality** of FCS, where the former is methodologically stronger and hence the preferable option.

However, MS and FCS not only differ w.r.t. the syntactic level which is subject to the compositionality requirement, but also w.r.t. the notion of compositionality itself. The interpretation of LF in FCS is compositional only in the weak sense of the Fregean Principle, while Montagues Principle of Compositionality of Interpretation is much stronger in that it requires **type correspondence**, i.e. expressions of the same syntactic category denote the same type of semantic objects. In the figure, the denotations of some English expressions under MS and under FCS are compared[5].

(50)

Example	English	Extensional MS	FCS
She loves him	S	t (set of sequences)	t (FCP)
he	DP	<<e,t>,t>	e (<<e,t>,t>)
a man	DP	<<e,t>,t>	t
every man	DP	<<e,t>,t>	no constituent at LF
man	N	<e,t>	<e,t>
a	D	<<e,t>,<<e,t>,t>>	e (<<e,t>,t>)
every	D	<<e,t>,<<e,t>,t>>	<t,<t, t>>
if	Comp	<t,<t, t>>	semantically empty
and	conjunction	<t,<t, t>>	<t,<t,t>>
owns	V (trans.)	<e,<e,t>>	<e,<e,t>>

It is easy to see that there is no type correspondence in FCS. While the determiner *every* denotes a 2-place predicate on formulae as conjunction does, the indefinite determiner *a* only introduces a variable and hence goes together with pronouns. DPs either denote FCP (if they are full definite or indefinite DPs), or variables etc.

The third objection concerns the status of the NFC. It remains totally unclear how the NFC could be integrated into a compositional reformulation of FCS, yet the truth-definition above relies crucially on it. The semantic difference between the indefinite article and a definite pronoun is stated only in terms of a condition which is in some sense external to the recursive machinery[6].

Of course, all these conceptual disadvantages of FCS are compensated by its overwhelming empirical success as long as we compare it with classical MS, but the optimal solution would be to combine the empirical advantages of FCS with the methodological rigor of MS.

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[5]Heim['82] defines the meaning of any simple expression apart from predicates syncategorematically, but it is a simple exercise to redefine FCS as a type theory such that every basic expression receives an interpretation of its own.

[6]Rooth ['87] gives a reformulation of FCS which avoids the usage of the Novelty Condition. This implies that the Familiarity Condition gets lost as well. Therefore his system is rather a predecessor of G&S's ['91a] "Dynamic Montague Grammar" than a variant of FCS, and the objections raised against the latter at the end of this chapter apply to it too.

2.3 Extensional Dynamic Predicate Logic

In the preceding section, it was shown that Heim modifies all three aspects of interpretation in the Montagovian framework: she heavily enriches the disambiguation procedure, and she assigns completely different semantic objects to English sentences, namely FCPs instead of truth conditions. Groenendijk & Stokhof ("G&S" in the rest of this thesis)['91a] chose a more conservative strategy. They leave Disambiguation and Translation roughly as they were in MS, and instead develop a new interpretation for Intensional Logic. The meaning this interpretation assigns to a formula is called **Context Change Potential** (ccp) and is very similar to Heim's FCP. We will proceed as follows: In a first step, a dynamic semantics for first-order predicate logic is introduced. In a second step, this semantics is extended to intensional type theory. Finally, the translation of a fragment of English into that type theory is presented.

2.3.1 The Syntax of EDPL

As a standard example for a dynamic first order calculus, I use Dekker's['93] **Extensional Dynamic Predicate Logic** (EDPL)[7] instead of G&S's['91b] Dynamic Predicate Logic, since the former bears some crucial advantages over the latter. The syntax of this language is familiar.

Definition 3.1: The Syntax of EDPL

Predicates:

For all $n \in N$: $P^{n\prime}$, $P^{n\prime\prime}$, $P^{n\prime\prime\prime}$, ... are n-ary predicates

Individual constants:

c', c'', c''', ... are individual constants

Variables:

v', v'', v''', ... are variables

Terms:

t is a **term** if t is variable or t is an individual constant

Formulae:

i) If P^n is an n-ary predicate and $t_1,...,t_n$ are terms, then
$P^n(t_1,...t_n)$ is an (atomic) formula

ii) If t_1 and t_2 are terms, then
$(t_1 = t_2)$ is an (atomic) formula

iii) If ϕ is a formula and x is a variable, then

---

[7] I am not completely sure whether the "E" in "EDPL" abbreviates "extensional" in Dekker['93]. Beaver['93] proposes "eliminative", but this seems not very felicitous to me since EDPL is not eliminative under the standard definition of the term. Anyway, it **is** an extensional and dynamic semantics for first order predicate logic.

$(\exists x.\phi)$ is a formula

iv) If ϕ and ψ are formulae, then
$(\phi\wedge\psi)$, $(\neg\phi)$ are formulae.

We follow the usual conventions in that we omit brackets where possible and abbreviate $(\neg\exists x.\neg\phi)$ as $(\forall x.\phi)$, $(\neg(\neg\phi\wedge\neg\psi))$ as $(\phi\vee\psi)$, $(\neg(\phi\wedge\neg\psi))$ as $(\phi\rightarrow\psi)$ and $(\neg(x=y))$ as $(x\neq y)$. We use the signs x, y, z, x', y'''' etc. for variables, a, b, c, ... for individual constants, P, P', Q, Q'''', R , ... for predicates and ϕ, ϕ', ψ, ... for formulae.

2.3.2 Contexts

As a model for EDPL, we use the standard definition of a first-order model:

Definition 3.2: Model for EDPL
A model $\mathcal{M}$ for EDPL is an ordered pair <E, F>, where

- E is a denumerable infinite set, the individual domain, and
- F is a function which maps every individual constant of EDPL to an element of E and every n-ary predicate of EDPL to a subset of E^n

Remember that a file in FCS is a pair of a domain of natural numbers and a set of sequences, i.e. functions from the set of natural numbers into the individual domain. This pairing is restricted in such a way that the set of sequences of a file contain only information about the numbers in the domain. Hence it does not really matter what value a particular sequence assigns to a number that is not in the domain. Therefore we would loose nothing if we say that a file contains only partial functions whose domain is just the domain of the file[8]. Indices play much the same role in FCS as variables in EDPL. The EDPL-counterpart of Heim's files, **contexts**, therefore contain **partial** functions from the set of variables into the individual domain.

Definition 3.3: Assignment Functions
An assignment function g is a partial function from Var (the set of EDPL-variables) into E.
$G =_{def} \bigcup_{V\subseteq Var} E^V$

Definition 3.4: Contexts
A context ct is a set of assignment functions which share their domain.
$CT =_{def} \bigcup_{V\subseteq Var} POW(E^V)$

One, but not the only, advantage of the usage of partial assignment functions ("assignments"

[8]In Heim['83a], FCS is modified in just this way.

for short) instead of total ones (as in G&S['91b]) is that we do not need to encode the domain of a context explicitly. This is implicitly defined via the domain of the assignment functions in it.

Definition 3.5: Domain of a Context
$\mathrm{Dom}(ct) = D$ iff $ct \subseteq E^D$

Some further notational conventions are useful. The set of contexts exhibits certain orderings.

Definition 3.6:
$ct \leq_D ct'$ iff $\mathrm{Dom}(ct) = \mathrm{Dom}(ct') = D$ and $ct' \subseteq ct$

This ordering forms a complete lattice, since it is simply the superset-relation over the powerset of E^x. The join and the meet of this lattice are Ø and E^D respectively. "$\leq_D$" expresses the relative degree of information about the value of the variables in D that a context encodes. The more information a context contains, the fewer the possible values for a variable that are left open. Ø, formally the top element in this hierarchy, is called the **absurd context**. The anti-atoms, i.e. those contexts which are singleton sets, are called **maximally informative w.r.t. D** since they give a unique value for every variable in D.

Another way to increase the information a context contains is to extend its domain.

Definition 3.7: Context Inclusion
$ct \sqsubseteq ct'$ iff $\mathrm{Dom}(ct) \subseteq \mathrm{Dom}(ct') \wedge$
$\forall i \in ct: \exists j \in ct': i \subseteq j \wedge \forall k \in ct': \exists l \in ct: l \subseteq k$

ct' includes ct iff ct' contains exactly the same information about the variables in Dom(ct) as ct itself contains, but ct' also contains information about additional variables. This is again an ordering of the informational content of contexts. Hence we can combine both orderings.

Definition 3.8: Informativity
$ct \leq ct'$ iff $\exists ct''[ct \leq_{\mathrm{Dom}(ct)} ct'' \wedge ct'' \sqsubseteq ct']$

This says that every assignment in ct', the more informative context, is an extension (formally: a superset) of an assignment in ct, but there may be assignments in ct which do not have an extension in ct'.

Fact 3.1:
$ct \leq ct'$ iff $\mathrm{Dom}(ct) \subseteq \mathrm{Dom}(ct') \wedge \forall i[\, i \in ct' \rightarrow \exists j[\, j \in ct \wedge j \subseteq i]]$

This notion of informativity can easily be related to basic set-theoretical relations: every context uniquely defines a set of total assignments, its **completion**:

Definition 3.9: Completion of a Context
$\text{compl}(ct) =_{def} \{g \in E^{Var} | \ \exists i[i \in ct \wedge i \subseteq g]\}$

The completion of a context ct contains the same information about the value of the variables that are in the domain of ct. Now it holds that:

Fact 3.2
$ct \leq ct' \text{ iff } \text{compl}(ct') \subseteq \text{compl}(ct) \wedge \text{Dom}(ct) \subseteq \text{Dom}(ct')$

To be able to return from the completion of a context to the context itself, we need the notion of the **restriction of a context to a domain**:

Definition 3.10: Restriction of a Context
i) $j \backslash D =_{def} j \cap \{\langle v,a \rangle | \ v \in D \wedge a \in E\}\}$ (with $D \subseteq Var$)
ii) $ct \backslash D =_{def} \{i \mid \exists j \ [j \in ct \wedge i = j \backslash D]\}$

Fact 3.3
For any context ct: $ct = \text{compl}(ct) \backslash \text{Dom}(ct)$

Since the informativity-ordering between contexts reduces to a conjunction between a subset-relation between the domains and a superset-relation between the completions, the whole set of contexts form a complete lattice w.r.t. informativity. Accordingly, the **join** and the **meet** operations are straightforwardly definable in terms of set union and intersection:

Definition 3.11: Join and Meet
$ct \sqcap ct' =_{def} [\text{compl}(ct) \cap \text{compl}(ct')] \backslash [\text{Dom}(ct) \cup \text{Dom}(ct')]$
$ct \sqcup ct' =_{def} [\text{compl}(ct) \cup \text{compl}(ct')] \backslash [\text{Dom}(ct) \cap \text{Dom}(ct')]$

Fact 3.4
$\forall ct, ct'[ct \leq ct \sqcap ct' \wedge ct' \leq ct \sqcap ct' \wedge \forall ct''[ct \leq ct'' \wedge ct' \leq ct'' \rightarrow ct \sqcap ct' \leq ct'']]$
$\forall ct, ct'[ct \geq ct \sqcup ct' \wedge ct' \geq ct \sqcup ct' \wedge \forall ct''[ct \geq ct'' \wedge ct' \geq ct'' \rightarrow ct \sqcup ct' \geq ct'']]$

This gives us the minimal and the maximal elements of the informativity-ordering, the **context of ignorance** (called **1**) and the **absurd context** (called **0**) respectively:

Definition 3.12:
1 $=_{def}$ {Ø}
0 $=_{def}$ Ø

Fact 3.5

1 = $\sqcup$ CT

0 = $\sqcap$ CT

Again, we have the set of anti-atoms as the maximally informative contexts:

Definition 3.13: Maximal Contexts
ct is maximal iff ct = {i} and Dom(ct) = Var

Now remember that the meanings of formulae, ccps, are partial functions from contexts to contexts. We define:

Definition 3.14: Context Change Potentials
CCP $=_{def} \bigcup_{c \subseteq CT} CT^c$

According to this definition, it is possible that the output of the application of a ccp is less informative than the input. It is highly probable that we need such ccps if we try to model belief-revision phenomena, but in this dissertation, only informative ccps are investigated. Following the terminology in G&S['93], ccps that increase the informativity of a context have the **update property** or, for short, are **updates**:

Definition 3.15: Updates
A ccp τ has the update property iff for all contexts ct such that τ(ct) is defined:

$$ct \leq \tau(ct)$$

UP $=_{def}$ CCP $\cap$ *POW*($\leq$)

The semantics of EDPL that is given below ensures that the interpretation of a formula is always an update. There is one particular update that is a prerequisite for the definition of existential quantification:

Definition 3.16: Domain Extension
$ct[x] =_{def} \{j \mid \exists i[i \in ct \wedge a \in E \wedge j = i \cup \{\langle x,a \rangle\}]\}$ iff $x \notin Dom(ct)$, undefined else

Fact 3.6

$Dom(ct[x]) = Dom(ct) \cup \{x\}$	if ct[x] is defined
$compl(ct[x]) = compl(ct)$	if ct[x] is defined

Literally speaking, this defines a whole family of updates, one for every variable in Var. The idea is not too complicated; the domain of the input context is extended with x and x can receive any possible value in the output (hence we do not have additional information about the value of x in the output). The values assigned to the other variables do not change. The condition that the newly introduced variable must not be in the domain of the input is the EDPL-counterpart of the Novelty-Condition in FCS. Here, though, it is not an external condition which governs interpretation but an integral part of the interpretation itself. In principle, the definedness-condition is superfluous here; if x was already in the input domain, the elements of the output would not be functions and hence the output itself would - according to the definitions - not be a context.

2.3.3 The Semantics of EDPL

The interpretation rules are given in postfix notation, as is standard in the dynamic semantics literature.

Definition 3.17. Postfix Notation
For all EDPL-Models $\mathcal{M}$, EDPL-formulae ϕ and contexts ct:
$\|\phi\|_{\mathcal{M}}(ct) =_{def} ct[\phi]_{\mathcal{M}}$

Definition 3.18 Semantics of EDPL
Let an EDPL-Model $\mathcal{M} = \langle E,F \rangle$ be given. It holds for every context ct and every assignment i that

i) $\|c\|_{\mathcal{M},i} =_{def} F(c)$ iff c is an individual constant

ii) $\|x\|_{\mathcal{M},i} =_{def} i(x)$ iff x is a variable

iii) $ct[P(t_1, ..., t_n)]_{\mathcal{M}} =_{def} \{i \in ct | \langle \|t_1\|_{\mathcal{M},i}, ..., \|t_n\|_{\mathcal{M},i} \rangle \in F(P)\}$
iff $P(t_1, ... ,t_n)$ is an atomic formula and $Var \cap \{t_1, ... ,t_n\} \subseteq Dom(ct)$

iv) $ct[t_1 = t_2]_{\mathcal{M}} =_{def} \{i \in ct | \|t_1\|_{\mathcal{M},i} = \|t_2\|_{\mathcal{M},i}\}$
iff t_1, t_2 are terms and $Var \cap \{t_1,t_2\} \subseteq Dom(ct)$

v) $ct[\exists x.\phi]_{\mathcal{M}} =_{def} ct[x]_{\mathcal{M}}[\phi]_{\mathcal{M}}$
iff x is a variable and ϕ is a formula

vi) $ct[\phi \wedge \psi]_{\mathcal{M}} =_{def} ct[\phi]_{\mathcal{M}}[\psi]_{\mathcal{M}}$
iff ϕ and ψ are formulae

vii) $ct[\neg\phi]_{\mathcal{M}} =_{def} (compl(ct) - compl(ct[\phi]))\backslash Dom(ct)$
iff ϕ is a formula

The first two clauses are standard from classical logic. The clauses for atomic formulae are very similar to the interpretation rules for atomic formulae in FCS. First, the truth or falsity of the formula is evaluated w.r.t. the single assignments in the input context. Afterwards, those assignments that make the formula true "survive" in the output, while those that make the formula false are in turn filtered out. If the formula contains variables the assignments are not defined for (i.e. that are not in the domain of the input), evaluation becomes impossible and hence the output is not defined. Every atomic formula containing free variables is defined only for those contexts that define values for these variables. This is the counterpart of the Familiarity Condition in FCS.

Dynamic conjunction is defined as function composition, which again is reminiscent of the FCS-interpretation of molecular formulae. Since function composition is generally associative, we automatically have:

Fact 3.7 Associativity of Dynamic Conjunction
For all formulae ϕ,ψ,χ:

$$\|((\phi \wedge \psi) \wedge \chi)\| = \|(\phi \wedge (\psi \wedge \chi))\|$$

But we will see that - contrary to static conjunction - dynamic conjunction is not generally commutative.

In static logic, negation is usually - explicitly or implicitly - defined as set complementation. A straightforward dynamic adaptation of this idea would be

(51) $ct[\neg\phi] =_{def} ct - ct[\phi]$

There are in fact dynamic calculi where negation is defined in this way. But in EDPL, it is not generally the case that the output of an update function is a subset of the input. Set inclusion is only provided if we shift from partial to total assignments. This motivates the use of the completion function. To reach the final output, we have to restrict the domain again. There are two candidates for the output-domain: Dom(ct) and Dom(ct[ϕ]). Remember that free variables, which correspond to FCS's file cards, model anaphora and that accordingly the logical counterparts of indefinites - dynamic existential quantifiers - introduce new variables (file cards). Hence it is an empirical question, whether we allow indefinites in the scope of a negation to bind anaphora outside that scope.

(52) John does not own a car_i. *It is a Porsche.

(53) John does not own a car_i anymore. He sold it_i last week.

The examples show that there is empirical motivation for both points of view, but it is reasonable to assume that the specific usage of the indefinite *a car* in (53) requires an additional mechanism, while the nonspecific use is the default case. Hence we assume that negative statements do not change the domain of the context.

The most interesting aspect of EDPL is certainly its treatment of existential quantification. In a certain sense, it is just this aspect that makes EDPL dynamic. Remember that existential quantification in classical logic is defined as a meta-linguistic existential statement over assignments. In EDPL, the assignments that make the formula quantified over true are created by updating. Take an example:

(54) $\exists x.\mathbf{farmer'}(x)$

Remember that **1** is a singleton set that contains the empty assignment function as its only member. We update **1** with (54).

(55) $\mathbf{1}[\exists x.\mathbf{farmer'}(x)] = \mathbf{1}[x][\mathbf{farmer'}(x)]$
$= \{j |\ i \in \{\emptyset\} \wedge a \in E \wedge j = i \cup \{<x,a>\}\}[\mathbf{farmer'}(x)]$
$= \{i |\ a \in E \wedge i = \emptyset \cup \{<x,a>\}\}[\mathbf{farmer'}(x)]$
$= \{\{<x,a>\} |\ a \in E\}[\mathbf{farmer'}(x)]$
$= E^{\{x\}}\ [\mathbf{farmer'}(x)]$
$= \{\{<x,a>\} |\ \|x\|_{\{<x,a>\}} \in F(\mathbf{farmer'})\}$
$= \{\{<x,a>\} |\ a \in F(\mathbf{farmer'})\}$

The output contains only singleton functions with x as the only element in its domain and the extension of *farmer* as its range. If we abstract away from a particular input, we have:

(56) a. $ct[\exists x.\mathbf{farmer'}(x)] = ct[x][\mathbf{farmer'}(x)]$
$= \{j |\ i \in ct \wedge a \in E \wedge j = i \cup \{<x,a>\}\}[\mathbf{farmer'}(x)]$
$= \{j |\ i \in ct \wedge a \in F(\mathbf{farmer'}) \wedge j = i \cup \{<x,a>\}\}$
iff $x \notin Dom(ct)$, undefined else

b. $x \in Dom(ct[\exists x.\mathbf{farmer'}(x)])$

c. $compl(ct[\exists x.\mathbf{farmer'}(x)]\ = compl(ct) \cap \{g |\ g \in E^{Var} \wedge g(x) \in F(\mathbf{farmer'})\}$

Note that the last three lines are nearly identical to the interpretation of *There is a farmer* under FCS, if "context" is replaced by "file" and "completion" by "satisfaction", but we do not need to make reference to morphosyntactic notions like [-definite] here.

The essentially "dynamic" character of EDPL-"∃" allows it to "bind" variables that are outside its syntactic scope.

(57) $ct[\exists x(\mathbf{farmer'}(x)) \wedge \mathbf{walk'}(x)] = ct[\exists x.\mathbf{farmer'}(x)][\mathbf{walk'}(x)]$
$= \{j |\ i \in ct \wedge a \in F(\mathbf{farmer'}) \wedge j = i \cup \{<x,a>\}\}[\mathbf{walk'}(x)]$
$= \{j |\ i \in ct \wedge a \in F(\mathbf{farmer'}) \wedge a \in F(\mathbf{walk'}) \wedge j = i \cup \{<x,a>\}\}$

$= \{j|\ i \in ct \wedge a \in (F(\mathbf{farmer'}) \cap F(\mathbf{walk'})) \wedge j = i \cup \{<x,a>\}\}$
$= ct[\exists x\ (\mathbf{farmer'}(x) \wedge \mathbf{walk'}(x))]$
$\quad \text{iff } x \notin Dom(ct)$

This corresponds to the FCS-interpretation of *A farmer walks.* Generally, it holds that

Fact 3.8 Dynamic Variable Binding

$$\|(\exists x.\phi) \wedge \psi\| = \|\exists x.(\phi \wedge \psi)\|$$

This follows immediately from the associativity of function composition. If we assume that sentence-sequencing is translated as dynamic conjunction, cross-sentential anaphora no longer cause difficulties:

(58) A man$_i$ walks. He$_i$ whistles.

$ct[(\exists x.(\mathbf{man'}(x) \wedge \mathbf{walk'}(x)) \wedge \mathbf{whistle'}(x)] = ct[(\exists x.(\mathbf{man'}(x) \wedge \mathbf{walk'}(x) \wedge \mathbf{whistle'}(x))]$
$= \{j|\ \exists i,a\text{: } i \in ct \wedge a \in (F(farmer) \cap F(\mathbf{walk'}) \cap F(\mathbf{whistle'})) \wedge j = i \cup \{<x,a>\}\}$

It does not come as a surprise that, as everywhere in life, we have to pay for this advantage. First, alphabetic variation is not valid in EDPL.

Fact 3.9

It does not generally hold that $\|\phi\| = \|\phi[y/x]\|$

Second, dynamic conjunction is, contrary to its classical counterpart, not generally commutative:

Fact 3.10 Non-commutativity

There are EDPL-formulae ϕ and ψ such that

$$\|\phi \wedge \psi\| \neq \|\psi \wedge \phi\|$$

An obvious example is "$\phi = \exists x.Px$, $\psi = Qx$". "$\|Qx \wedge \exists xPx\|$" is just the empty function since the first conjunct requires x to be an element of the input domain while the second conjunct is only defined if this is not the case. "$\|\exists x.Px \wedge Qx\|$", on the other hand, is defined in every context where x is not in the domain yet. But there is a restricted version of commutativity in EDPL.

Fact 3.11 Restricted Commutativity

For any EDPL-formulae ϕ and ψ, it holds that

$\|\phi \wedge \psi\| = \|\psi \wedge \phi\|$ if neither $\|\phi \wedge \psi\| = \emptyset$ nor $\|\psi \wedge \phi\| = \emptyset$

A third crucial difference with respect to classical logic arises if we investigate the interaction of dynamic quantification and dynamic negation.

(59) $ct[\neg\exists x.Px\ ] = (compl(ct) - compl(ct[\exists x.Px]))\backslash ct$ % $x \notin Dom(ct)$
$= ct$ iff $F(P) = \emptyset$,
$\mathbf{0}$ iff $F(P) \neq \emptyset$

Since the only variable in the formula considered in (59) is x and x must not be in the domain of the input, the output does not really depend on the particular input-assignments but only on the model. Now see what happens if we negate a negated formula:

(60) $ct[\neg\neg\exists x.Px\ ] = (compl(ct) - compl(ct[\neg\exists x.Px]))\backslash ct$ % $x \notin Dom(ct)$
$= compl(ct[\exists x.Px])\backslash ct$
$= ct$ iff $F(P) \neq \emptyset$,
$\mathbf{0}$ iff $F(P) = \emptyset$.

The double negation of an existential formula boils down to an ordinary, "quasi-static" existential statement about the extension of the predicate in the model. This is why double negation is sometimes called **static closure**.

Fact 3.12 Double Negation
It does not generally hold that $\|\phi\| = \|\neg\neg\phi\|$.

But again, there is a restricted version. Double Negation has the effect of restricting the output to the domain of the input.

Fact 3.13
For all formulae ϕ and contexts ct it holds that
$ct[\neg\neg\phi] = ct[\phi]\backslash Dom(ct)$

The proof follows immediately from the definitions. If a formula does not contain an active[9] occurrence of $\exists$, it does not change the domain anyway. Hence static closure has no effect at all.

[9]An **active occurrence of** $\exists$ is an existential quantifier that is not in the scope of negation.

Fact 3.14 Restricted Law of Double Negation
For all formulae ϕ, all formulae ψ that are (improperly) contained in ϕ, and contexts ct, it holds that

$$\|\phi\| = \|\phi[(\neg\neg\psi)\backslash\psi]\| \text{ iff } \mathrm{Dom}(ct[\phi]) = \mathrm{Dom}(ct[\phi[(\neg\neg\psi)\backslash\psi]])$$

Particularly, this implies that $\|\neg\neg\neg\phi\| = \|\neg\phi\|$, $\|\neg\neg\neg\neg\phi\| = \|\neg\neg\phi\|$ etc.

It is worth noting that although an existential quantifier in the scope of negation cannot bind variables outside of this scope, an existential quantifier can bind into the scope of negation.

(61) a. A man_i walks. He_i does not talk.
b. $ct[(\exists x.\ \mathbf{man'}(x) \wedge \mathbf{walk'}(x)) \wedge \neg\mathbf{talk'}(x)]$
$= ct[x][\mathbf{man'}(x)][\mathbf{walk'}(x)][\neg\mathbf{talk'}(x)]$
$= \{i|\ \exists j,a: j \in ct \wedge a \in ((F(\mathbf{man'}) \cap F(\mathbf{walk'})) - F(\mathbf{talk'})) \wedge i = j \cup \{<x,a>\}\}$

To analyze the donkey constructions, we first have to consider the behaviour of implication and the universal quantifier. We start with implication.

Fact 3.15 Dynamic Implication

$$\begin{aligned}
ct[\phi\rightarrow\psi] &= ct[\neg(\phi\wedge\neg\psi)] && \text{\% by definition}\\
&= \{i\in ct|\ i \notin ct[\neg\neg[\phi\wedge\neg\psi]\}\\
&= \{i\in ct|\ i \notin ct[\neg\neg\phi] \vee i \in ct[\neg\neg\phi] \wedge i \notin ct[\neg\neg(\phi\wedge\neg\psi)]\}\\
&= \{i\in ct|\ i \notin ct[\neg\neg\phi] \vee i \in ct[\neg\neg\phi] \wedge i \in ct[\neg\neg(\phi\wedge\psi)]\}\\
&= \{i\in ct|\ i \in ct[\neg\neg\phi] \rightarrow i \in ct[\neg\neg(\phi\wedge\psi)]\}\\
&= \{i\in ct|\ \forall j(i \subseteq j \wedge j \in ct[\phi] \rightarrow \exists k: j \subseteq k \wedge k \in ct[\phi\wedge\psi])\}
\end{aligned}$$

At the metalinguistic level, dynamic implication is closely connected to classical implication. The situation is similar for dynamic universal quantification.

Definition 3.19
$ct[x/a] =_{def} \{i\cup\{<x,a>\}|\ a \in E \wedge i \in ct\}$ % $x \notin \mathrm{Dom}(ct)$

Fact 3.16 Dynamic Universal Quantification

$$\begin{aligned}
ct[\forall x.\phi] &= ct[\neg\exists x.\neg\phi] && \text{\% by definition}\\
&= \{i\in ct|\ i \notin ct[\neg\neg\exists x.\neg\phi]\} && \text{\% } x \notin \mathrm{Dom}(ct)\\
&= ct \text{ iff } \forall a\in E: ct[x/a][\phi] \neq \emptyset,\\
&\quad \mathbf{0} \text{ else}
\end{aligned}$$

Universal quantification acts as a test. If the result of updating ct with $[\exists x.\phi]$ does not depend on the particular value of x, the input is left unchanged. Otherwise the absurd state results.

The basis for the analysis of donkey constructions is the following equivalence:

Fact 3.17 Donkey Equivalence
For all formulae ϕ and ψ and variables x, it holds that

$$\|\exists x.\phi \rightarrow \psi\| = \|\forall x(\phi \rightarrow \psi)\|$$

Proof:

1. $\|\exists x.\phi \rightarrow \psi\| = \|\neg(\exists x.\phi \wedge \neg\psi)\|$ % by definition
$= \|\neg(\exists x.(\phi \wedge \neg\psi))\|$ % dynamic binding
$= \|\neg\exists x.\neg\neg(\phi \wedge \neg\psi)\|$ % restr. ¬¬
$= \|\forall x(\neg(\phi \wedge \neg\psi))\|$ % by definition
$= \|\forall x(\phi \rightarrow \psi)\|$ % by definition

□

The equivalence also holds in classical logic, but only with the restriction that the variable bound by the quantifier does not occur free in the consequence. In EDPL, there is no restriction. A linguistic example at hand is

(62) a. If a man$_i$ is in Athens, he$_i$ is not in Rhodes.
b. Every man who is in Athens is not in Rhodes.

EDPL correctly predicts that these sentences are equivalent.

The treatment of the actual donkey sentences is now pretty straightforward.

(63) If a farmer$_i$ owns a donkey$_j$, he$_i$ beats it$_j$

$\|\exists x(\mathbf{farmer'}(x) \wedge \exists y(\mathbf{donkey'}(y) \wedge \mathbf{own'}(x,y))) \rightarrow \mathbf{beat'}(x,y)\|$
$= \|\exists x(\mathbf{farmer'}(x) \wedge \exists y.\mathbf{donkey'}(y) \wedge \mathbf{own'}(x,y)) \rightarrow \mathbf{beat'}(x,y)\|$ % dynamic binding
$= \|\exists x\exists y(\mathbf{donkey'}(y) \wedge \mathbf{farmer'}(x) \wedge \mathbf{own'}(x,y)) \rightarrow \mathbf{beat'}(x,y)\|$ % restr. comm.
$= \|\exists x\exists y(\mathbf{farmer'}(x) \wedge \mathbf{donkey'}(y) \wedge \mathbf{own'}(x,y)) \rightarrow \mathbf{beat'}(x,y)\|$ % restr. comm.
$= \|\forall x(\exists y(\mathbf{farmer'}(x) \wedge \mathbf{donkey'}(y) \wedge \mathbf{own'}(x,y)) \rightarrow \mathbf{beat'}(x,y))\|$ % donkey eq.
$= \|\forall x\forall y(\mathbf{farmer'}(x) \wedge \mathbf{donkey'}(y) \wedge \mathbf{own'}(x,y) \rightarrow \mathbf{beat'}(x,y))\|$ % donkey eq.

(64) Every farmer who owns a donkey$_i$ beats it$_i$

$\|\forall x(\mathbf{farmer'}(x) \wedge \exists y(\mathbf{donkey'}(y) \wedge \mathbf{own'}(x,y)) \rightarrow \mathbf{beat'}(x,y))\|$
$= \|\forall x(\mathbf{farmer'}(x) \wedge \exists y.\mathbf{donkey'}(y) \wedge \mathbf{own'}(x,y) \rightarrow \mathbf{beat'}(x,y))\|$ % dynamic binding
$= \|\forall x(\exists y.\mathbf{donkey'}(y) \wedge \mathbf{farmer'}(x) \wedge \mathbf{own'}(x,y) \rightarrow \mathbf{beat'}(x,y))\|$ % restr. comm.
$= \|\forall x\forall y(\mathbf{donkey'}(y) \wedge \mathbf{farmer'}(x) \wedge \mathbf{own'}(x,y) \rightarrow \mathbf{beat'}(x,y))\|$ % donkey eq.

EDPL predicts that the sentences are equivalent. Furthermore, they are interpreted as a test update. This update leaves the input context unchanged if it holds that for every pair <f,d> of individuals in E such that f falls under the extension of *farmer*, d falls under the extension of *donkey* and <f,d> falls under the extension of *own*, then <f,d> falls under the extension of *beat*. Otherwise the absurd context results. These are just the truth conditions of the relevant sentences. This is a nice example for the fact that truth conditions, though superfluous for the semantics of EDPL, can be derived from the dynamic interpretation.

2.3.4 Truth and Entailment in EDPL

This way of deriving truth conditions of a formula from its update potential can be generalized. The first step is the notion of **truth in a context**. Here the notion of context inclusion introduced earlier becomes important.

Definition 3. 20 Truth in a Context
For all models $\mathcal{M}$, contexts ct, and formulae ϕ, it holds that

$$ct \vDash_{M} \phi \text{ iff } ct \sqsubseteq_{\mathcal{M}} ct[\phi]_{\mathcal{M}}$$

The underlying idea is that a true update does not eliminate possibilities in the input, although it may extend them. It follows immediately from the definitions that:

Fact 3.18
For all models M, contexts ct, and formulae ϕ, it holds that:

$$ct \vDash_{\mathcal{M}} \phi \text{ iff } ct[\neg\neg\phi]_{\mathcal{M}} = ct$$

There are several ways to generalize this to the quasi "context free" notion of **truth in a model**. We either require the formula to be evaluated to be true in some designated context (**1** is obviously the best candidate), to be true in any context where it is defined, or to be true in some context.

Definition 3. 21

$\vDash_{\mathcal{M}}^{1} \phi$ iff $\mathbf{1} \vDash_{\mathcal{M}} \phi$

$\vDash_{\mathcal{M}}^{2} \phi$ iff for all contexts such that ct[ϕ] is defined, it holds that
ct $\vDash_{\mathcal{M}} \phi$

$\vDash_{\mathcal{M}}^{3} \phi$ iff there is a context ct such that
ct $\vDash_{\mathcal{M}} \phi$

These three variants of truth collapse as long as we consider closed formulae, but they differ w.r.t. formulae containing free variables.

Fact 3.19
For all variables x, formulae ϕ containing an occurrence of x that is not dynamically bound, and models $\mathcal{M}$, it holds that:

$\not\models_{\mathcal{M}}^{1} \phi$
$\models_{\mathcal{M}}^{2} \phi$ iff $\models_{\mathcal{M}}^{2} \forall x.\phi$
$\models_{\mathcal{M}}^{3} \phi$ iff $\models_{\mathcal{M}}^{3} \exists x.\phi$

The second version corresponds to truth in classical first order logic and the third to truth in FCS. The first version gives us a kind of three-valued semantics (or a semantics with truth value gaps, to be precise), since x is free in $\neg\phi$ too and hence neither the formula itself nor its negation are true. The decision between these options is not as simple as it might look. Take an arbitrary sentence containing a "free" pronoun.

(65) He is a lawyer.

It is hard to judge whether this sentence is true or false (or neither) even if we knew everything about the world, as long as we do not know what *he* refers to. Unequivocally, it is true if there are only lawyers all over the world. Hence the second version is not completely upside down, although it might be too strong. The third option, which only requires that there is at least one lawyer, is presumably too weak. The first option leads to very counterintuitive results.

(66) If she_i is a lawyer, she_i is a lawyer.

This sentence is intuitively true no matter who *she* is or how the world looks like, but according to truth definition No. 1, it lacks a truth value, while it is true both under the second and third truth definition. The second one is not very convincing either, since under this definition, any formula with unsatisfiable presuppositions would be a tautology. Take "$P(x) \wedge \exists x.\neg P(x)$" as an example. Its interpretation is just the empty function since "x" cannot be new and old at the same time. Nevertheless it is true in every model according to $\models_{\mathcal{M}}^{2}$. Hence it should be required that the formula is defined at least in one context. A combination of the second and the third option is closest to intuition.

Definition 3.22 Truth in a Model

$\models_{\mathcal{M}}\phi$ iff $\models_{\mathcal{M}}^{2} \phi$ and $\models_{\mathcal{M}}^{3} \phi$

This discussion illustrates once again the fact that truth conditions are not fine-grained enough to describe meanings sufficiently.

The definition of **logical truth** is now obvious.

Definition 3.23 Logical Truth

$\vDash \phi$ iff for any model $\mathcal{M}$: $\vDash_{\mathcal{M}} \phi$

Before defining entailment formally, we have to decide how an intuitively satisfactory dynamic consequence relation should look. The following deduction is surely valid.

(67) A man_i is in Athens.

He_i is in Athens.

But the next deduction obviously is not valid.

(68) A man_i is in Athens.

There are men and every man is in Athens.

Hence the traditional definition of entailment ("The consequence is true in every model/index where the premises are true") would lead to absurd results (remember that "P(x)" and "$\exists$x.P(x) $\wedge$ $\forall$y.P(y)" have the same truth conditions). Therefore this definition has to be modified slightly.

Definition 3.24 Entailment

$\phi \vDash_{\mathcal{M}} \psi$ iff for all contexts ct: ct $\vDash_{\mathcal{M}} \phi$ implies ct $\vDash_{\mathcal{M}} (\phi \wedge \psi)$

$\phi \vDash \psi$ iff for all models $\mathcal{M}$: $\phi \vDash_{\mathcal{M}} \psi$

This ensures that entailment is dynamic in that an existential quantifier in the premise licenses a free variable in the conclusion. As an example, it holds that "$\exists$x.P(x) $\vDash$ P(x)", which corresponds to (67).

To see that the effort pays, let us consider an example where static semantics fails to predict the correct entailments.

(69) a. If someone_i is a man, (s)he_i is mortal.

Socrates is a man.

Socrates is mortal.

b. $(\exists x.\mathbf{man'}(x) \rightarrow \mathbf{mortal'}(x)) \wedge \mathbf{man'}(\mathbf{s'}) \vDash \mathbf{mortal'}(\mathbf{s'})$

$\forall \mathcal{M}$,ct:[ct $\sqsubseteq$ ct$[(\exists x.\mathbf{man'}(x) \rightarrow \mathbf{mortal'}(x)) \wedge \mathbf{man'}(\mathbf{s'})]_{\mathcal{M}} \rightarrow$

ct $\sqsubseteq$ ct$[(\exists x.\mathbf{man'}(x) \rightarrow \mathbf{mortal'}(x)) \wedge \mathbf{man'}(\mathbf{s'}) \wedge \mathbf{mortal'}(\mathbf{s'})]_{\mathcal{M}}$

1. $ct \sqsubseteq ct[(\exists x.\mathbf{man'}(x) \rightarrow \mathbf{mortal'}(x)) \wedge \mathbf{man'}(\mathbf{s'})]_{\mathcal{M}}$
2. $x \notin Dom(ct)$
3. $ct[(\exists x.\mathbf{man'}(x) \rightarrow \mathbf{mortal'}(x)) \wedge \mathbf{man'}(\mathbf{s'})]_{\mathcal{M}} = ct$ iff
   $\|\mathbf{man'}\|_{\mathcal{M}} \subseteq \|\mathbf{mortal'}\|_{\mathcal{M}}$ and $\|\mathbf{s'}\|_{\mathcal{M}} \in \|\mathbf{man'}\|_{\mathcal{M}}$, **0** else
4. $ct \not\sqsubseteq \mathbf{0}$
5. $\|\mathbf{man'}\|_{\mathcal{M}} \subseteq \|\mathbf{mortal'}\|_{\mathcal{M}}$ and $\|\mathbf{s'}\|_{\mathcal{M}} \in \|\mathbf{man'}\|_{\mathcal{M}}$
6. $\|\mathbf{s'}\|_{\mathcal{M}} \in \|\mathbf{mortal'}\|_{\mathcal{M}}$
7. $ct[\mathbf{mortal'}(\mathbf{s'})]_{\mathcal{M}} = ct$ iff $\|\mathbf{s'}\|_{\mathcal{M}} \in \|\mathbf{mortal'}\|_{\mathcal{M}}$, **0** else
8. $\forall ct'$: $ct'[\mathbf{mortal'}(\mathbf{s'})]_{\mathcal{M}} = ct'$
9. $ct[(\exists x.\mathbf{man'}(x) \rightarrow \mathbf{mortal'}(x)) \wedge \mathbf{man'}(\mathbf{s'})]_{\mathcal{M}} = ct$
10. $ct[(\exists x.\mathbf{man'}(x) \rightarrow \mathbf{mortal'}(x)) \wedge \mathbf{man'}(\mathbf{s'}) \wedge \mathbf{mortal'}(\mathbf{s'})]_{\mathcal{M}} = ct$
11. $ct \sqsubseteq ct[(\exists x.\mathbf{man'}(x) \rightarrow \mathbf{mortal'}(x)) \wedge \mathbf{man'}(\mathbf{s'}) \wedge \mathbf{mortal'}(\mathbf{s'})]_{\mathcal{M}}$

□

2.4 Dynamic Extensional Type Theory

The aim of the whole enterprise is the combination of the theoretical insights and the empirical coverage of File Change Semantics with the methodological rigor of Montague Semantics. But at the present stage, we are rather in the position of Pre-Montagovian semanticists. We have developed a logical calculus which shows some features that are very desirable for linguistic semantics, but there is no link between English or any other natural language and EDPL besides an intuitive correspondence relation between English sentences and EDPL-formulae. Particularly, there are no direct EDPL-counterparts to English lexemes like *every*, *a*, *be* etc. In general, it is impossible to formulate a compositional translation function between English and any first-order language. The consequence that a higher-order language is necessary seems inevitable. Specifically, the language has to be augmented with the λ-operator. At first glance, this does not seem to be too difficult. We could simply extend the syntax and the semantics of EDPL with some additional clauses:

(70) a. Besides individual variables, there are predicate variables V_n' , V_n'' ..., ranging over n-ary predicates.
b. If ϕ is a formula and v is a variable, $\lambda v.\phi$ is a predicate.

(71) $\|\lambda x.a(b)\|_g = \|a\|_h$, where h is exactly like g besides it maps x to $\|b\|_g$

But this strategy causes serious problems, since assignments are already occupied by their dynamic functions. EDPL-formulae are interpreted as updates, i.e. functions from sets of assignments to sets of assignments. Hence their interpretation cannot depend on some particular assignment. But this dependency is necessary to make λ-conversion work. As it turns out, the dynamics of EDPL blocks an extension of the language with the λ-operator in the usual way.

G&S['91a], elaborating on Janssen['84], make a really ingenious proposal to overcome this difficulty. They observe that this problem is similar in nature to the semantics of intensional contexts.

(72) It is possible that John is a lawyer.

As everybody knows, the (extensional) meaning of this sentence (its truth value in static semantics) does not depend functionally on the meaning/truth value of the embedded clause. The modal operator *possible* acts like an existential quantifier over possible worlds, and the embedded clause is evaluated w.r.t. the worlds introduced by this quantifier, not only to the actual world. The conclusion Montague draws from this observation is that the meaning of the complement clause in is not its truth value but a proposition, i.e. a characteristic function over the set of possible worlds. Similarly, the dynamic existential quantifier introduces new assignment functions, and formulae following such a quantifier have to be interpreted w.r.t. to these new assignments. Hence it is convenient to use the technical tools developed in Montague's Intensional Logic but to replace worlds by assignments. Accordingly, the dynamic existential quantifier becomes literally a modal operator, and the logical counterparts of pronouns, variables in EDPL, are formally not any longer variables, but rather a special kind of constant. Hence "ordinary" variables become free to be used to define λ-abstraction.

The concrete realization of these ideas that is presented here differs in some respects from G&S's Dynamic Montague Grammar. The most important modification is the use of partial sequences instead of total ones[10]. This reflects just the difference between DPL and EDPL at the first-order level and therefore makes a crucial difference. The second point is rather a matter of taste. G&S start to define a full-grown static type theory with truth-conditional sentence connectives, quantifiers etc. The dynamic connectives and quantifiers are derived from the static ones and are actually abbreviations of quite complex static expressions. I think that it is more convenient to define the dynamic operators as logical constants, but I suppose that this does not make a real difference. The major advantage of my strategy is the fact that Dynamic Extensional Type Theory (DETT for short) is syntactically as close to EDPL as possible.

[10]To be precise, G&S use "states" instead of possible worlds, where states are primitive entities, and the "dynamic variables" (discourse markers) denote functions from states to individuals. But every G&S-state defines a unique total sequence (by application of the function $\lambda s \lambda d.F(d)(s)$), and hence it makes no practical difference whether the "worlds" are identified with states or sequences. For a more extensive discussion of the issue, see Beaver['93], p. 22.

2.4.1 The Syntax of DETT

As mentioned above, besides "ordinary" constants and "ordinary" variables, there is a third kind of nonlogical expression in DETT, which play much the same role as variables in EDPL. Following G&S['91a], I call these entities **discourse markers**. For simplicity, they are identified with natural numbers, although it should be kept in mind that the ordering plays no role here. There are some new types and operators in EDPL, but for the reader who knows Intensional Logic, this should not cause major problems.

Definition 4.1 Types
TYPE, the set of types of DETT, is the smallest set such that:
e,t,up $\in$ TYPE,
If α and $\beta \in$ TYPE, $<\alpha,\beta> \in$ TYPE.
If $\alpha \in$ TYPE, $<s,\alpha> \in$ TYPE

Definition 4.2 Vocabulary
For any type $\tau \in$ TYPE, $Con_\tau = \{c_\tau, c_\tau', c_\tau'', ...\}$ are the constants of type τ.
$Con = \cup_{\tau \in TYPE} Con_\tau$.
For any type $\tau \in$ TYPE, $Var_\tau = \{v_\tau, v_\tau', v_\tau'', ...\}$ are the variables of type τ.
$Var = \cup_{\tau \in TYPE} Var_\tau$
DM = $\mathbb{N}$ is the set of discourse markers.
DETT = Con $\cup$ Var $\cup$ DM $\cup$ $\{=,\wedge,\neg,\Uparrow,\Downarrow,{}^\wedge,{}^\vee,\lambda,\exists,\forall,\mathfrak{E},(,),.\}$

Definition 4.3 The Syntax of DETT
Exp, the set of well-formed expressions of DETT, is the smallest set such that

i) If $\alpha \in VAR_\tau \cup CON_\tau$, $\alpha \in Exp_\tau$
ii) If $\alpha \in DM$, $\alpha \in Exp_e$
iii) If $\alpha \in Exp_{<\sigma,\tau>}$ and $\beta \in Exp_\sigma$, $(\alpha(\beta)) \in Exp_\tau$
iv) If $\alpha \in Exp_\tau$ and $v \in VAR_\sigma$, $(\lambda v.\alpha) \in Exp_{<\sigma,\tau>}$
v) If $\alpha \in Exp_\tau$ and $\beta \in Exp_\tau$, $(\alpha = \beta) \in Exp_{up}$
vi) If $\phi \in Exp_{up}$, $(\neg\phi) \in Exp_{up}$
vii) If $\phi \in Exp_{up}$ and $v \in VAR$, $\exists v.\phi \in Exp_{up}$
viii) If $\phi \in Exp_{up}$ and $v \in VAR$, $\forall v.\phi \in Exp_{up}$
ix) If $\phi \in Exp_{up}$ and $d \in DM$, $\mathfrak{E}d.\phi \in Exp_{up}$
x) If $\phi,\psi \in Exp_{up}$, $(\phi\wedge\psi) \in Exp_{up}$
xi) If $\phi \in Exp_t$, $\Uparrow\phi \in Exp_{up}$
xii) If $\phi \in Exp_{up}$, $\Downarrow\phi \in Exp_t$
xiii) If $\phi \in Exp_\tau$, ${}^\wedge\phi \in Exp_{<s,\tau>}$

xiv) If $\phi \in Exp_{<s,\tau>}$, $^{\vee}\phi \in Exp_{\tau}$

xv) For all $\tau \in$ TYPE, if $\alpha \in Exp_{\tau}$, $\alpha \in Exp$

Following the usual conventions, we omit brackets where possible, and we write $\phi \vee \psi$ for $\neg(\neg\phi \wedge \neg\psi)$, $\phi \rightarrow \psi$ for $\neg(\phi \wedge \neg\psi)$, $\top$ for $\exists$v.v=v, $\bot$ for $\neg\exists$v.v=v, $\alpha \neq \beta$ for $\neg(\alpha = \beta)$, and $\mathscr{A}$d.ϕ for $\neg\mathscr{E}$d.$\neg\phi$.

One might object that the usage of a third basic type ("up" for "update") besides the usual ones ("e" and "t") complicates ontology in comparison with DMG, but this is not really a problem, since, as we will see immediately, the interpretations of DETT-expressions are made from individuals, truth values and natural numbers only, just like in DMG or FCS.

2.4.2 Models, Domains and Contexts

Although DETT has an intensional outfit, the interpretations of DETT-expressions are purely extensional entities (that's why it is called Dynamic **Extensional** Type Theory). Hence DETT-models do not differ significantly from models for a static extensional type theory.

Definition 4.4 Model for DETT

A model $\mathscr{M}$ for DETT is an ordered pair <E,F>, where

- E is a denumerable infinite set, the individual domain, and
- F is a function that maps each DETT-constant of type τ to an element of Dom(τ).

The counterpart of possible worlds in IL are good old **sequences**, i.e. total functions from the set of discourse markers into the individual domain, just as in DIL. These objects are familiar from FCS.

Definition 4.5 Sequences

$S =_{def} E^{DM}$

The definition of a **context** is much the same as in EDPL, with the technical difference that we have discourse markers instead of variables and partial sequences instead of assignments. Crucially important is the fact that interpretation is relativized to **total** sequences, while contexts are made from **partial** ones. Hence a reduction of the type "up" to "<<s,t>,<s,t>>" or to "<s,<<s,t>,t>>", as in DIL, is impossible here.

Definition 4.6 Contexts

A context ct is a set of sequences which share their domain.

$CT =_{def} \bigcup_{D \subseteq DM} POW(E^{D})$

The various orderings and algebraic operations over the set of contexts (context inclusion, informativity, completion, join, meet, ...) and the designated contexts **0** and **1** are analogous to the corresponding notions in EDPL. I therefore omit the definitions here.

Definition 4.7 Domains
$\mathrm{Dom}(e) =_{def} E$
$\mathrm{Dom}(t) =_{def} \{1,0\}$
$\mathrm{Dom}(up) =_{def} \bigcup_{f,n \subseteq DM,\, f\cap n = \emptyset} \{u \in CT^{\{ct \mid f \subseteq \mathrm{Dom}(ct)\}} \cap \mathit{POW}(\leq) \mid$
$\forall ct\,[\,\mathrm{Dom}(u(ct)) - \mathrm{Dom}(ct) = n]\} \cup \{\emptyset\}$
For all types $\tau,\sigma \in$ TYPE:
$\mathrm{Dom}(<s,\tau>) =_{def} \mathrm{Dom}(\tau)^S$
$\mathrm{Dom}(<\sigma,\tau>) =_{def} \mathrm{Dom}(\tau)^{\mathrm{Dom}(\sigma)}$

A few comments on the definition of Dom(up) might be in order. in EDPL, all upward monotonic partial functions on contexts were considered to updates. Nevertheless, only a part of this domain occurred as possible interpretation of a formula. Undefinedness only occurred as consequence of a violation of the counterpart of the Novelty-Familiarity-Condition. Consequently, for any EDPL-formula interpretation, there are two mutually exclusive fixed sets "f" and "n" of familiar and new variables respectively such that any context in the domain of the update includes f and excludes n. The domain of the output of the updates differs from the domain of the input exactly insofar that it also includes n.

Since in DETT, there are also type-up constants and variables, we have to ensure that their interpretations show these properties too. This is the idea behind the first part of the definition. Since this set excludes the empty function, but the latter may occur as interpretation of certain complex formulae (like the DETT-counterpart of "$P(x) \wedge \forall x.P(x)$"), the empty function has to be added to Dom(up) explicitly.

2.4.3 The Semantics of DETT

Variables (as opposed to discourse markers) are interpreted by means of assignment functions in the usual way.

Definition 4.8 Assignments
The set G of assignment functions is the set of functions that have the set of variables as their domain and assign to each variable of type τ an element of $\mathrm{Dom}(\tau)$.

If $g \in G$, $x \in Var_\tau$, and $a \in \mathrm{Dom}(\tau)$, it holds that
$$g[x/a] =_{def} \iota f(f \in G \wedge f(x) = a \wedge \forall y[y \neq x \rightarrow f(y) = g(y)])$$

Before the we can give the semantics of DETT, we need the notion of the **open discourse markers** of a DETT-expression as a prerequisite. A discourse marker d in a DETT-expression α is called "open" iff the meaning of the expressions properly depends on the value d receives under different sequences.

Definition 4.9 Open Discourse Markers

$\forall s,s',d[s \sim_d s' \equiv_{def} \mathrm{Dom}(s-s') = \mathrm{Dom}(s'-s) = \{d\}]$

$\forall d,g[d \in od(\alpha) \equiv_{def} \exists s,s'[s \sim_d s' \wedge \|\alpha\|_{g,s} \neq \|\alpha\|_{g,s'}]$

The definitions for formulae (type-up-expressions) are again given in postfix notation. Relativization to the model $\mathcal{M}$ is omitted for convenience.

Definition 4.10 Semantics of DETT

For any model $\mathcal{M}$= <E,F>, g $\in$ G and s $\in$ S, it holds that

i) $\|c\|_{g,s} =_{def} F(c)$ iff $c \in$ Con,

ii) $\|v\|_{g,s} =_{def} g(v)$ iff $v \in$ Var,

iii) $\|d\|_{g,s} =_{def} s(d)$ iff $d \in$ DM,

iv) $\|\alpha(\beta)\|_{g,s} =_{def} \|\alpha\|_{g,s}(\|\beta\|_{g,s})$,

v) $\|\lambda v_\tau.\alpha_\sigma\|_{g,s} =_{def} \iota f(f \in \mathrm{Dom}(<\tau,\sigma>) \wedge \forall x: f(x) = \|\alpha\|_{g[v/x],s})$,

vi) $\|{}^\wedge\alpha_\tau\|_{g,s} =_{def} \iota f(f \in \mathrm{Dom}(<s,\tau>) \wedge \forall t \in S: f(t) = \|\alpha\|_{g,t})$,

vii) $\|{}^\vee\alpha\|_{g,s} =_{def} \|\alpha\|_{g,s}(s)$,

viii) $ct[\alpha = \beta]_{g,s} =_{def} \{t \in ct|\forall s'[t \subseteq s' \rightarrow \|\alpha\|_{g,s'} = \|\beta\|_{g,s'}]\}$
iff $od(\alpha) \cup od(\beta) \subseteq \mathrm{Dom}(ct)$, undefined else[11],

ix) $ct[\neg\phi]_{g,s} =_{def} ct - \{t| \exists t': t \subseteq t' \wedge t' \in ct[\phi]_{g,s}\}$,

x) $ct[\phi\wedge\psi]_{g,s} =_{def} ct[\phi]_{g,s}[\psi]_{g,s}$,

xi) $ct[\exists v_\tau.\phi]_{g,s} =_{def} \bigsqcup_{x \in \mathrm{Dom}(\tau)} ct[\phi]_{g[v/x],s}$,

xii) $ct[\forall v_\tau.\phi]_{g,s} =_{def} \bigsqcap_{x \in \mathrm{Dom}(\tau)} ct[\phi]_{g[v/x],s}$,

xiii) $ct[\mathcal{E}d.\phi]_{g,s} =_{def} (compl(ct)\backslash(\mathrm{Dom}(ct) \cup \{d\}))[\phi]_{g,s}$
iff $d \notin \mathrm{Dom}(ct)$, undefined else,

xiv) $ct[\Uparrow\alpha]_{g,s} =_{def} \{t \in ct| \forall s'[t \subseteq s' \rightarrow \|\alpha\|_{g,s'} = 1]\}$
iff $od(\alpha) \subseteq \mathrm{Dom}(ct)$, undefined else,

xv) $\|\Downarrow\phi\|_{g,s} =_{def} 1$ iff $\|\phi\|_{g,s} \neq \varnothing \wedge$
$\forall t[t \subseteq s \wedge \{t\}[\phi]_{g,s}$ is defined $\rightarrow \{t\}[\phi]_{g,s} \neq \mathbf{0}]$.

Contrary other extensional type theories, the interpretation of an expression is relativized not only to the model and the assignment function, but to sequences too. In particular, the

[11] Note that the **interpretation** of α=β **is** defined in every index. This interpretation may be a partial function, but this is another story. In other words, DETT is **not** a partial logic in the sense of Muskens['89].

interpretation of the discourse markers immediately depends on the particular sequence. If we borrow the terminology of possible-world semantics, constants and variables are rigid expressions. It is noteworthy that in the clauses where updates are built from the meanings of non-update-type expressions (identity and up-arrow), the interpretation does not depend on the particular sequence either, and this property is transferred to complex updates. But on the other hand, whether an update provides an output in a certain input context depends on the domain of the input. Hence we have to distinguish between **open** and **familiar** discourse markers. The definition of "open discourse marker" is given above. It says that the **interpretation** of an expression depends on the interpretation of certain discourse markers. It is important that the set of open discourse markers does not necessarily depend on the syntactic form of the expression. By way of illustration, consider the following examples, where a discourse marker not bound by a quantifier is not open, and one where an open discourse marker does not occur syntactically:

(73) a. $od({}^\wedge 8) = \emptyset$

b. Suppose it holds that $\forall g,s$: $\|intension\_of\_five_{<s,e>}\|_{g,s} = \|{}^\wedge 5\|_{g,s}$.

Then $od({}^\vee intension\_of\_five) = \{5\}$

The set of familiar discourse markers, on the other hand, is defined only for updates. It contains those discourse markers that matter for the **output** of the update when applied to a particular input.

Definition 4. 11 Familiar Discourse Markers

For all $\phi \in Exp_{up}$, it holds that:

$fd(\phi) =_{def} Dom(\bigsqcup \{ct|\ ct[\phi] \text{ is defined}\})$

The notion of familiar discourse markers of a formula corresponds to the notions of old discourse referents in DRT or familiar file cards in FCS. Obviously, there is a close connection between open and familiar d-markers.

Fact 4.1

i) $fd(\alpha=\beta) = od(\alpha) \cup od(\beta)$

ii) $fd(\Uparrow\alpha_t) = od(\alpha)$

iii) $od(\Downarrow\phi) \subseteq fd(\phi)$

The last clause follows from the following fact which is a consequence of the way Dom(up) is defined.

Fact 4.2
For all models $\mathcal{M}$, sequences s, assignments g, contexts ct and ct', and formulae $\phi \in Exp_{up}$, it holds that:

i) $[ct[\phi]_{g,s}$ is defined $\equiv$ $ct'[\phi]_{g,s}$ is defined] if Dom(ct) = Dom(ct'),

ii) $(ct \sqcup ct')[\phi]_{g,s}$ is defined if $ct[\phi]_{g,s}$ and $ct'[\phi]_{g,s}$ are defined.

Note that the implications go only in one direction.

The clauses of the intensor and the extensor are equivalent to the corresponding ones in IL. Identity is a straightforward generalization of the corresponding notion in EDPL, but since it is a relation between meanings of arbitrary types now, it allows for instance to state equivalence between updates in the object language itself and not only in the metalanguage as in the EDPL-paragraphs. Negation and conjunction are analogous to the EDPL-connectives, and **dynamic existential quantification** ("$\mathcal{E}$") is practically equivalent to $\exists$ in EDPL, too, except that we have discourse markers instead of variables. The definition of **static existential quantification** ("$\exists$") and **static universal quantification** ("$\forall$") is an extrapolation of the following properties of quantification in IL into DETT.

(74) a. $\{<w,t>|\ \|\exists v_\tau.\phi\|_{w,t,g} = 1\} = \bigcup_{x\in Dom(\tau)} \{<w,t>|\ \|\phi\|_{w,t,g[v/x]} = 1\}$

b. $\{<w,t>|\ \|\forall v_\tau.\phi\|_{w,t,g} = 1\} = \bigcap_{x\in Dom(\tau)} \{<w,t>|\ \|\phi\|_{w,t,g[v/x]} = 1\}$

Static universal quantification is not definable in terms of existential quantification and negation, since negation (and hence also $\neg\exists v\neg$) blocks the dynamic binding potential of the formula in its scope, while static universal quantification does not.

Up-arrow and down-arrow provide a tool to switch between static meanings (truth conditions) and dynamic ones (updates). Let us start with up-arrow. What does it mean to update a context, i.e. a set of partial sequences, with a static formula? The most natural way to do so is simply to filter out those sequences in the context that fail to make the formula true. But this only works if the context happens to consist only of total sequences. In the more common case where a context consists of properly partial sequences, we have to complete these partial objects to make them legitimate indices for the evaluation of the formula. But then we get values for discourse markers that were not in the domain of the original sequence. Hence we have to ensure that these discourse markers do not matter for evaluation, i.e. are not open in the formula.

The argumentation is similar with down arrow. Intuitively, an update is true w.r.t. a particular sequence if and only if the update can felicitously be applied to the maximal context that consists only of this sequence. But if the update contains an occurrence of the dynamic existential quantifier, there is no output defined. Therefore we restrict attention to those values the sequence defines that in fact matter for the interpretation of the update. In principle, up-arrow is definable from down-arrow, identity and tautology.

Fact 4.3 Definability of $\Uparrow$

For all $\alpha \in Exp_t$, sequences s, and assignments g, it holds that

$$\|\Uparrow\alpha\|_{g,s} = \|(\alpha = \Downarrow\top)\|_{g,s}$$

The proof follows immediately from

Fact 4.4 Tautology

For all sequences s and assignments g:

(i) $\|\Downarrow\top\|_{g,s} = 1$

Proof:

1. $\|\Downarrow\top\|_{g,s} = \|\Downarrow\exists v.v{=}v\|_{g,s}$ % definition of $\top$
2. $\|\Downarrow\top\|_{g,s} = 1$ iff $\{s\}\backslash od(\exists v.v{=}v)[\exists v.v{=}v]_{g,s} \neq \mathbf{0}$
3. $od(\exists v.v{=}v) = \emptyset$
4. $\{s\}\backslash\emptyset = \mathbf{1}$
5. $\mathbf{1}[\exists v_\tau.v{=}v]_{g,s} = \bigsqcup_{x \in Dom(\tau)} \mathbf{1}[v{=}v]_{g[v/x],s}$
6. $\mathbf{1}[\exists v_\tau.v{=}v]_{g,s} = \bigsqcup_{x \in Dom(\tau)} \mathbf{1}$
7. $\mathbf{1}[\exists v.v{=}v]_{g,s} = \mathbf{1} \neq \mathbf{0}$

□

As can be seen from the proof, the interpretation of the tautology is in fact the identity function on contexts. Contradiction, on the other hand, maps any input to the absurd context **0**.

Down-arrow makes the definition of truth in a context, truth in a model, and logical truth rather simple.

Definition 4.12 Truth

For all models $\mathcal{M}$, contexts ct, and formulae $\phi \in Exp_{up}$, it holds that:

$ct \vDash_{\mathcal{M}} \phi$ iff $\forall s,g[s \in compl(ct) \rightarrow \|\Downarrow\phi\|_{\mathcal{M},g,s} = 1]$

$\vDash_{\mathcal{M}} \phi$ iff $\forall s,g{:}\ \|\Downarrow\phi\|_{\mathcal{M},g,s} = 1$

$\vDash \phi$ iff $\forall \mathcal{M},s,g{:}\ \|\Downarrow\phi\|_{\mathcal{M},g,s} = 1$

Note that again, a formula containing free variables or familiar discourse markers that are not in the domain of the context of evaluation is true if and only if the corresponding universally quantified formula is true.

The corresponding notions of entailment are straightforward.

Definition 4.13 Entailment

For all models $\mathscr{M}$, contexts ct, and formulae $\phi,\psi \in \mathrm{Exp}_{up}$, it holds that:

$$\phi \vDash_{\mathscr{M},ct} \psi \quad \text{iff } \forall s,g: ct[\phi]_{\mathscr{M},s,g} \vDash_{\mathscr{M}} \psi$$
$$\phi \vDash_{\mathscr{M}} \psi \quad \text{iff } \forall ct,s,g[ct[\phi]_{\mathscr{M},s,g} \text{ is defined } \rightarrow ct[\phi]_{\mathscr{M},s,g} \vDash_{\mathscr{M}} \psi]$$
$$\phi \vDash \psi \quad \text{iff } \forall \mathscr{M},ct,s,g[ct[\phi]_{\mathscr{M},s,g} \text{ is defined } \rightarrow ct[\phi]_{\mathscr{M},s,g} \vDash_{\mathscr{M}} \psi]$$

As already mentioned, syntactic identity allows to state identity of interpretation. This is not as trivial as in static semantics since an identity statement in DETT is interpreted as an update and hence does not have a truth value *per se*.

Fact 4.5 Identity

For all models $\mathscr{M}$ and type-identical expressions α and β, it holds that:

$$\vDash_{\mathscr{M}} (\alpha = \beta) \text{ iff } \forall s,g: \|\alpha\|_{\mathscr{M},s,g} = \|\beta\|_{\mathscr{M},s,g}$$

Proof (left to right):

1. $\vDash_{\mathscr{M}} \alpha = \beta$
2. $\forall s,g: \|\Downarrow(\alpha=\beta)\|_{g,s} = 1$
3. $\forall s,g,t[\ t \subseteq s \wedge \{t\}[\alpha=\beta]_{g,s} \text{ is defined} \rightarrow \{t\}[\alpha=\beta]_{g,s} \neq \mathbf{0}]$
4. $\forall s,g,t[\ t \subseteq s \wedge od(\alpha) \cup od(\beta) \subseteq Dom(\{t\}) \rightarrow \{t\}[\alpha=\beta]_{g,s} \neq \mathbf{0}]$
5. $\forall s,s',g,t[\ t \subseteq s \wedge od(\alpha) \cup od(\beta) \subseteq Dom(\{t\}) \wedge t \subseteq s' \rightarrow \|\alpha\|_{g,s'} = \|\beta\|_{g,s'}\ ]$
6. $\forall s,s',g,t[\ t \subseteq s \cap s' \wedge od(\alpha) \cup od(\beta) \subseteq Dom(\{t\}) \rightarrow \|\alpha\|_{g,s'} = \|\beta\|_{g,s'}\ ]$
7. $\forall s,s',g[\ od(\alpha) \cup od(\beta) \subseteq Dom(\{s \cap s'\}) \rightarrow \|\alpha\|_{g,s'} = \|\beta\|_{g,s'}\ ]$
8. $od(\alpha) \subseteq Dom(\{s \cap s'\}) \rightarrow \|\alpha\|_{g,s} = \|\alpha\|_{g,s'}$
9. $\forall s,g[\ \|\alpha\|_{g,s} = \|\beta\|_{g,s}\ ]$

□

The crucial step is line 8. Its validity follows immediately from the definition of open discourse markers, and it implies that the interpretation of both α and β is identical under s and s' in line 7. The proof in the other direction is obvious.

λ-conversion holds with roughly the same restrictions as in DIL.

Fact 4.6 λ-Conversion

$\vDash \lambda v.\alpha(\beta) = [\beta/v]\alpha$ if:

i) all free variables in β are free for v in α, and
ii) for every subexpression γ of α that contains v as a subexpression, it holds that:

$$od(\beta) \subseteq od([\beta/v]\gamma).$$

The second clause ensures that no d-marker open in β becomes closed after λ-conversion.

Especially, if β contains open d-markers, v must not stand in the scope of "^", "$\Uparrow$", or "=" in α.

Fact 4.7 $^{\vee\wedge}$-Elimination

$$\vDash \ {}^{\vee\wedge}\alpha = \alpha$$

This theorem is of course familiar from IL, and it is equally familiar that $^{\wedge\vee}\alpha = \alpha$ only holds if α is intensionally closed, i.e. od(α) = Ø in DETT.

Up-arrow and down-arrow behave similarly in this respect.

Fact 4.8 $\Downarrow\Uparrow$-Elimination

$$\vDash \ \Downarrow\Uparrow\alpha = \alpha$$

$\Uparrow\Downarrow\phi = \phi$ is only valid if ϕ is **statically closed**, i.e. ϕ does not introduce **new discourse markers**.

Definition 4.14 New Discourse Markers

$$nd(\phi) =_{def} Dom(\bigsqcup\{ct|\ ct[\phi] \text{ is defined}\}[\phi]) - fd(\phi)$$

The way Dom(up) is defined ensures that a given update introduces the same set of discourse markers in every context it is applied to.

Fact 4.9

For all models $\mathscr{M}$, sequences s, assignments g, contexts ct, and formulae $\phi \in Exp_{up}$, it holds that:

$$nd(\phi) = Dom(ct[\phi]_{g,s}) - Dom(ct)$$

There are several rules that specify how the sets of familiar and new d-markers of a complex update depend on the respective sets of their parts.

Fact 4.10

i) $fd(\phi\wedge\psi) = fd(\phi) \cup (fd(\psi) - nd(\phi))$

$nd(\phi\wedge\psi) = nd(\phi) \cup nd(\psi)$

ii) $fd(\neg\phi) = fd(\phi)$

$nd(\neg\phi) = \emptyset$

iii) $fd(\mathfrak{E}d.\phi) = fd(\phi) - \{d\}$

$nd(\mathfrak{E}d.\phi) = nd(\phi) \cup \{d\}$

iv) $fd(\exists v.\phi) = fd(\forall v.\phi) = fd(\phi)$

$nd(\exists v.\phi) = nd(\forall v.\phi) = nd(\phi)$

The facts are all well-known from EDPL; newly introduced d-markers in the first conjunct dynamically bind familiar ones in the second conjunct, negation closes off the dynamic binding potential of newly introduced d-markers while the familiar ones are unaffected, and the dynamic existential quantifier introduces a new d-marker.

The close connection between DETT and EDPL ensures that the crucial equivalences (and non-equivalences) that hold in DETT are also valid in DETT. Commutativity still requires a further restriction.

Definition 4.15 Distributivity
An update ϕ is called **distributive** iff for all Models $\mathcal{M}$, contexts ct, sequences s and assignments g, it holds that:

$$ct[\phi]_{\mathcal{M}s,g} = \bigcup_{i \in ct} \{i\}[\phi]_{\mathcal{M}s,g}$$

Fact 4.11

i) Associativity of dynamic conjunction

$$\vDash ((\phi \wedge \psi) \wedge \chi) = (\phi \wedge (\psi \wedge \chi))$$

ii) Dynamic binding

$$\vDash \mathcal{E}d.\ \phi \wedge \psi = \mathcal{E}d.\ (\phi \wedge \psi)$$

iii) Restricted commutativity

$$\vDash \phi \wedge \psi = \psi \wedge \phi$$

iff $nd(\phi) \cap fd(\psi) = nd(\psi) \cap fd(\phi) = \emptyset$ and both ϕ and ψ are distributive

iv) Restricted law of double negation

$$\vDash \phi = \neg\neg\phi \quad \text{iff } nd(\phi) = \emptyset$$

v) Donkey equivalence

$$\vDash \mathcal{E}d.\phi \rightarrow \psi = \mathcal{A}d(\phi \rightarrow \psi)$$

2.4.4 DETT and DIL

For the readers that are familiar with G&S's Dynamic Intensional Logic, the relation between this logic and DETT will be sketched. The syntax of both languages is closely related. Both have e and t as basic types and allow for intensional types. Hence all the DIL-constants and -variables are at the same time DETT-constants and -variables. As long as the set of discourse markers in DIL is a denumerably infinite set, these expressions may be identified too. But since DETT makes use of a third basic type "up", the nonlogical vocabulary of DIL is a proper subset of that of DETT.

Things are similar w.r.t. the semantics. From the last sentence, it follows immediately that every DETT-interpretation-function can be restricted to a DIL-interpretation function. Hence there is a simple function from DETT-models to DIL-models.

Definition 4.16 Model Correspondence
For every DETT-model $\mathcal{M}_{DETT} = \langle E, F_{DETT}\rangle$, there is a unique DIL-model $\mathcal{M}_{DIL} = \langle E, S, F_{DIL}\rangle$ such that:

i) $S = E^{DM}$

ii) $\forall s \in S, d \in DM : F_{DIL}(d)(s) =_{def} s(d)$

iii) $\forall c \in (Con_{DIL} - DM): F_{DIL}(c) =_{def} F_{DETT}(c)$

With this background, it is possible to define a simple compositional translation function from a very large fragment of DIL into DETT. This fragment includes all DIL-expressions G&S['91a] use in their Dynamic Montague Grammar.

Definition 4.17 Translation DIL ==> DETT
$[\![\alpha]\!]$ is the DETT-translation of the DIL-expression α.

i)	$[\![\alpha]\!] = \alpha$		iff $\alpha \in Con_{DIL} \cup Var_{DIL} \cup DM$
ii)	$[\![\alpha(\beta)]\!] = [\![\alpha]\!]([\![\beta]\!])$		
iii)	$[\![\alpha \wedge \beta]\!]$	$= \Downarrow(\Uparrow[\![\alpha]\!] \wedge \Uparrow[\![\beta]\!])$	
iv)	$[\![\neg\alpha]\!]$	$= \Downarrow\neg\Uparrow[\![\alpha]\!]$	
v)	$[\![\exists v.\alpha]\!]$	$= \Downarrow\exists v.\Uparrow[\![\alpha]\!]$	
vi)	$[\![\alpha = \beta]\!]$	$= \Downarrow([\![\alpha]\!] = [\![\beta]\!])$	
vii)	$[\![\lambda v.\alpha]\!] = \lambda v.[\![\alpha]\!]$		
viii)	$[\![\{\alpha/d\}\beta]\!]$	$= \Downarrow(\mathcal{E}d.\ d = [\![\alpha]\!] \wedge \Uparrow[\![\beta]\!])$	iff $\beta \in Exp_t$
ix)	$[\![\{\alpha/d\}\beta]\!]$	$= \lambda v_\tau \Downarrow(\mathcal{E}d.\ d = [\![\alpha]\!] \wedge \Uparrow[\![\beta]\!](v))$	iff $\beta \in Exp_{\langle\tau,t\rangle}$
x)	$[\![{}^\wedge\alpha]\!]$	$= {}^\wedge[\![\alpha]\!]$	
xi)	$[\![{}^\vee\alpha]\!]$	$= {}^\vee[\![\alpha]\!]$	

It holds that the meaning of the translations under $\mathcal{M}_{DETT}$ are identical to the meanings of the corresponding DIL-expressions under the corresponding model $\mathcal{M}_{DIL}$.

In DIL, "state switchers" may apply to expressions of arbitrary type, but the translation works only if β in viii) and ix) has a type that is either identical or based on t[12]. Nevertheless, in all DIL-expressions that G&S['91a] use as translations of their fragment of English, state switchers only apply to formulae. This ensures that Dynamic Montague Grammar is completely expressible within DETT.

A meaning-preserving translation from DETT to DIL, on the other hand, is impossible since updates in DIL are **total** functions over contexts and contexts are sets of states, and states may be identified with **total** sequences, while DETT-updates may be partial in both dimensions. As we will see in the next paragraph, the DETT-translations of English sentences

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[12]If the ι-operator were defined in DETT, the general translation rule for state-switchers would be: $[\![\{\alpha/d\}\beta]\!] = \iota x.\forall y \mathcal{A}d.(d=[\![\alpha]\!] \wedge \Uparrow y([\![\beta]\!]) \rightarrow \Uparrow y(x))$.

I will propose will usually denote updates that are not expressible in DIL, although they are truth-conditionally equivalent to the interpretations of the same sentences under DMG.

2.5 Interpreting English with DETT

The formal language DETT, as it is developed so far, allows us to interpret a (admittedly very small) fragment of English such that the interpretation is fully (S-)compositional in the rigid sense defined at the beginning of the chapter, but the model-theoretic objects that are assigned to English sentences are very much identical to the interpretation these sentences receive under File Change Semantics. The treatment of more complex lexemes like the definite determiner or adverbs of quantification is left to the next chapters.

The strategy we will follow is well-known from Montague Grammar. Instead of stating the interpretations of English lexical items and the combinatory rules connecting them directly, we will give a translation from English to DETT, and the compositionality of this translation function ensures that an interpretation of English is implicitly defined, namely the function composition of the translation and the interpretation of DETT that was given above.

Let me first make a terminological remark. In MS, sentences are translated into IL-formulae, i.e. type-t-expressions. The interpretation of a formula is a truth value, but it is relativized to the possible world of interpretation. Therefore the meaning of a formula (and *ceteris paribus* a sentence) is usually identified with its intension, i.e. a characteristic function over the set of possible worlds (which is equivalent to a set of possible worlds). We will translate sentences into type-up-expressions. Accordingly, meanings of sentences should be identified with intensions of those expressions, namely functions from sequences to updates. But the updates we will be dealing with are always intensionally closed, and therefore their intensions are constant functions. For simplicity, when talking about the **meaning** of a sentence, we will refer to the **extension** of its translation under an arbitrary sequence, i.e. an update.

We will restrict our attention to the constructions that were discussed so far, i.e. donkey sentences and cross-sentential anaphora. Syntactically, indefinites and universally quantified DPs, proper nouns, pronouns, VPs with both transitive and intransitive verbs, relative clauses, and *if*-conditionals were involved. For this purpose, a very simple context-free grammar will suffice.

Definition 5.1 The Syntax of a Fragment of English

i)	S	==> DP, VP
ii)	S	==> $\bar{S}$, S
iii)	DP	==> PN
iv)	DP	==> D, NP
v)	NP	==> N
vi)	NP	==> NP, RC

vii) RC ==> RP, VP
viii) VP ==> IV
ix) VP ==> TV, DP
x) VP ==> AUX, PrP
xi) PrP ==> {A, DP}
xii) $\bar{S}$ ==> C, S
xiii) T ==> S
xiv) T ==> S, T

The last two rules extend the coverage of the syntax to the text-level, as it is common from FCS.

Definition 5.2 The Lexicon of a Fragment of English
i) PN ==> {he$_d$, she$_d$, it$_d$, someone$_d$, John$_d$, Socrates$_d$, Fido$_d$, ...} with $d \in DM$
ii) D ==> {a$_d$, every$_d$}
iii) N ==> {man, farmer, donkey, ...}
iv) RP ==> who
v) IV ==> {walks, talks, ...}
vi) TV ==> {owns, beats, ...}
vii) C ==> if
viii) AUX ==> is
ix) A ==> {mortal,...}

The first two lines of the lexicon are literally meta-rules for an infinite class of lexical rules, one for every discourse marker.

Before the concrete translations and translation rules can be given, we have to fix how the syntactic categories of English are mapped to DETT-types. The only thing we know *a priori* is that the categories S and T are mapped to type "up". To keep the translation procedure simple, it is convenient to assume that syntactic concatenation generally corresponds to function-application-in-intension, with the exception that text formation corresponds to dynamic conjunction.

Definition 5.3 Type Correspondence
i) S --> up
ii) NP --> <<s,e>,up> (= pred)
iii) N --> pred
iv) VP --> pred
v) IV --> pred
vi) DP --> <<s,pred>,up> (= term)
vii) D --> <<s,pred>,term>

viii) PN --> term
ix) TV --> <<s,term>,pred>
x) RC --> <<s,pred>,pred>
xi) RP --> <<s,pred>,<<s,pred>,pred>>
xii) $\bar{S}$ --> <<s,up>,up>
xiii) C --> <<s,up>,<<s,up>,up>>
xiv) T --> up

The best way to explain this is to look at concrete examples.

(75) He$_d$ talks.

The interpretation of the verb *talks* should in some way be related to the one-place first-order predicate constant $\mathbf{talk'}_{<e,t>}$, which is interpreted as the set of talking individuals. But *talks* is an intransitive verb, and therefore its translation has to be a dynamic predicate, i.e. an expression of type <<s,e>,up>. Both types can be related by a kind of type-shifting.

(76) talks --> $\lambda x.{\Uparrow}\mathbf{talk'}({}^{\vee}x)$

The lowercase Latin letters x,y,z,... are meant to range over variables of the type <s,e>.

The pronoun *he$_d$*, on the other hand, should be related to the discourse marker d, since the syntactic (or rather lexical) indices are intended to be identical to the discourse markers occurring in the translation. Discourse markers have the type e and the translation of pronouns have the type term, hence type-shifting is required again. (P,Q,... range over variables of type <s,pred>)

(77) he$_d$ --> $\lambda P.P\{{}^{\wedge}d\}$

I adopt Montague's brace-convention and write $\alpha\{\beta\}$ instead of ${}^{\vee}\alpha(\beta)$.

The DETT-operations corresponding to the syntactic rules of English follow a uniform principle: non-branching nodes inherit the translation from the daughter node and the translation of a binary node is the function-application-in-intension of the translations of the daughters, the direction depending on their logical types.

(78) a. talks :: IV :: $\lambda x.\Uparrow\mathbf{talk'}(\check{}x)$
|
talks :: VP :: $\lambda x.\Uparrow\mathbf{talk'}(\check{}x)$
|
| he_d :: PN :: $\lambda P.P\{\hat{}d\}$
| |
| he_d :: DP :: $\lambda P.P\{\hat{}d\}$
| /
He_d talks :: S :: $\lambda P.P\{\hat{}d\}(\hat{}\lambda x.\Uparrow\mathbf{talk'}(\check{}x))$

b. $\lambda P.P\{\hat{}d\}(\hat{}\lambda x.\Uparrow talk'(\check{}x))$ = $\hat{}\lambda x.\Uparrow talk'(\check{}x)\{\hat{}d\}$ % λ-conversion
= $\check{}\hat{}\lambda x.\Uparrow talk'(\check{}x)(\hat{}d)$ % brace convention
= $\lambda x.\Uparrow talk'(\check{}x)(\hat{}d)$ % $\check{}\hat{}$-elimination
= $\Uparrow\mathbf{talk'}(\check{}\hat{}d)$ % λ-conversion
= $\Uparrow\mathbf{talk'}(d)$ % $\check{}\hat{}$-elimination

c. $ct[\Uparrow\mathbf{talk'}(d)]$ = $\{s \in ct|\ s(d) \in F(\mathbf{talk'})\}$
iff $d \in Dom(ct)$, undefined else

The meaning of *He*$_d$ *talks* is the update that is defined in all contexts containing d in its domain, and it filters out those partial sequences in the input context that map d to a talking individual. The truth-conditional impact of this update can be calculated by application of down-arrow.

(79) $\Downarrow\Uparrow\mathbf{talk'}(d) = \mathbf{talk'}(d)$ % $\Downarrow\Uparrow$-elimination
$\forall s,g$: $\|\mathbf{talk'}(d)\|_{s,g} = 1$ iff $s(d) \in F(\mathbf{talk'})$

In words: The formula **talk'**(d) (and hence the sentence *He*$_d$ *talks*) is true under all sequences where d is mapped to a talking individual. The same thing is predicted by FCS.

(80) A_d man walks.

Do not be confused by the fact that the determiner and not the DP bears the index; you may imagine that the index percolates from the head to the DP. The translations of *walks* and *man* are similar to *talks*, and the indefinite article is translated as a dynamic two-place second-order predicate based on the dynamic existential quantifier.

(81) a. walks :: IV :: $\lambda x.\Uparrow\mathbf{walk'}({}^{\vee}x)$

|

VP a_d :: D :: $\lambda P\lambda Q.\mathcal{E}d.P\{{}^{\wedge}d\} \wedge Q\{{}^{\wedge}d\}$

| |

| | man :: N :: $\lambda x.\Uparrow\mathbf{man'}({}^{\vee}x)$

| | |

| | NP

| | /

| a_d man :: DP :: $(\lambda P\lambda Q.\mathcal{E}d.P\{{}^{\wedge}d\}\wedge Q\{{}^{\wedge}d\})({}^{\wedge}\lambda x.\Uparrow\mathbf{man'}({}^{\vee}x))$

| /

A_d man walks :: S :: $(\lambda P\lambda Q.\mathcal{E}d.P\{{}^{\wedge}d\}\wedge Q\{{}^{\wedge}d\})({}^{\wedge}\lambda x.\Uparrow\mathbf{man'}({}^{\vee}x))({}^{\wedge}\lambda x.\Uparrow\mathbf{walk'}({}^{\vee}x))$

b. $(\lambda P\lambda Q.\mathcal{E}d.P\{{}^{\wedge}d\} \wedge Q\{{}^{\wedge}d\})({}^{\wedge}\lambda x.\Uparrow\mathbf{man'}({}^{\vee}x))({}^{\wedge}\lambda x.\Uparrow\mathbf{walk'}({}^{\vee}x))$

$= (\lambda Q.\mathcal{E}d.{}^{\wedge}\lambda x.\Uparrow\mathbf{man'}({}^{\vee}x)\{{}^{\wedge}d\} \wedge Q\{{}^{\wedge}d\})({}^{\wedge}\lambda x.\Uparrow\mathbf{walk'}({}^{\vee}x))$ % λ-conversion

$= \mathcal{E}d.{}^{\wedge}\lambda x.\Uparrow\mathbf{man'}({}^{\vee}x)\{{}^{\wedge}d\} \wedge {}^{\wedge}\lambda x.\Uparrow\mathbf{walk'}({}^{\vee}x)\{{}^{\wedge}d\}$ % λ-conversion

$= \mathcal{E}d.{}^{\vee\wedge}\lambda x.\Uparrow\mathbf{man'}({}^{\vee}x)({}^{\wedge}d) \wedge {}^{\vee\wedge}\lambda x.\Uparrow\mathbf{walk'}({}^{\vee}x)({}^{\wedge}d)$ % brace-conv.

$= \mathcal{E}d.\lambda x.\Uparrow\mathbf{man'}({}^{\vee}x)({}^{\wedge}d) \wedge \lambda x.\Uparrow\mathbf{walk'}({}^{\vee}x)({}^{\wedge}d)$ % ${}^{\vee\wedge}$-elimination

$= \mathcal{E}d.\Uparrow\mathbf{man'}({}^{\vee\wedge}d) \wedge \Uparrow\mathbf{walk'}({}^{\vee\wedge}d)$ % λ-conversion

$= \mathcal{E}d.\Uparrow\mathbf{man'}(d) \wedge \Uparrow\mathbf{walk'}(d)$ % ${}^{\vee\wedge}$-elimination

c. $ct[\mathcal{E}d.\Uparrow\mathbf{man'}(d) \wedge \Uparrow\mathbf{walk'}(d)] = \{s \cup \langle d,a\rangle \mid s\in ct \wedge a \in F(\mathbf{man'}) \cap F(\mathbf{walk'})\}$

iff $d \notin Dom(ct)$, undefined else

The meaning of the sentence is an update that is defined in those contexts that do not contain d in their domain and it introduces d into the domain of the input such that d is interpreted as an arbitrary walking man. Note that the effect of the Novelty-Familiarity-Condition is achieved in (78) and (81) without making reference to syntactic features like [+/- definite].

The truth-conditional impact does not come as a surprise:

(82) $\forall s,g$: $\|\Downarrow(\mathcal{E}d.\Uparrow\mathbf{man'}(d) \wedge \Uparrow\mathbf{walk'}(d))\|_{s,g} = 1$ iff $F(\mathbf{man'}) \cap F(\mathbf{walk'}) \neq \varnothing$

The truth value of the sentence does not depend on a particular sequence but only on the model of interpretation. If there is a walking man in the model, it is true, otherwise false. In other words, the truth-conditions are equivalent to the static interpretation of the first-order formula

(83) $\exists x\ [\mathbf{man'}(x) \wedge \mathbf{walk'}(x)]$

The dynamics of the system presented here come into play if we pass over to text formation.

(84) A_d man walks. He_d talks.

As mentioned above, the translation rule for text formation forms an exception since it does not involve function application but dynamic conjunction.

(85) a. A_d man walks. :: S :: $\mathcal{E}d.\Uparrow\mathbf{man'}(d) \wedge \Uparrow\mathbf{walk'}(d)$
|
T He_d talks. :: S :: $\Uparrow\mathbf{talk'}(d)$
| /
A_d man walks. He_d talks. :: T :: $\mathcal{E}d.\Uparrow\mathbf{man'}(d) \wedge \Uparrow\mathbf{walk'}(d) \wedge \Uparrow\mathbf{talk'}(d)$

b. $ct[\mathcal{E}d.\Uparrow\mathbf{man'}(d) \wedge \Uparrow\mathbf{walk'}(d) \wedge \Uparrow\mathbf{talk'}(d)]$
$= \{s \cup \langle d,a\rangle \mid s \in ct \wedge a \in F(\mathbf{man'}) \cap F(\mathbf{walk'}) \cap F(\mathbf{talk'})\}$
iff $d \notin Dom(ct)$, undefined else

c. $\forall s,g$: $\|\Downarrow\mathcal{E}d.\Uparrow\mathbf{man'}(d) \wedge \Uparrow\mathbf{walk'}(d) \wedge \Uparrow\mathbf{talk'}(d)\|_{g,s} = 1$ iff
$F(\mathbf{man'}) \cap F(\mathbf{walk'}) \cap F(\mathbf{talk'}) \neq \emptyset$

The truth-conditional impact is again intensionally closed, i.e. the truth value does not depend on sequences but only on the model, and it is equivalent to the static interpretation of:

(86) $\exists x[\mathbf{man'}(x) \wedge \mathbf{walk'}(x) \wedge \mathbf{talk'}(x)]$

In Montague Grammar, the interpretation of a proper noun like *John* is assumed to be the ultrafilter generated by the individual "John" ($\lambda P.P\{\mathbf{j'}\}$). We cannot take over this analysis as it is since proper nouns have a dynamic impact, similar to indefinite expressions.

(87) $John_d$ walks. He_d talks.

There are two options for dealing with this phenomenon. It is obvious that the translation of *John* involves the discourse marker d in one way or the other, but it is unclear whether it introduces or rather picks out this d-marker. To put it another way round, we have to decide whether *John* should be analyzed as synonymous to *an individual named John* or to *he - his name is John* - . There are arguments for either view. This is a first instance of the more general problem of how to treat definite full DP's as opposed to definite pronouns. The issue will be discussed in some length in the next chapter. For the time being, I follow G&S['91a] in advocating the "indefinite" analysis, but it should be kept in mind that this is not the whole story.

(88) $John_d$ --> $\lambda P.\mathcal{E}d.\ \mathbf{j'} = d \wedge P\{{}^\wedge d\}$

j' is a type-e-constant rigidly denoting the individual named John. Since the syntactic structure and the translation procedure of (87) is obvious, only the result is given.

(89) a. $\mathcal{E}d.\ \mathbf{j'} = d \wedge \Uparrow\mathbf{walk'}(d) \wedge \Uparrow\mathbf{talk'}(d)$

b. $ct[\mathcal{E}d.\ \mathbf{j'} = d \wedge \Uparrow\mathbf{walk'}(d) \wedge \Uparrow\mathbf{talk'}(d)] =$

$\{s \cup \{<d, F(\mathbf{j'})>\} \mid s \in ct \wedge F(\mathbf{j'}) \in F(\mathbf{walk'}) \cap F(\mathbf{talk'})\}$

iff $d \notin Dom(ct)$, undefined else

c. $\forall s,g$: $\|\Downarrow\mathcal{E}d.\ \mathbf{j'} = d \wedge \Uparrow\mathbf{walk'}(d) \wedge \Uparrow\mathbf{talk'}(d)\|_{s,g} = 1$

iff $F(\mathbf{j'}) \in F(\mathbf{walk'}) \cap F(\mathbf{talk'})$

d. $\mathbf{walk'}(\mathbf{j'}) \wedge \mathbf{talk'}(\mathbf{j'})$

The translation is given in (a), its meaning in (b), the truth-conditional content in (c) and an equivalent static formula in (d).

(90) If someone$_d$ is a$_{d'}$ man, he$_d$ is mortal

The translation of the indefinite pronoun is straightforward; *someone* is just an indefinite DP without descriptive content. The treatment of the copula *is* is similar to Montague's analysis, but we have to take care that the referential index of the predicative DP becomes neutralized somehow. This can be done by application of $\Uparrow\Downarrow$, since it makes occurrences of the dynamic existential quantifier in its scope in some sense invisible from outside.

Fact 5.1 Up-Down

$\vDash \Uparrow\Downarrow\mathcal{E}d.\ \alpha_{pred}(\hat{}d) = \exists y.\ \alpha(\hat{}y)$ iff $\alpha(\hat{}d)$ is distributive.

This is not identical to the effect of static closure (double negation), since $\Uparrow\Downarrow$ also cancels the presupposition that the d-markers introduced in its scope are new, while double negation only blocks their dynamic binding potential.

(91) a. someone$_d$ --> $\lambda P.\mathcal{E}d.P\{\hat{}d\}$

b. is --> $\lambda T\lambda x.\Uparrow\Downarrow T\{\hat{}\lambda y.\check{}x=\check{}y\}$

c. mortal --> $\lambda P.\exists x(\Uparrow\mathbf{mortal'}(x) \wedge P\{\hat{}x\})$

We start with the translation of the single clauses.

(92) a. is a$_{d'}$ man --> $\lambda T\lambda x.\Uparrow\Downarrow T\{\hat{}\lambda y.\check{}x=\check{}y\}(\hat{}\lambda P.\mathcal{E}d'.\Uparrow\mathbf{man'}(d') \wedge P\{\hat{}d'\})$

$= \lambda x.\ \Uparrow\Downarrow(\lambda P.\mathcal{E}d'.\Uparrow\mathbf{man'}(d') \wedge P\{\hat{}d'\})(\hat{}\lambda y.\check{}x=\check{}y)$

$= \lambda x.\ \Uparrow\Downarrow\ \mathcal{E}d'.\ \Uparrow\mathbf{man'}(d') \wedge \lambda y.\check{}x=\check{}y(\hat{}d')$

$= \lambda x.\ \Uparrow\Downarrow\ \mathcal{E}d'.\ \Uparrow\mathbf{man'}(d') \wedge \check{}x=d'$

$= \lambda x.\ \Uparrow\Downarrow\ \mathcal{E}d'.\ \lambda z.(\Uparrow\mathbf{man'}(\check{}z) \wedge \check{}x=\check{}z)(\hat{}d')$

$= \lambda x.\Uparrow\Downarrow\exists y.\ \lambda z.(\Uparrow\mathbf{man'}({}^\vee z) \wedge {}^\vee x={}^\vee z)({}^\wedge y)$

$= \lambda x.\exists y(\Uparrow\mathbf{man'}(y) \wedge {}^\vee x=y)$

$= \lambda x.\Uparrow\mathbf{man'}({}^\vee x)$

b. Someone$_d$ is a$_{d'}$ man --> $\mathcal{E}d.\ \Uparrow\mathbf{man'}(d)$

(93) a. is mortal --> $\lambda T\lambda x.\Uparrow\Downarrow T\{{}^\wedge\lambda y.{}^\vee x={}^\vee y\}({}^\wedge\lambda P.\exists z(\Uparrow\mathbf{mortal'}(z) \wedge P\{{}^\wedge z\}))$

$= \lambda x.\Uparrow\Downarrow\lambda P.\exists z(\Uparrow\mathbf{mortal'}(z) \wedge P\{{}^\wedge z\})({}^\wedge\lambda y.{}^\vee x={}^\vee y\})$

$= \lambda x.\Uparrow\Downarrow.\exists z(\Uparrow\mathbf{mortal'}(z) \wedge \lambda y.{}^\vee x={}^\vee y({}^\wedge z))$

$= \lambda x.\Uparrow\Downarrow.\exists z(\Uparrow\mathbf{mortal'}(z) \wedge {}^\vee x=z)$

$= \lambda x.\Uparrow\mathbf{mortal'}({}^\vee x)$

b. He$_d$ is mortal --> $\Uparrow\mathbf{mortal'}(d)$

The complementizer *if* is translated as implication as usual. Since Novelty-Condition effects are not desired for indefinites in the scope of a conditional (see below), $\Uparrow\Downarrow$ applies both to the consequence and the implication as a whole.

(94) if --> $\lambda p\lambda q.\Uparrow\Downarrow({}^\vee p \rightarrow \Uparrow\Downarrow{}^\vee q)$

(95)

he$_d$ is mortal :: S :: $\Uparrow\mathbf{mortal'}(d)$

|

| if :: C :: $\lambda p\lambda q.\Uparrow\Downarrow({}^\vee p \rightarrow \Uparrow\Downarrow{}^\vee q)$

| |

| | someone$_d$ is a$_{d'}$ man :: S :: $\mathcal{E}d.\ \Uparrow\mathbf{man'}(d)$

| | /

| if someone$_d$ is a$_{d'}$ man :: $\bar{S}$ :: $\lambda q.\Uparrow\Downarrow(\mathcal{E}d.\ \Uparrow\mathbf{man'}(d) \rightarrow \Uparrow\Downarrow{}^\vee q)$

| /

If someone$_d$ is a$_{d'}$ man, he$_d$ is mortal :: S :: $\Uparrow\Downarrow(\mathcal{E}d.\Uparrow\mathbf{man'}(d) \rightarrow \Uparrow\mathbf{mortal'}(d))$

According to the donkey equivalence, we have

(96) a. $\Uparrow\Downarrow(\mathcal{E}d.\Uparrow\mathbf{man'}(d) \rightarrow \Uparrow\mathbf{mortal'}(d)) = \Uparrow\Downarrow(\mathcal{A}d(\Uparrow\mathbf{man'}(d) \rightarrow \Uparrow\mathbf{mortal'}(d)))$

b. $ct[\Uparrow\Downarrow(\mathcal{A}d(\Uparrow\mathbf{man'}(d) \rightarrow \Uparrow\mathbf{mortal'}(d)))] = ct$ iff $F(\mathbf{man'}) \subseteq F(\mathbf{mortal'})$, $\mathbf{0}$ else

c. $\Downarrow\Uparrow\Downarrow(\mathcal{A}d(\Uparrow\mathbf{man'}(d) \rightarrow \Uparrow\mathbf{mortal'}(d))) = \Downarrow(\mathcal{A}d(\Uparrow\mathbf{man'}(d) \rightarrow \Uparrow\mathbf{mortal'}(d)))$

d. $\|\Downarrow(\mathcal{A}d(\Uparrow\mathbf{man'}(d) \rightarrow \Uparrow\mathbf{mortal'}(d)))\| = 1$ iff $F(\mathbf{man'}) \subseteq F(\mathbf{mortal'})$

e. $\forall x(\mathbf{man'}(x) \rightarrow \mathbf{mortal'}(x))$ % static first-order formula

The meaning of (90) is a pure test update. If every man is mortal in the model, it equals tautology, otherwise contradiction. This is the first time that the interpretation our system assigns to a sentence differs significantly from the Heimian interpretation. FCS predicts the same truth conditions, but Heim argues in some length that it is necessary for the indices of indefinites to be novel file cards, no matter whether the indefinite is embedded into a conditional or not. To put it another way round, she wants the Novelty Condition to apply not only to the interpretation of a sentence as a whole but to every part of it too. Nevertheless I cannot convince myself that statements like (90) bear any presupposition. According to my intuitions, the sentence is felicitous/defined in any file/context, and this is just what is predicted by the system presented here.

The truth-conditions given in (96d,e) should be linked to the sentence *Every man is mortal* too, since this sentence is intuitively equivalent to (90). Let us prove this formally.

(97) every_d --> λPλQ.⇑⇓∀d. (P{^d} → ⇑⇓Q{^d})

(98)

```
is mortal :: VP :: λx.⇑mortal'(ˇx)
|
|        every_d : D :: λPλQ.⇑⇓∀d. (P{^d} → ⇑⇓Q{^d})
|        |
|        |    man :: NP :: λx.⇑man'(ˇx)
|        |    /
|        every_d man :: DP :: λQ. ⇑⇓∀d (⇑man'(d) → ⇑⇓Q{^d})
|        /
Every_d man is mortal :: S :: ⇑⇓∀d (⇑man'(d) → ⇑mortal'(d))
```

From the preceding discussion, it should be clear that the deductions

(99) a. Every man is mortal. Socrates is a man. ________________ Socrates is mortal.	b. If someone_d is a man, he_d is mortal. Socrates is a man. __________________________ Socrates is mortal

are correctly predicted to be valid.

Now the analysis of the donkey sentences is a pure formality. We still need the translations of transitive verbs and the relative pronoun.

(100) owns --> λTλx.T{^λy.⇑**own'**(ˇx,ˇy)}
who --> λPλQλx. P{x} ∧ Q{x}

The treatment of transitive verbs is borrowed from Montague's analysis of extensional transitive verbs. T is a variable that ranges over term-intensions, and $\mathbf{own}_{<e,<e,t>>}$ of course denotes the ownership-relation. The translation of *who* is just a type-shifted version of dynamic conjunction.

(101)
owns :: TV :: λTλx.T{^λy.⇑**own'**(ˇx,ˇy)}
|
| a$_{d'}$ donkey :: DP :: λQ.ℰd'.⇑**donkey'**(d') ∧ Q{^d'}
| /
owns a$_{d'}$ donkey :: VP:: λx.ℰd'. ⇑**donkey'**(d') ∧ ⇑**own'**(ˇx,d')
|
| who :: RP :: λPλQλx. P{x} ∧ Q{x}
| /
who owns a donkey :: RC :: λx. ℰd'.⇑**donkey'**(d') ∧ ⇑**own'**(ˇx,d')
|
| farmer :: NP :: λx.⇑**farmer'**(ˇx)
| /
farmer who owns a$_{d'}$ donkey :: NP :: λx.⇑**farmer'**(ˇx) ∧ ℰd'.⇑**donkey'**(d') ∧ ⇑**own'**(ˇx,d')
|
| every$_{d}$ :: D :: λPλQ.⇑⇓𝒜d(P{^d} → ⇑⇓Q{^d})
| /
every$_{d}$ farmer who owns a$_{d'}$ donkey :: DP
:: λQ.⇑⇓𝒜d𝒜d'(⇑**farmer'**(d) ∧ ⇑**donkey'**(d') ∧ ⇑**own'**(d,d') → ⇑⇓Q{^d})
|
| beats :: TV :: λTλx.T{^λy.⇑**beat'**(ˇx,ˇy)}
| |
| | it$_{d'}$ :: DP :: λP.P{^d'}
| | /
| beats it$_{d'}$ :: VP :: λx.⇑**beat'**(ˇx,d')
| /
Every$_{d}$ farmer who owns a$_{d'}$ donkey beats it$_{d'}$ :: S
:: ⇑⇓𝒜d𝒜d'(⇑**farmer'**(d) ∧ ⇑**donkey'**(d') ∧ ⇑**own'**(d,d') → ⇑**beat'**(d,d'))

(102)
a_d farmer :: DP :: $\lambda Q.\mathcal{E}d.\Uparrow\mathbf{farmer'}(d) \wedge Q\{{}^\wedge d\}$
|
| owns $a_{d'}$ donkey :: VP:: $\lambda x.\mathcal{E}d'.\ \Uparrow\mathbf{donkey'}(d') \wedge \Uparrow\mathbf{own'}({}^\vee x,d')$
| /
a_d farmer owns $a_{d'}$ donkey :: S :: $\mathcal{E}d\ \mathcal{E}d'.\Uparrow\mathbf{farmer'}(d) \wedge \Uparrow\mathbf{donkey'}(d') \wedge \Uparrow\mathbf{own'}(d,d')$
|
| if :: C :: $\lambda p\lambda q.\Uparrow\Downarrow{}^\vee p \rightarrow \Uparrow\Downarrow{}^\vee q$
| /
if a_d farmer owns $a_{d'}$ donkey :: $\bar{\mathbf{S}}$
:: $\lambda q.\ \Uparrow\Downarrow\mathcal{A}d\mathcal{A}d'(\Uparrow\mathbf{farmer'}(d) \wedge \Uparrow\mathbf{donkey'}(d') \wedge \Uparrow\mathbf{own'}(d,d') \rightarrow \Uparrow\Downarrow{}^\vee q)$
|
| beats $it_{d'}$ :: VP :: $\lambda x.\Uparrow\mathbf{beat'}({}^\vee x,d')$
| |
| | he_d :: DP :: $\lambda P.P\{{}^\wedge d\}$
| | /
| he_d beats $it_{d'}$ :: S :: $\Uparrow\mathbf{beat'}(d,d')$
| /
If a_d farmer owns $a_{d'}$ donkey, he_d beats $it_{d'}$ :: S
:: $\Uparrow\Downarrow\mathcal{A}d\mathcal{A}d'(\Uparrow\mathbf{farmer'}(d) \wedge \Uparrow\mathbf{donkey'}(d') \wedge \Uparrow\mathbf{own'}(d,d') \rightarrow \Uparrow\mathbf{beat'}(d,d'))$

(103) a. $ct[\Uparrow\Downarrow\mathcal{A}d\mathcal{A}d'(\Uparrow\mathbf{farmer'}(d) \wedge \Uparrow\mathbf{donkey'}(d') \wedge \Uparrow\mathbf{own'}(d,d') \rightarrow \Uparrow\mathbf{beat'}(d,d'))]$
$= ct$ iff $F(\mathbf{farmer'}) \times F(\mathbf{donkey'}) \cap F(\mathbf{own'}) \subseteq F(\mathbf{beat'})$, $\mathbf{0}$ else
b. $\|\Downarrow\mathcal{A}d\mathcal{A}d'(\Uparrow\mathbf{farmer'}(d) \wedge \Uparrow\mathbf{donkey'}(d') \wedge \Uparrow\mathbf{own'}(d,d') \rightarrow \Uparrow\mathbf{beat'}(d,d'))\|_{s,g}$
$= 1$ iff $F(\mathbf{farmer'}) \times F(\mathbf{donkey'}) \cap F(\mathbf{own'}) \subseteq F(\mathbf{beat'})$
c. $\forall x\forall y(\mathbf{farmer'}(x) \wedge \mathbf{donkey'}(y) \wedge \mathbf{own'}(x,y) \rightarrow \mathbf{beat'}(x,y))$

The two donkey sentences are predicted to be equivalent. Their meaning is a test update that leaves the input context unchanged if the truth conditions are fulfilled by the model. These truth conditions can be paraphrased with *Every farmer beats every donkey he owns*.

To conclude the chapter, a few comments about the role of the Novelty-Familiarity-Condition (or its DETT-counterparts) are in order. It was already mentioned that G&S's DMG uses only **total** updates as the interpretation of English sentences. Consequently, contexts are sets of total assignments in their theory, without any specification of a discourse domain as in FCS. As an example, take a minimal pair of sentences which only differ w.r.t. the (in-)definiteness of a certain pronoun.

(104) a. $Someone_d$ walks.
b. He_d walks.

According to DMG, both sentences are defined in **any** context of utterance, including the minimal context of complete ignorance (called **1** in DETT). In the first place, DETT and FCS predict that nothing is wrong with the a-sentence in this context, while the b-example does not define an output or is infelicitous respectively. In contrast, DMG does not only fail to predict this contrast in felicity, it even assigns the same output to both updates. The reason for this disadvantage is the fact that DIL is unable to express the presupposition/partiality triggered by a definite pronoun (translated into a familiar discourse marker in DETT). This argumentation shows that something corresponding to Heim's Familiarity Condition is indispensable.

The picture changes as soon as we consider the Novelty-part of the NFC. It seems extremely counterintuitive to me that indefinites give rise to any notion of partiality. The fact that the file card introduced by an indefinite DP has to be new in FCS is in fact nothing more than an artifact of the way FCS deals with syntactic indices, and I cannot see any empirical motivation for it. In the theory presented here, the undesired consequences of the Novelty Condition in the context of conditionals and universal quantifiers can be avoided by application of the $\Uparrow\Downarrow$-operation (see above), but there is no straightforward way to escape them as far as matrix indefinites are concerned. It might appear that this is the price we have to pay for the advantages of the Familiarity-Condition, but as we will see in the next chapter, there is a way to get rid of the Novelty Condition without touching familiarity.

Chapter Three:
Topic-Comment-Articulation and Definiteness

3.1 Definiteness = Familiarity?

3.1.1 Heim's Theory of Definiteness

In the preceding chapter, we were merely concerned with indefinites (both pronouns and full DPs) and definite pronouns, ignoring definite full DPs. As far as indefinites are concerned, the contrast between a pronominal and a non-pronominal DP is simply the absence vs. presence of a predicate restricting the value of the discourse marker introduced.

(1) a. Someone$_d$ walks. ==> $\mathcal{E}d.\ \Uparrow\mathbf{walk'}(d)$
b. A$_d$ man walks. ==> $\mathcal{E}d.\ \Uparrow\mathbf{man'}(d) \wedge \Uparrow\mathbf{walk'}(d)$

The first idea that comes to mind is to treat definites in parallel fashion.

(2) a. He$_d$ walks. ==> $\Uparrow\mathbf{walk'}(d)$
b. The$_d$ man walks. ==> $\Uparrow\mathbf{man'}(d) \wedge \Uparrow\mathbf{walk'}(d)$

But as Heim['82,p.232] correctly observes, such an analysis leads to counterintuitive predictions. For instance, it fails to express that there is a certain asymmetry between the predicate expressed by the NP (*man* in (2b)) and the one corresponding to the VP (*walks*). Hence (2b) is predicted to be equivalent to both (3a) and (b), which is clearly the wrong result.

(3) a. The$_d$ walking entity is a man.
b. He$_d$ is a man and he$_d$ walks.

On the other hand, there is striking evidence that definites sometimes do pick up familiar discourse markers that were previously introduced by an indefinite.

(4) a. A$_d$ man comes in. ... The$_d$ man wears a hat.
b. If a farmer owns a$_d$ donkey, the$_d$ donkey kicks him.

(4b) is particularly interesting since it neither presupposes nor asserts the existence of a **unique** donkey (the farmer may own as many donkeys as you want). Therefore an analysis that assumes uniqueness (presupposed or asserted) as part of the meaning of a definite description makes wrong predictions, too. Hence the proposal in (2) seems to hint at a solution. Heim says:

"Generalizing from the example [...], I am proposing that the present theory [FCS, G.J.] be augmented by the following assumption: Definites contrast with indefinites in yet another respect, aside from their different behaviours w.r.t. [...] the Novelty Condition: In definites, the descriptive content of the NP is presupposed, whereas in indefinites it is (merely) asserted."
Heim['82], p. 223

In her file-metaphor, this means that a definite does not pick up just any arbitrary familiar file card, but one that already contains an entry matching with the meaning of the NP c-commanded by the article. The same objections that were made against the aspects of the Novelty-Familiarity-Condition already discussed carry over to the technical implementation of this idea: Heim makes the presupposition a part of a felicity condition that depends on the syntactic feature [+definite]. In our compositional reformulation, we again make use of partiality instead of felicity.

The only presuppositions that are expressible in DETT are those concerning the familiarity or novelty of a particular discourse marker. To incorporate Heim's proposal, we have to augment this language with an operator that expresses restrictions on the value of a d-marker. Since its semantics is very similar to the dynamic necessity operator to be introduced later, the same symbol is used. We add a clause both to the syntax and to the semantics of DETT and give the "Heimian" translation of the definite article.

(5) a. If $\phi \in Exp_{up}$, $\Box\phi \in Exp_{up}$.
b. $ct[\Box\phi]_{g,s} =_{def} ct$ iff $ct \vDash \phi$, undefined else.
c. the_d ==> $\lambda P \lambda Q.\Box P\{^\wedge d\} \wedge Q\{^\wedge d\}$

The sentence in (2b) now translates to

(6) $\Box \Uparrow \mathbf{man'}(d) \wedge \Uparrow \mathbf{walk'}(d)$

There are two possible sources of undefinedness of this update in a particular context: Either d is not in the domain of the input context at all, or there are sequences in the input that map d to a non-man. Hence an output is defined if and only if both parts of Heim's Felicity condition (familiarity of the file card and presupposition of the descriptive content) are fulfilled.

3.1.2 Anaphoric and Referential Definites

This theory works well for a subclass of definites that are called "anaphoric" in the literature (cf. Quirk et al.['85]).

(7) a. A_d man walks. He_d talks.
b. A_d man walks. The_d man talks.

These sentences translate to

(8) a. $\mathcal{E}d.{\Uparrow}\mathbf{man'}(d) \wedge {\Uparrow}\mathbf{walk'}(d) \wedge {\Uparrow}\mathbf{talk'}(d)$
b. $\mathcal{E}d.{\Uparrow}\mathbf{man'}(d) \wedge {\Uparrow}\mathbf{walk'}(d) \wedge \Box{\Uparrow}\mathbf{man'}(d) \wedge {\Uparrow}\mathbf{talk'}(d)$

(8a) and (b) can easily be shown to be equivalent. This is in accordance with the intuition that (7b), although it sounds a little bit odd, is nevertheless synonymous to (7a). The difference is a stylistic rather than a semantic one. This similarity between personal pronouns and full definite DPs carries over to occurrences in the scope of negation, conditionals quantifiers etc. The examples are straightforward.

Up to this point, one might hypothesize that there is no crucial **semantic** difference between definite full DPs and pronouns. The only purpose of the descriptive content of a definite description is to narrow down the possible indices of the DP. In other words, there are many more **syntactic** structures for a given surface structure containing a pronoun than for the corresponding surface structure containing a full DP. But given an indexing that guarantees the sentence to be felicitously interpretable, definites and pronouns are semantically interchangeable.

There are a couple of counterexamples to this view. We start with those occurrences of definites which Quirk et al.['85] call "Immediate situation use" and "Larger situation use".

(9) a. The PRINter is out of order.
b. The SUN is shining.

Capital letters indicate a pitch accent. Neither the printer in (9a) nor the sun in (9b) have to be mentioned earlier in the discourse or to be otherwise contextually salient. Both sentences are perfectly felicitous as out-of-the-blue-utterances. This sharply contrasts (9) with (10), where the subject is a pronoun.

(10) a. IT is out of order.
b. IT is shining.

There are contexts where the sentences in (10) are felicitous, but at the beginning of a conversation, they are surely misplaced.

Heim['82, 372pp.] proposes that all non-anaphoric occurrences of definites should be rescued by means of a special accommodation mechanism. In the case of (9a), this presumably should work as follows:

a) recognize that (9a) is infelicitous in the current file under any indexing
b) add a new file card to the file
c) coindex the DP *the printer* with this file card

d) write "is a printer" at the new file card
e) update the modified file with (9a)

Apart from being methodologically dubious, such an approach leads to a counterintuitive result since the output of the whole procedure would be completely identical to the file achieved by processing

(11) A printer is out of order.

But (9a) is much stronger than (11). The latter only claims that there is a printer somewhere which is out of order, while the former says something about a certain printer that is identifiable by all conversants. To put it another way round, the DP *the printer* in (9a) is "directly referential" (cf. Heim['91]), since the sentence is only felicitous if there **exists** a **unique** referent for it. I will call this reading of definite descriptions **referential** for short[1], as opposed to the **anaphoric** reading in (7).

3.1.3 Topics and German Scrambling

Maybe this epistemic uniqueness-requirement can be achieved by means of a more elaborate theory of accommodation, but there is a more fundamental objection to such an approach. Accommodation, as Heim uses this term, is a kind of repair mechanism that is triggered by the violation of certain felicity conditions, i.e. the Familiarity Condition. It is, so to speak, blind to the syntactic structure of the infelicitous utterance. Hence we expect both the anaphoric and the referential reading of definites to be possible for every syntactic construction involving definites, and this prediction is not supported by the facts. It is no accident that the examples in (9) with the referential reading are both **thetic** sentences (cf. Sasse['87]), i.e. they consist of one phonological phrase and bear the main stress on the subject. In **categorical** statements, where the VP is accented, only the anaphoric reading is available.

(12) Last week, I bought a computer and a_d printer.
  a. The_d printer is out of ORder.
  b. *The_d PRINter is out of order.

(12b), which is a categorical statement, is only possible if a printer was already mentioned in the previous discourse. The thetic statement in (12b) behaves just the other way round, here the anaphoric reading is excluded.

An apologist of Heim's approach might argue that the thetic/categorical distinction is a

[1]This should not be confused with Donellan's['66] terminology.

purely pragmatic one and that therefore the contrast in (12) does not form a counterexample[2]. However, there are many languages in which this contrast is expressed syntactically. One example at hand is German, where subjects of categorical statements scramble in embedded clauses while subjects of thetic statements don't.

(13) a. (daß) wahrscheinlich [$_{VP}$der DRUCker kaputt ist]
(that) presumably the printer out-of-order is
'(that) the PRINter is out of order'
b. (daß) der Drucker$_i$ wahrscheinlich [$_{VP}$ t_i kaPUTT ist]
(that) the printer presumably out-of-order is
'(that) the printer is out of ORder'

According to standard assumptions about German syntax, adverbials like *wahrscheinlich* ("presumably") mark the VP-boundary[3]. There are two subject positions available. In (13a), the subject *der Drucker* ("the printer") is VP-internal, which is most likely its base-position. This is the usual position for subjects of thetic statements in embedded clauses. If the subject is definite, a referential reading results. In categorical statements like (13b), the subject is moved to some VP-external position (SpecAgrSP or whatever). We get an anaphoric reading.

The shift from the referential to the anaphoric reading is not necessarily connected to the thetic/categorical distinction. We observe the same contrast with (un-)scrambled objects.

(14) a. Peter hat wahrscheinlich [$_{VP}$ die BIbel gelesen]
Peter has presumably the Bible read PAST PRT
'Presumably, Peter was reading (in) the Bible'
b. Peter hat die Bibel$_i$ wahrscheinlich [$_{VP}$ t_i geLEsen]
Peter has the Bible presumably read
'As for the Bible, Peter presumably read it (through)'

In (14a), where the object *die Bibel* ('the Bible') is *in situ* (or at least VP-internal), we have the referential reading, while the object scrambling in (14b) forces an anaphoric interpretation (Besides this, there is an aspectual contrast between (a) and (b) that is not at issue here, cf. Jäger['95b]). The referential interpretation in (14a) forces a uniqueness-presupposition which is rarely fulfilled in unmarked contexts with more common DPs like 'the book', 'the man' etc. This

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[2]This would presuppose that there is a direct connection between prosody and pragmatics which is not very attractive anyway.

[3]This assumption is not unproblematic. However, material on the left hand side of the adverbial is surely outside VP. To decide whether material on its right hand side belongs to the VP, prosodic facts have to be taken into account. As a rule of thumb, an argument can safely be considered to be *in situ* if it bears the sentence accent without being narrowly focused.

is why scrambling of definites seems to be obligatorily in many cases.

(15) a. ???Peter hat wahrscheinlich [$_{VP}$ das BUCH gelesen]
Peter has presumably the book read PAST PRT
'Presumably, Peter was reading (in) the book'
b. Peter hat das Buch$_i$ wahrscheinlich [$_{VP}$ t_i geLEsen]
Peter has the book presumably read
'As for the book, Peter presumably read it (through)'

(15a), with the object *das Buch* ('the book') *in situ*, sounds very odd, while (15b) is fully acceptable. Such observations have led some authors to the wrong conclusion that scrambling has something to do with definiteness. This claim is obviously contradicted by examples like (13a) or (14a). According to the proposal defended here, (15a) is completely grammatical, but requires the existence of a unique book recognizable as such by each conversant. This condition is rarely fulfilled, while the presupposition of the uniqueness of the sun or the Bible does not cause any harm.

This is not the place for a thorough discussion of the semantic impact of scrambling. What is important here is the fact that the anaphoric/referential distinction among definites is linked to a syntactic distinction. This strongly implies that the contrast at issue is a matter of semantics, and not of pragmatics, as Heim assumes. At a descriptive level, the definite determiner is indeed ambiguous.

In Jäger['95b], it is argued at some length that scrambling is triggered by a syntactic feature called [+Topic]. The terminology is motivated by the fact that a) thetic and categorical statements are distinguished by means of scrambling and b) this distinction is usually described as the presence vs. absence of a Topic-Comment-articulation in the clause at hand. The notion of "Topic" as it is used here should not be confused with so-called "discourse topics" or any "aboutness"-relation, and it is also largely independent of the syntactic notion of "topicalization". Büring['95a] proposes [d-linked], which would suit equally well. The counterpart "Comment" may be identified with the S-structure VP and is hence dispensable as far as German embedded clauses are concerned.

As a descriptive generalization, we can now state:

(16) **In German, full DPs bearing the feature [+Topic] scramble obligatorily while DPs lacking this feature remain *in situ*.**[4]

The restriction to full DPs is motivated by the fact that pronouns form a class of their own

[4]In matrix clauses, the effect of scrambling is sometimes invisible because of V-2-effects. Therefore embedded clauses usually make better test cases. The picture is also sometimes confused by focus effects, since narrowly focused DPs never scramble, whether anaphoric or not.

syntactically. I assume that [+Topic] is a universal feature occurring in every language, whose grammatical realization may differ across languages. In English, for example, its only effect is deaccentuation.

The previous discussion on the distribution of anaphoric and referential definites now leads to the straightforward conclusion:

(17) **Full definite DPs lacking the feature [+Topic] are to be interpreted referentially, while definites bearing this feature are interpreted anaphorically.**

There is still a technical remark to be made. It was proposed above that the definite **determiner** is ambiguous, while the Topic-feature which induces the ambiguity is assigned to the whole DP. This discrepancy can be bridged by the plausible assumption that [+Topic] is a head-feature, i.e. a DP is [+Topic] just if its head-D is.

3.1.4 Associative Anaphoric Definites

Until now, we have considered two readings of definites that are linked to different syntactic environments. Heim's theory fails to predict the correct interpretations for those DPs that are [-Topic], i.e. the referential ones, while the instantiations of the [+Topic]-interpretation which we investigated so far seem to get the reading FCS predicts. But this is not entirely true. Heim['82, p.384] herself gives the following example:

(18) a. John is married. His wife is nice.
b. John is married. ??She is nice.

It is quite obvious that *his wife* in (18a) is [+Topic]. The sentence is a categorical statement, and in parallel German examples where scrambling is observable, it is obligatory.

(19) a. John ist verheiratet. Ich glaube, daß seine Frau wirklich [$_{VP}$ nett ist].
I think that his wife really nice is
'John is married. I think that his wife is really nice.'
b. John ist verheiratet. ???Ich glaube, daß wirklich [$_{VP}$ seine Frau nett ist].
I think that really his wife nice is

Hence (18a) is an instance of the anaphoric reading. Nevertheless, there is no familiar discourse marker that could be picked up by the definite description *his wife*. If there were a repair mechanism to make such a discourse acceptable, we would expect that (18b), with a pronoun instead of the definite, should be acceptable too, but it isn't. Heim further observes that this contrast cannot be accounted for by means of the presence vs. absence of descriptive content.

The woman in (20) has hardly any more content than *she*; nevertheless there is a clear cut contrast.

(20) John is married. {$^{?}$The woman/ $^{???}$She} is nice.

As it turns out, the asymmetry between personal pronouns on the one hand and definite descriptions on the other is much stronger than the familiarity theory of definiteness would lead us to expect.

3.2 A Dynamic Approach to Definiteness

3.2.1 Flexible Domains: The Peg System

As far as the unexpected asymmetry between pronouns and descriptions is concerned, Heim has a tentative proposal to make:

"The impression that one gathers from the difference between 'she' and 'the woman' in the context of [(20)] is that pronouns obey a constraint of their own that restricts their use even when there is no danger of ambiguity: For a pronominal definite NP_i to be felicitous w.r.t. a file F, i must be a prominent element of Dom(F). [...]

What does 'prominent' mean? Let us assume that a file is not just an amorphous bunch of cards, but is organized in such a way that a small number of cards enjoy a privileged place, 'on the top of the file', so to speak. These are always the cards that the file clerk had to handle most recently, i.e., that were most recently introduced or updated. The number of those cards, a small and constantly shifting subset of the domain of the file, are the prominent elements of the domain, and only they can appear as the indices of pronouns. So anaphoric pronouns will have to have antecedents in the recent previous discourse ..."
Heim['82], page 385 f.

In recent work, Gronendijk, Stokhof & Veltman['93, '94] (GSV for short) have developed a system that bears a strong resemblance to this proposal. It serves as a starting point for the rest of the chapter.

In Heim's proposal, we still have one unique domain of a file. A subset of it is designated as "prominent". But this virtually gives us two different but related domains: the set of file cards as a whole, and the set of prominent file cards. For a variety of reasons, it is more convenient to keep these domains apart and to state a function that maps the prominent elements to a subset of the file cards as a whole. Since only the prominent entities are linked to anaphoric pronouns, they are called **discourse markers**[5]. For the set of file cards in Heim's metaphor, GSV choose the term **pegs** (they borrow the term from Landman['86], but the underlying idea is quite different). The interpretation of a pronoun now works in three steps:

[5]In GSV's system, these things are simply variables, since these authors only define a first-order language.

a) link the pronoun to a discourse marker
b) map the discourse marker to a peg
c) interpret the peg in the model

Since pegs and not discourse markers are interpreted in the model, propositional content now restricts the interpretation of the pegs and not of the discourse markers, contrary to the system of the preceding chapter.

To make more transparent what is going on, we will use a graphical representation for contexts/files. Though it is quite similar to DRS-boxes in DRT, it is purely illustrative, similar to Heim's file-metaphor. Our ultimate goal is of course a compositional and non-representational semantics. A **Context Representation Structure** (CRS) consists of four parts:

a) a set of discourse markers,
b) a set of pegs,
c) a mapping from the former to the latter, called **referent function**, and
d) a set of CRS-conditions that restrict the interpretation of the pegs.

(21)

d, d', d'', d''',...	<==	discourse markers
p_i, p_j,..., p_n	<==	pegs
d → p_j, d' → p_i, d'' →p_n, ...	<==	referent function
farmer'(p_i) **donkey'**(p_k) **own'**(p_i, p_j) ...	<==	CRS-conditions

It is important to note that a CRS like (21) does **not** represent the meaning of a sentence but a **context**, i.e., the input or output before or after the processing of a sentence. The well-formedness-conditions of CRSs are only informally given here. The domain of the referent function in the third line is the set of the discourse markers in the first line, its range has to be **an improper subset** of the set of pegs in the second line, and the pegs used as arguments in the CRS-conditions have to be elements of the set of pegs in the second line. The set of pegs corresponds to Heim's file cards, and the image of the set of discourse markers under the referent function corresponds to the prominent file cards. Since there may be non-prominent file cards, the referent function is an into-function.

To illustrate the update potential of a sentence, we have to give two CRSs, one representing the conditions every legitimate input context of the sentence must meet, and one representing the corresponding output conditions. We start with a simple example involving just a pronoun and a predicate.

(22) a. He_d walks.

b.

d
p_i
$d \rightarrow p_i$

==>

d
p_i
$d \rightarrow p_i$
walk'(p_i)

The index of an anaphoric pronoun has to be a familiar discourse marker as in DETT. Therefore "d" is present in the first line of the box on the left, representing the input context. Since every discourse marker has to be mapped to a peg, there is already a peg in the input too, call it p_i, and d is mapped to p_i. There is nothing more about the input we can infer from (22a). Hence the body of the box is empty. Updating with the sentence only means to introduce a CRS-condition into the context, namely that the individual that *he* refers to via the peg p_i, walks.

(23) a. A_d man walks.

b.

==>

d
p_n
$d \rightarrow p_n$
man'(p_n) **walk'**(p_n)

Updating with an indefinite is even simpler: There are no conditions on the input. The discourse marker of the indefinite, a corresponding peg, and the conditions of NP and VP are introduced. Note that we do not demand that "d" is new. A transition as in (24) is completely legitimate.

(24)

d
p_i
$d \rightarrow p_i$

==>

d
p_i, p_n
$d \rightarrow p_n$
man'(p_n) **walk'**(p_n)

If "d" is already present in the input, what is introduced is merely a new peg, and "d" is mapped to this new peg. The former image of "d" ("p_i" in the example) changes, so to speak, from a prominent to a non-prominent file card, but it remains present. Hence the intuition remains valid that indefinites introduce something new, but nevertheless we do not have a Novelty Condition with its shortcomings. This advantage over FCS, EDPL, or DETT is GSV's main motivation for proposing a peg system.

Although GSV designed this system for the only purpose of getting rid of the Novelty Condition, it allows us to formalize the properties of anaphoric definites in a straightforward way[6]. The notorious example is repeated.

(25) John$_d$ is married. The$_{d'}$ woman is nice.

Obviously, *the woman* does not pick up a familiar discourse marker, since there is no linguistic antecedent for *the woman*. But it introduces one into the context, since it is possible to continue with *She*$_{d'}$ *loves him*$_d$. As far as discourse markers are concerned, definite descriptions behave just like indefinites. But a definite description induces a restriction on the peg system of the input. The processing of *the*$_{d'}$ *woman* in (25) roughly works as follows:

a) introduce d' into the domain of discourse markers
b) introduce a new peg p_n into the peg-domain and link d' to it
c) pick up a familiar peg p_i such that **woman'**(p_i) is a CRS-condition
d) identify the new peg p_n with p_i

In a sense, anaphoric definites are hybrids between indefinites and anaphoric pronouns: they introduce a new discourse marker (or reset a familiar one), like indefinites, and they pick up a familiar peg, like pronouns. The update defined by the second sentence of (25) looks as follows.

[6] In the course of writing this dissertation, it came to my knowledge that GSV['95] propose an analysis of definite descriptions that is in some respects comparable to the one advocated here.

(26)

p_i
woman'(p_i)

==>

d'
p_i, p_n
d → p_n
woman'(p_i) $p_i = p_n$ **nice'**(p_n)

The output of the first sentence *John is married* hence has to contain at least the information that is represented in the left box above. There seems to exist a way of introducing pegs without introducing a corresponding discourse marker. In our example, this is presumably licensed by the fact that we are able to infer from the fact that John is married to the fact that there is a woman that is John's wife. This knowledge can be stated by means of Meaning Postulates (Notice that Meaning Postulates are classical first-order-, not DETT-formulae):

MP 1: ∀x [**married'**(x) ∧ **male'**(x) → ∃y[**woman'**(y) ∧ **wife'**(x,y)]]
MP 2: ∀x [x = **j** → **male'**(x)]

Meaning postulates restrict the array of possible contexts or, equivalently, they form a kind of well-formedness condition for CRSs. The set of pegs of a CRS, together with the CRS conditions, define something like a class of "small" or "partial" models that are modified by updates. These models can be used as first-order models, and we can interpret the Meaning Postulates in them. A CRS is **well-formed w.r.t. a Meaning Postulate** if the postulate is true in every model defined by the CRS. If a CRS is well-formed modulo every Meaning Postulate, it is simply called **well-formed**. Now suppose we have a well-formed CRS and an update, such that the output of updating the CRS is not well-formed. Than we have to minimally update this intermediate output such that the ultimate output is both well-formed and an extension of the intermediate one. Let us illustrate this with the first sentence of our example (25).

(27) a. John$_d$ is married.
b.

==>

d
p_j
$d \rightarrow p_j$
$p_j = \mathbf{j}$ **married'**(**j**)

c.

d
p_j
$d \rightarrow p_j$
$p_j = \mathbf{j}$ **married'**(**j**)

==>

d
p_j, p_i
$d \rightarrow p_j$
$p_j = \mathbf{j}$ **married'**(**j**) **male'**(**j**) **woman'**(p_i) **wife'**(p_j,p_i)

The left box in (27b) shows the "structural" output of processing (27a) in an empty CRS. It is ill-formed since it is compatible with models were John is not male or where he is male but does not have a wife. Hence we need a second transition, given in (27c), that minimally extends this intermediate output such that the final output is well-formed. This CRS now fulfills the input requirements of the subsequent sentence *The woman is nice*, since the definite description can pick up the peg p_i.

Before we extend the system with an analysis of referential definites, we summarize the update-behaviour of the classes of DPs investigated so far.

(28)

	Indefinites	*Anaphoric Definites*	*Anaphoric Pronouns*
Discourse Marker	new/ familiar+resetting	new/ familiar+resetting	familiar (no resetting)
Peg	new	identified with a familiar peg	familiar

Indefinites either introduce a new discourse marker or reset a familiar one, but this discourse marker is always mapped to a new peg in the output. The question of whether there is any linguistic motivation for the choice of one option or the other is not at issue here. However, one might imagine that for instance the tense morpheme never introduces a new temporal discourse marker except in the beginning of a discourse; instead, it again and again resets one and the same discourse marker ("reference point" or whatever) to a newly introduced temporal peg.

Anaphoric definites behave like indefinites w.r.t. discourse markers, but they pick up a familiar peg; and anaphoric pronouns do not introduce anything new at all.

3.2.2 Referential Definites

It was mentioned above that referential definites are completely acceptable in out-of-the-blue utterances.

(29) The PRINter is out of order.

What does (29) exactly mean? The requirement that there is one and only one printer all over the world is of course much too strong. Nevertheless the printer referred to is unique, although in a weaker sense. The sentence is only felicitous if there is one and only one printer that is **perceivable** as a printer by the conversants. Hence the domain the uniqueness-requirement applies to is somehow given epistemically. For the time being, we adopt the idealization that the model of interpretation only contains objects that are epistemically given in an appropriate way, and we assume provisionally that the strong uniqueness condition is fulfilled. This idealization is useful since the appropriate domain is determined by the **extralinguistic** context, at least partially, and we are only dealing with the **linguistic** context here.

The update defined by (29) is partially characterized by the CRS-transition below.

(30)

		d
	==>	p_i
		$d \rightarrow p_i$
		printer'(p_i) **out_of_order'**(p_i)

This also represents the meaning of ***A** printer is out of order*. If we wanted to express the condition that p_i is interpreted as the only printer in the model, we would have to define recursive and negated CRSs. Of course this is possible, but since CRSs only serve for illustration, I refrain from doing so. For the time being, we content ourselves with informally stating the uniqueness condition. The "official" theory to be presented below will of course formally distinguish between indefinites and referential definites.

We now augment the chart above with an additional column:

(31)

	Referential Definites
Discourse Marker	new/ familiar+resetting
Peg	new, interpreted as the object uniquely satisfying the description

3.2.3 Unifying the Anaphoric and the Referential Reading

The model that has been developed up to now is anything else than satisfactory. The two readings of the definite determiner are apparently more or less unrelated. They behave similarly w.r.t. the discourse marker (which is new or reset), but this property they share with indefinites; and the conditions on the peg are totally different.

This picture changes when we take a closer look at the data.

(32) Sue met Mary. *The woman wore a hat.

The second sentence is predicted to be three-way ambiguous. We do expect that the referential reading is blocked, since the uniqueness requirement is contradicted by the first sentence (of course, we have to ensure by means of appropriate Meaning Postulates that both Sue and Mary are women). But there is still the anaphoric reading available, and it even branches into two options: *the woman* could pick up the peg introduced by *Sue* or the one introduced by *Mary*[7] (the presence of CRS-conditions that both pegs denote women is guaranteed by the same Meaning Postulates together with the mechanism described above). Nevertheless the sentence is odd under either reading. Heim['82, p. 236] attributes this kind of observation to just this ambiguity, but it would be the first time that an ambiguity gave rise to unacceptability. Compare (32) with (33):

(33) Sue met Mary. She wore a hat.

(33) is ambiguous in just the way FCS predicts (32) to be, but nevertheless, it is completely acceptable. Therefore it seems to be more reasonable to assume that the **semantics** of the anaphoric definite determiner requires there to be a **unique peg** satisfying the description, and

[7]Note that coreference between an anaphoric definite and its antecedent no longer entails identity of the syntactic index/discourse marker.

that this is the condition that is violated in (32).

Under this perspective, the anaphoric and the referential reading become much more similar. Both carry a uniqueness condition. In the case of the anaphoric variant, this condition governs the mapping from the discourse marker to the pegs, and in the case of the referential reading, it governs the interpretation of the peg in the model. That is the whole difference. We may even go one step further. In both readings, the interpretation of the discourse marker (mediated by the peg) is uniquely defined. A referential definite creates a new peg that is interpreted as the unique individual satisfying the description. There must not be any source of nondeterminism[8]. An anaphoric definite picks up a familiar peg, but it has to be ensured that there is one and only one individual in the model which both satisfies the description and which **is the image of a familiar peg**. Again the process is fully deterministic. Hence the formal difference between the two readings boils down to the fact that a referential definite introduces a new peg and an anaphoric definite picks up a familiar peg. I assume that there is a template corresponding to the formal feature [+Topic] that shifts the referential reading to the anaphoric one.

The idea that definites always require uniqueness, and that it is only the domain that differs, is anything but new, and there are standard counterarguments against it.

(34) The$_{d}$ dog was fighting with another$_{d'}$ dog.

It is argued that examples like this cannot be accounted for if we assume that *the dog* means *the one and only dog* in whatever independently fixed domain, since the sentence as a whole asserts the existence of at least two dogs. One possible way out is to assume that each DP contains a hidden anaphor that restricts the domain further (cf. v. Fintel['94] among others). I think it is not unfair to say that this strategy has a slight flavour of what has been called "pragmatic waste-basket". The failure of the argument lies in the assumption that - unless we fall back on otherwise unmotivated pragmatic mechanisms - we are obliged to interpret every part of a the sentence w.r.t. one and the same domain. This might be true in static semantics, but in a dynamic approach, this obviously does not hold.

[8]There is an unessential source of indeterminism concerning the name of the new peg, but this can be excluded by a linear ordering of the set of possible pegs. If you create a new peg, you are always bound to choose the next one in the line.

(35)

p_i
dog'(p_i)

==>

d
p_i
$d \rightarrow p_i$
dog'(p_i)

==>

d, d'
p_i, p_j
$d \rightarrow p_i$, $d' \rightarrow p_j$
dog'(p_i) **dog'**(p_j)

==>

d, d'
p_i, p_j
$d \rightarrow p_i$, $d' \rightarrow p_j$
dog'(p_i) **dog'**(p_j) **fighting'**(p_i,p_j)

In our system, we update the input context step by step, first with the DPs in the order of their syntactic scope, and afterwards with the verb. In (34), the subject takes wide scope. Hence the input context has to contain exactly one dog-peg, call it p_i. The discourse marker d is introduced or reset and mapped to p_i. In the second step, we introduce a new peg p_j, introduce or reset d' to p_j and write the condition **dog'**(p_j) into the body of the box. Finally, we create the CRS-condition **fighting'**(p_i,p_j). Now we do have two dogs (and, accordingly, you cannot use *the dog* in the subsequent discourse), but before we had only one and the uniqueness condition was fulfilled.

This strategy extends to so-called "bridging"-examples in a quite natural way.

(36) In every city, the city hall is next to the market place.

Without going into detail, this kind of apparent counterexample to the uniqueness analysis causes no harm either, as long as we assume Meaning Postulates like

MP3: $\forall$x[**city'**(x) $\rightarrow$ $\exists$y[**city-hall'**(y)]]
MP4: $\forall$x[**city'**(x) $\rightarrow$ $\exists$y[**market-place'**(y)]]

The formal analysis of quantificational expressions is given later, but the idea is roughly: Update your input context with *There is a city*. Due to the Meaning Postulates, you have to introduce three new pegs, one for the city, one for the city hall, and one for the market place **of that city**.

There are as many ways of interpreting the city-peg as there are cities in the model. In the next step, you update the current context with *The city hall is next to the market place.* The uniqueness condition is fulfilled for both definite descriptions. If you succeed with this update, no matter what the interpretation of the city-peg is, the quantificational statement (36) as a whole succeeds too, and the output context is identical to the input context. Of course, this update may fail, but only if there are cities in the model such that their city hall is not next to the market place. The definite descriptions run smoothly, although there are as many city halls and market places as there are cities.

Surely this way of stipulating Meaning Postulates employed here seems to be *ad hoc*, but there are at least two arguments in defence. First of all, hidden anaphors or indices that restrict the quantificational domain further are at least as *ad hoc* as Meaning Postulates. Furthermore, they predict a (possibly infinite) ambiguity of surface structures no-one ever observed. It always strikes me as a great miracle how pragmatics manages to single out just the one reading we are after. Secondly, it is arguable that (36) in fact **presupposes** the two propositions that are necessary as Meaning Postulates. To make this a little more explicit, we could go through all possible combinations of Meaning Postulates and check whether the output of (36) is defined in every input. We will find that those Meaning Postulate systems that do so are just those that entail MP3 and MP4. This is a reasonable reconstruction of the notion of a presupposition (cf. Beaver['93]). To conclude, the way in which Meaning Postulates are used here is less stipulative than it might look, as soon as we consider them to be presuppositions of a special kind.

Another point concerns the question of whether it is appropriate to treat the kind of knowledge that Meaning Postulates represent here as something fixed; and there is no doubt that the answer is no.

(37) a. Every student in the course owns a computer. ... John only plays games with the computer.
b. John only plays games with the computer. ... Every student in the course owns a computer.

From (36a) you can infer that John uses the computer he owns for playing, while in (36b), it might be any computer. This is expected if we assume that the propositional context of the first sentence in (36a) becomes part of the "Meaning Postulates" that are the background for the processing of the second sentence. It is an exciting question, what this updating of the background knowledge looks like exactly, but we cannot pursue it any further here, and leave it for further research.

The most natural next step is to investigate whether the [+Topic]-feature has some influence on the interpretation of indefinites and quantifiers too. But obviously, we have already suffered from the limitations of this informal discussion now, and therefore, I first proceed with extending the formal system from chapter two with the intuitive insights presented above.

3.3 DETT Augmented with a Peg System

The language that will be used as a medium for the interpretation of English is syntactically nearly identical to DETT, but the semantics of course differs. It is still a dynamic type theory, but interpretation is now relativized to possible worlds[9]. I called it **Dynamic Intensional Type Theory** (DITT). It has the same types and the same non-logical vocabulary as DETT. The only syntactic difference is the presence of two one-place update-operators, "◇" and "**T**".

Definition 3.1: The Syntax of DITT

a) Every DETT-expressions of type α is a DITT-expression of type α.

b) If $\phi \in$ Exp(up), ($\Diamond\phi$), ($\mathbf{T}\phi$) $\in$ Exp(up).

DITT-models are similar to DETT-models, but as additional components, we now have a set of possible worlds and set of Meaning Postulates. The latter are formulae of Modal Predicate Logic having a special form:

Definition 3.2 Inference Rules

$\forall x_1,...,x_n\ [\Box\phi_1, ..., \Box\phi_i \rightarrow \exists y_1,...,y_m\ \Box\psi_1, ..., \Box\psi_j]$ is called an inference rule iff

i) $0 \leq i,m,n\ ,\ 1 \leq j$,

ii) $\phi_1, ..., \phi_i\ ,\psi_1, ..., \psi_j$ are literals consisting of first-order DITT-predicate-constant, variables and possibly negation, and

iii) all variables are bound.

The restriction to implications where both antecedent and consequence consist only of a conjunction of necessitated literals serves to ensure that there is no nondeterminism in the application of the rules. Note that the antecedent may consist of the tautology only. In this case, the rule boils down to a fact.

Definition 3.3: Model of DITT

A model $\mathcal{M}$ for DITT is a quadruple <E, W, F, MP>, such that

- E is a denumerably infinite set (the individual domain)
- F is an Interpretation Function that maps each constant to a function from W into the domain of the type of that constant
- W is non-empty (the set of "possible worlds")
- MP is a set of inference rules
- all elements of MP are true in <E,W,=,F'> under static Modal Predicate Logic

[9]Although the basic concepts are adopted from GSV['94], there are some crucial differences. These authors give a semantics for first order modal logic only and therefore use variables instead of discourse markers.

interpretation, where $F'(P)(w) =_{def} F(P)(w)$ for all first-order predicate constants P and worlds w.

3.3.1 Contexts and Updates

The most important difference between FCS/DETT and GSV's['94] system lies in the different notion of a context which they each elaborate. Let us start by defining them formally. The basic ingredients are discourse markers and pegs.

Definition 3.4 Discourse Markers and Pegs

i)	$DM =_{def} N$	% Discourse Markers
ii)	$P_n =_{def} \{p_i \mid 0 \le i < n\}$	% The first n pegs
iii)	$P_\omega =_{def} \{p_i \mid i \in N\}$	% The set of pegs

The set of pegs is linearly ordered by means of their indices. (GSV use the natural numbers themselves as pegs, but since we have already identified discourse markers with numbers, this would lead to confusion). Discourse markers are mapped to pegs by means of referent functions[10].

Definition 3.5: Referent Functions

$R =_{def} \bigcup_{D \subseteq DM} \bigcup_{n \in N} P_n{}^D$

Peg interpretations map a sequence of n pegs to the elements of domain of the model.

Definition 3.6 Peg Interpretations

$PI_n =_{def} E^{P(n)}$

A **possibility** consists of a set of discourse markers, a sequence of pegs such that the relevant mappings are fixed, and a possible world.

Definition 3.7 Possibilities

$Pos =_{def} \{<D,n,r,i,w> \mid D \subseteq DM \wedge n \in N \cup \{\omega\} \wedge r \in P_n{}^D \wedge i \in PI_n \wedge w \in W\}$

The first two members of a possibility (D and n) are literally redundant, since they are just the domains of the respective functions, but some definitions are more transparent when they are given explicitly.

In a certain stage of a conversation, we may be uncertain both about the referent function

[10]GSV implicitly assume that these functions are one-to-one. We are more liberal here in admitting many-to-one mappings.

and about the peg interpretation. But there is no nondeterminism about the question of which pegs and which discourse markers belong to the context. Accordingly, a **context** is a set of possibilities that maximally differ w.r.t. the functions involved.

Definition 3.8 Contexts
$CT =_{def} \bigcup_{D \subseteq DM} \bigcup_{n \in N} POW(\{D\} \times \{n\} \times P_n^D \times PI_n \times W)$

Since the set of discourse markers and the set of pegs belonging to the possibilities of a context are identical, we may define the **discourse domain**, the **peg domain** and the **world set** of a context.

Definition 3.9 Domains of a Context
Let ct be a context, $D \subseteq DM$, and $n \in N$, such that
$ct \subseteq POW(\{D\} \times \{n\} \times P_n^D \times PI_n \times W)$
i) $Ddom(ct) =_{def} D$
ii) $Pdom(ct) =_{def} P_n$
iii) $Wdom(ct) =_{def} \{w \mid \exists r,i: \langle D,n,r,i,w \rangle \in ct\}$

As is familiar from DETT, possibilities and contexts are ordered according to the information they carry. There are a weak and a strong notion of "being more informative". According to the former, resetting of a discourse marker does not increase information, according to the latter, it does.

Definition 3.10 Informativity
i) $\langle D,n,r,i,v \rangle \leq \langle D',m,r',j,w \rangle$ iff
$D \subseteq D' \wedge n \leq m \wedge i \subseteq j \wedge v=w$
ii) $\langle D,n,r,i,v \rangle \sqsubseteq \langle D',m,r',j,w \rangle$ iff
$D \subseteq D' \wedge n \leq m \wedge r \subseteq r' \wedge i \subseteq j \wedge v=w$
iii) $ct \leq ct'$ iff
$\forall k[\, k \in ct' \rightarrow \exists l[\, l \in ct \wedge l \leq k]]$
iv) $ct \sqsubseteq ct'$ iff
$\forall k[\, k \in ct' \rightarrow \exists l[\, l \in ct \wedge l \sqsubseteq k]]$

The set of contexts forms a complete lattice w.r.t. to the stronger version ("$\sqsubseteq$"), but not w.r.t. the weaker one. Nevertheless, there is a unique minimal and a unique maximal element for both partial orderings.

Definition 3.11 Join, Meet, Empty and Inconsistent Context

i) $\{<D,n,r,i,v>\} \sqcup \{<D',m,s,j,w>\} =_{def}$

$\quad Pos \cap \{<D\cap D',\min(\{n,m'\}),t,k,u>|\ t\subseteq r \wedge k\subseteq i \wedge u = v \vee t \subseteq s \wedge k \subseteq j \wedge u=w\}$

ii) $\{<D,n,r,i,v>\} \sqcap \{<D',m,s,j,w>\} =_{def}$

$\quad Pos \cap \{<D\cup D',\max(\{n,m'\}),t,k,v>|\ r,s \subseteq t \wedge i,j \subseteq k \wedge v=w\}$

iii) $ct \sqcup ct' =_{def} \bigcup_{k \in ct} \bigcup_{l \in ct'} \{k\} \sqcup \{l\}$

iv) $ct \sqcap ct' =_{def} \bigcap_{k \in ct} \bigcap_{l \in ct'} \{k\} \sqcap \{l\}$

v) $\mathbf{1} =_{def} \bigsqcup CT = \{<\emptyset,0,\emptyset,\emptyset,w>|w\in W\}$

vi) $\mathbf{0} =_{def} \bigsqcap CT = \emptyset$

We are not really interested in the whole range of contexts that exist, rather, we only need those where the Meaning Postulates are fulfilled. Hence we have to make precise when a certain static modal formula is valid in a context.

From a non-absurd context and a DITT-model, a model for (static) Modal Predicate Logic without individual constants can be derived in a natural way. The possibilities which the context consists of correspond to possible worlds, and the pegs correspond to the individual domain. An m-tupel of pegs falls under the "extension" of an n-ary predicate in a certain possibility iff the m-tupel of images of the pegs falls under the interpretation of the predicate in the respective world under the DITT-model.

Definition 3.12 Context-Model

Let $\mathscr{M}$ = <E, W, F, MP> be a DITT-model, ct a context such that each of its possibilities contains n pegs, and Q^m an m-ary first-order predicate constant from DITT. The Modal Predicate Logic Model corresponding to ct is defined as follows:

$M_{ct} =_{def} <P_n,ct,ct\times ct,G>$, such that:

$$G(Q^m)(<D,n,r,i,w>) = \{<q_1, ..., q_m> \in P_n^m \mid <i(q_1), ..., i(q_m)> \in F(Q^m)(w)\}$$

Every possibility ("possible small world", if you want) is accessible from all possibilities in the context. Hence the corresponding logic is S5. A context is called **realistic** iff all Meaning Postulates are valid in the corresponding model.

Definition 3.13 Realistic Contexts

$CTR =_{def} \{ct \in CT \mid M_{ct} \vDash MP\}$

What can be done if the output of an update turns out to be unrealistic? We have to minimally change the context in such a way that it becomes realistic. The **realistic extension** of a context is the smallest context that is both realistic and strongly more informative that the original context.

Definition 3.14 Realistic Extension of a context
$rex(\mathrm{ct}) =_{def} \bigsqcup \{\mathrm{ct}' | \mathrm{ct} \sqsubseteq \mathrm{ct}' \wedge \forall k \in \mathrm{ct} \exists l \in \mathrm{ct}'[k \sqsubseteq l] \wedge \mathrm{ct}' \in \mathrm{CTR}\}$

The restriction of admissible Meaning Postulates to inference rules together with the fact that the Meaning Postulates have to be true in the model as a whole guarantees that every possibility in a context survives in the realistic extension of the context. The only effect of the operation is the possible introduction of new pegs.

So much for the notion of a context in DITT. We now turn to transitions over contexts. A **Context Change Potential** is a partial function over contexts, as before.

Definition 3.15 Context Change Potentials
$\mathrm{CCP} = \bigcup_{C \subseteq CT} \mathrm{CT}^C$

Monotonic ccps are those ccps that (weakly) increase the information a context contains.

Definition 3.16 Monotonic Context Change Potentials
$\mathrm{CCPM} = \mathrm{CCP} \cap POW(\leq)$

The meanings of type-up-formulae should be ccps that are monotonic, and, additionally, they should always give a realistic context as output.

Definition 3.17 Updates
$\mathrm{UP} = \bigcup_{C \subseteq CT} \mathrm{CTR}^C \cap POW(\leq)$

To define the Topic-operator, we still need a special ccp. Remember that [+Topic]-definites introduce a new discourse marker and a new peg, like indefinites, but the new peg in turn becomes identified with a familiar peg. Hence the newly introduced peg is superfluous. We may as well let it entirely disappear. Therefore this operation is called **Peg Deletion**. The peg to be deleted is always the one that was introduced last (p_n in the definition). It is to be identified with a familiar peg p_i. In the first step, the discourse markers that are mapped to p_n are reset so that they are mapped to p_i in the output, and in the second step, p_n is deleted. The properties of the other discourse markers and pegs are not affected.

Definition 3.18 Peg Deletion
Let $\mathrm{ct} \in \mathrm{CT}$.

$$\mathrm{ct}[p_n = p_i] =_{def} \{\langle D,n,r,i,w\rangle | \exists s,j[\langle D,n+1,s,j,w\rangle \in \mathrm{ct} \wedge i \subset j \wedge \forall d \in D\ [[s(d) \neq p_n \rightarrow r(d) = s(d)] \wedge [s(d) = p_n \rightarrow r(d) = p_i]]\}$$

if $\mathrm{Pdom}(\mathrm{ct}) = P_{n+1} \wedge p_i \in \mathrm{Pdom}(\mathrm{ct})$, undefined else.

Note that this ccp is not an update. Neither is it monotonic, since the number of pegs is reduced. Nevertheless, under certain circumstances, we can use it in combination with updates to yield a new update. Notice that Peg Deletion is undefined if Pdom(ct) = Ø or Pdom(ct) = P_ω.

3.3.2 The Semantics of DITT

At first glance, the semantics of DITT is pretty similar to DETT. The crucial fact to be noted is that every DITT-possibility <D,n,r,i,w> uniquely defines a partial sequence s. We simply have to compose the referent function r with the peg interpretation i. Interpretation is again relativized to a total sequence and an assignment function, and additionally to possible worlds. The latter have the same function as in Montague's IL and need no further comment. Contexts and sequences are related to each other by means of these partial sequences defined by the elements of the context. The definitions of extensional domains, sequences, assignments, open, familiar, and new discourse markers etc. are identical to the corresponding definitions of DETT. I therefore omit them here. The domains of intensional types are now relativized to worlds and sequences.

Definition 3.19 Intensional Types
If τ is a DITT-type, $Dom(<s,\tau>) =_{def} Dom(\tau)^{S\times W}$

The most important formal difference with respect to DETT, besides intensionality, is the fact that the output of an update is always the realistic extension of the context achieved by the familiar "structural" operations. The motivation for this move is of course the treatment of the bridging phenomena discussed above.

Definition 3.20 The Semantics of DITT
For any model $\mathcal{M}$ = <E, W, F, MP>, world w, total sequence s, and assignment g, it holds that:

i) $\|c\|_{g,s,w} =_{def} F(c)(w)$ iff $c \in Con$,

ii) $\|v\|_{g,s,w} =_{def} g(v)$ iff $v \in Var$,

iii) $\|d\|_{g,s,w} =_{def} s(d)$ iff $d \in DM$,

iv) $\|\alpha(\beta)\|_{g,s,w} =_{def} \|\alpha\|_{g,s,w}(\|\beta\|_{g,s,w})$,

v) $\|\lambda v_\tau.\alpha_\sigma\|_{g,s,w} =_{def} \iota f(f \in Dom(<\tau,\sigma>) \wedge \forall x: f(x) = \|\alpha\|_{g[v/x],s,w})$,

vi) $\|{^\wedge}\alpha_\tau\|_{g,s,w} =_{def} \iota f(f \in Dom(<s,\tau>) \wedge \forall t \in S \forall v \in W: f(<t,v>) = \|\alpha\|_{g,t,v})$,

vii) $\|{^\vee}\alpha\|_{g,s,w} =_{def} \|\alpha\|_{g,s,w}(<s,w>)$,

viii) $ct[\alpha = \beta]_{g,s,w} =_{def} rex(\{<D,n,r,i,v> \in ct | \forall s'[\, r \circ i \subseteq s' \rightarrow \|\alpha\|_{g,s',v} = \|\beta\|_{g,s',v}]\})$
iff $od(\alpha) \cup od(\beta) \subseteq Ddom(ct)$, undefined else,

ix) $ct[\neg\phi]_{g,s,w} =_{def} rex(\{k \in ct | \neg\exists l[l \in ct[\phi]_{g,s,w} \wedge k \leq l]\})$

x) $ct[\phi \wedge \psi]_{g,s,w} =_{def} ct[\phi]_{g,s,w}[\psi]_{g,s,w}$,

xi) $ct[\exists v_\tau.\phi]_{g,s,w} =_{def} rex(\bigsqcup_{x \in Dom(\tau)} ct[\phi]_{g[v/x],s,w})$,

xii) $ct[\forall v_\tau.\phi]_{g,s,w} =_{def}$ $rex(\bigsqcap_{x \in Dom(\tau)} ct[\phi]_{g[v/x],s,w})$,

xiii) $ct[\mathcal{E}d.\phi]_{g,s,w} =_{def} (Pos \cap \{<D\cup\{d\},n+1,r[d/p_n],i\cup\{<p_n,a>\},v>|$
$<D,n,r,i,v> \in ct \wedge a \in E\})[\phi]_{g,s,w}$,

where $r[d/p_n]$ is exactly like r except that it maps d to p_n,

xiv) $ct[\Uparrow\alpha]_{g,s,w} =_{def} rex(\{<D,n,r,i,v>\in ct| \forall s'[r\circ i \subseteq s' \rightarrow \|\alpha\|_{g,s',v} = 1]\})$
iff $od(\alpha) \subseteq Ddom(ct)$, undefined else,

xv) $\|\Downarrow\phi\|_{g,s,w} =_{def} 1$ iff $\forall D,n,r,i[<D,n,r,i,w> \in Pos \wedge r\circ i \subseteq s$
$\wedge \{<D,n,r,i,w>\}[\phi]_{g,s,w}$ is defined $\rightarrow \{<D,n,r,i,w>\}[\phi]_{g,s,w} \neq \mathbf{0}]$.

xvi) $ct[\Diamond\phi]_{g,s,w} =_{def} \{k\in ct| ct[\phi]_{g,s,w} \neq \mathbf{0}\}$.

Auxiliary definition:

xvii) $ct[\mathbf{T}\phi]_{g,s,w} =_{def} \bigcup_{p\in Pdom(ct)} ct[p_n = p][\phi]_{g,s,w}$
if $\exists p\in Pdom(ct) : ct[p_n=p][\phi]_{g,s,w} \neq \mathbf{0}$, undefined else.

There are three major differences with respect to DETT, ignoring realistic extensions and intensionality. The first concerns the definition of the dynamic existential quantifier in clause xiii). It is no longer required that the discourse marker quantified over is a new one. If it is already present in the input, it is reset to the newly introduced peg. Accordingly, if a formula ϕ denotes a total update function, $\mathcal{E}d.\phi$ does too. This corresponds to the fact that there is no counterpart to Heim's Novelty Condition in DITT. The Familiarity Condition, on the other hand, is carried over (clause (viii) and (xiv)).

The second important innovation concerns the use of the Topic-operator **T**. This is just a syntactic counterpart of the Peg Deletion operation defined above. Since the output of this ccp is not generally more informative that the input - it contains fewer pegs - **T**ϕ does not generally denote an update. Therefore clause xvii) is not part of the "official" semantics. Nevertheless, it is useful for the definition of a Topic-operator that maps determiners to determiners.

In clause xvi), Veltman's['90] *might*-operator is introduced. This serves as a test. If the output of an update ϕ in an input context ct is defined and does not equal **0**, the input context remains unchanged. Otherwise **0** results. Note that it involves existential quantification over sequence-world pairs, not simply over worlds as in traditional modal logic. We will mainly use its dual, the dynamic necessity-operator.

Definition 3.21 Necessity
Let ϕ be a type-up-formula.
$\Box\phi =_{def} \neg\Diamond\neg\phi$

Its semantics is slightly more complicated. It roughly says: If updating with ϕ would delete possibilities in the input context, $\Box\phi$ gives **0** as output; and if ϕ would only extend possibilities, the input remains unchanged.

Fact 3.1 Necessity
For all contexts ct and updates ϕ, it holds that

$$ct[\Box\phi]_{g,s,w} = \begin{cases} ct \text{ iff } \forall k \in ct\ \exists l\ [l \in ct[\phi]_{g,s,w} \wedge k \leq l] \\ \mathbf{0} \text{ else} \end{cases}$$

The DETT-notion of truth in a context makes use of the completion of a context. A corresponding notion is straightforwardly definable in DITT. The completion is not simply a set of total sequences as in DETT but a set of sequence-world-pairs.

Definition 3.22 Completion of a Context
Let ct be a context and S the set of total sequences.
$compl(ct) =_{def} \{\langle s,w\rangle \in S\times W \mid \exists D,n,r,i\ [\langle D,n,r,i,w\rangle \in ct \wedge r\circ i \subseteq s]\}$

Now, the DETT-definitions of truth and entailment are also applicable to DITT.

I do not intend to investigate the logical properties of DITT here in detail; they are very similar to DETT. What we are really interested in is the application of this language as an interpretation medium for English. In particular, we are now able to deal with the different readings of the definite determiner, including bridging constructions, in a precise, formal, and, last but not least, compositional way.

3.4 A Compositional Treatment of Topicality and Bridging

3.4.1 Indefinites and Pronouns

The treatment of indefinites and pronouns in DITT is more or less a repetition of the corresponding translations in DETT. They will be presented rather briefly.

(38) A_d man walks. He_d talks.

The translations of the lexical entries involved are syntactically identical to the DETT-translations presented in the previous chapter. The same holds for the syntax of the fragment of English discussed there and the corresponding semantic operations. Therefore the translation of (38) into DITT is syntactically identical to its DETT-translation.

(39) $\mathcal{E}$d. ⇑**man'**(d) ∧ ⇑**walk'**(d) ∧ ⇑**talk'**(d)

But the interpretation of (39) is of course different from the interpretation of the corresponding DETT-formula[11].

(40) a. ct[$\mathcal{E}$d. ⇑**man'**(d) ∧ ⇑**walk'**(d) ∧ ⇑**talk'**(d)]$_{g,s,w}$ =
{<D∪{d},n+1,r[d/p_n],i∪{<p_n,a>},v>| <D,n,r,i,v> ∈ ct ∧
a ∈ F(**man'**)(v) ∩ F(**walk'**)(v) ∩ F(**talk'**)(v)}
b. ‖⇓$\mathcal{E}$d. ⇑**man'**(d) ∧ ⇑**walk'**(d) ∧ ⇑**talk'**(d)‖$_{g,s,w}$ = 1 iff
F(**man'**)(w) ∩ F(**walk'**)(w) ∩ F(**talk'**)(w) ≠ Ø, 0 else
c. ∃x[**man'**(x) ∧ **walk'**(x) ∧ **talk'**(x)]

The update corresponding to (38) introduces a new peg p_n, it fixes the value of d to this peg, no matter whether d was already present in the input or not, and it maps the new peg to an individual that is a walking and talking man in the respective world. These are just the operations we expected this discourse to execute in the informal discussion above. It should be noted that there are no straightforward counterparts to CRS-conditions in the "official" theory, their part is taken over by restrictions on the peg interpretation function "i". This is reminiscent of the role of file card entries in the metaphoric variant of FCS as compared with the formal theory.

Although the operations on contexts that an update executes in DITT are more complex than in DETT, the truth-conditional content remains the same, as can be seen from (40b), which corresponds to the first-order formula in (40c).

This similarity is carried over to sentences containing free anaphors.

(41) a. He$_d$ talks.
b. ⇑**talk'**(d)
c. ct[⇑**talk'**(d)]$_{g,s,w}$ = {<D,n,r,i,v> ∈ ct| i(r(d)) ∈ F(**talk'**)(v)}
d. ‖⇓⇑**talk'**(d)‖$_{g,s,w}$ = 1 iff s(d) ∈ F(**talk'**)(w)

(41b) singles out those possibilities in the input that map d to a talking individual, no matter which peg mediates this interpretation. If d is not an element of the discourse domain of the input, no output is defined. The truth-conditional contents of (41) under DETT and under DITT are just identical.

[11] As long as it is not indicated explicitly, we assume that the set of Meaning Postulates is empty. In this case, the realistic extension of a context is the context itself.

3.4.2 Referential Definites

The increased expressive power of DITT comes into play as soon as we try to extend the fragment to definites. Remember that a satisfactory analysis was impossible in DETT. Our example is repeated.

(38) The$_d$ PRINter is out of order.

In the CRS-model, we required that (38) both introduces a new printer-peg and fixes d to it. Besides this, we wanted to express that there is exactly one printer in the world/model, and that this printer happens to be out of order. How to express this in DITT? The first two steps are fairly simple.

(39) $\mathcal{E}d.\ \Uparrow\mathbf{printer'}(d)$

Uniqueness corresponds to the fact that any printer-peg introduced later is bound to be coreferential to d. A first attempt is the dynamic version of traditional translation of the definite determiner.

(40) $\mathcal{E}d.\ \Uparrow\mathbf{printer'}(d) \wedge \neg(\mathcal{E}d'.\ \Uparrow\mathbf{printer'}(d') \wedge d \neq d')$

But this formalization is not in accordance with intuition. Consider the example:

(41) The$_d$ man who ate his$_d$ hat ...

Generalizing from (40), we get

(42) $\mathcal{E}d.\ \Uparrow\mathbf{man'}(d) \wedge \Uparrow\mathbf{eat'}(d,\mathbf{hat'}(d)) \wedge \neg(\mathcal{E}d'.\ \Uparrow\mathbf{man'}(d') \wedge \Uparrow\mathbf{eat'}(d',\mathbf{hat'}(d)) \wedge d \neq d')$

This says roughly that there is a man x who ate his own hat and that there is no man y who ate **x**'s (!) hat. In other words, the bound-variable-reading of *his hat* cannot be carried over to the possible alternatives to the hat-eating man whose existence is denied. The index "d" of the anaphoric pronoun cannot be renamed. In FCS or DETT, this would be the end of the story, but since we do not have a Novelty Condition anymore, we do not need to introduce a new discourse marker d' in the second conjunct. Instead of (40) and (42) , we have:

(43) a. $\mathcal{E}d.\ \Uparrow\mathbf{printer'}(d) \wedge \exists x(d = x \wedge \neg(\mathcal{E}d.\ \Uparrow\mathbf{printer'}(d) \wedge d \neq x))$
b. $\mathcal{E}d.\ \Uparrow\mathbf{man'}(d) \wedge \Uparrow\mathbf{eat'}(d,\mathbf{hat'}(d)) \wedge \exists x(d = x \wedge \neg(\mathcal{E}d.\ \Uparrow\mathbf{man'}(d)$
$\wedge \Uparrow\mathbf{eat'}(d,\mathbf{hat'}(d)) \wedge d \neq x))$

(43a) says: In a first step, introduce a new printer-peg and fix d to this peg. In the following step, check whether it is possible to introduce another printer-peg with an interpretation different from the first printer-peg. If you succeed, give an error-message (formally: the output is **0**). Otherwise, move back to the stage after the first step. The first value of d is stored, so to speak, by means of the static variable x, to check whether d's second value is the same or not.

The translation of the VP *is out of order* does not cause further problems. The translation of (38) therefore should be

(44) $\mathcal{E}$d. ⇑**printer'**(d) ∧ ∃x(d = x ∧ ¬($\mathcal{E}$d. ⇑**printer'**(d) ∧ d≠x)) ∧ ⇑**out_of_order'**(d)

Since the last conjunct is outside the scope of the negation, d now gets its original value again.

It is a matter of an ongoing discussion, whether the existence and uniqueness claims tied to definites are to be treated as presuppositions or assertions. Since we have identified two readings of the definite article, the question has to be answered for either reading separately. As far as the referential reading is concerned, the presuppositional account is obviously wrong.

(45) a. Bill resembles Mary so closely that he really could be the brother of this girl.
b. Bill ähnelt Mary so sehr, daß er wirklich [$_{VP}$der Bruder des Mädchens sein könnte]
B. resembles M. that much that he really the brother theGEN girlGEN be could

According to the presuppositional account, the definite DP *the brother of this girl* triggers an existential and a uniqueness presupposition that is projected to the matrix clause. Hence the whole sentence should have this presupposition. Now suppose Mary does not have any brother at all. In this case, a presupposition failure should result, but it doesn't. The German translation shows that the DP at hand is not a Topic. Hence we conclude that referential definites **assert** existence and uniqueness of their referents. This is predicted by the translation in (44).

To develop the translation of the referential definite article itself, we have to abstract away from the predicates *printer* and *is out of order* in (44).

Definition 4.1 The Referential Reading of the Definite Determiner
the_d ==> λPλQ.$\mathcal{E}$d.P{^d} ∧ ∃x(d=x ∧ ¬($\mathcal{E}$d. P{^d} ∧ d≠x)) ∧ Q{^d}

For completeness, the compositional derivation of the translation is given.

(46) a.

the_d :: D :: $\lambda P \lambda Q.\mathcal{E}d.P\{^\wedge d\} \wedge \exists x(d{=}x \wedge \neg(\mathcal{E}d.\ P\{^\wedge d\} \wedge d \neq x)) \wedge Q\{^\wedge d\}$

|

| printer :: NP :: $\lambda x.\Uparrow\textbf{printer'}({}^\vee x)$

| /

the_d printer :: DP :: $\lambda Q.\mathcal{E}d.\Uparrow\textbf{printer'}(d) \wedge \exists x(d{=}x \wedge \neg(\mathcal{E}d.\Uparrow\textbf{printer'}(d) \wedge d \neq x)) \wedge Q\{^\wedge d\}$

|

| is out of order :: VP :: $\lambda x.\Uparrow\textbf{out\_of\_order'}({}^\vee x)$

| /

the_d printer is out of order :: S ::

$\mathcal{E}d.\Uparrow\textbf{printer'}(d) \wedge \exists x(d{=}x \wedge \neg(\mathcal{E}d.\Uparrow\textbf{printer'}(d) \wedge d \neq x)) \wedge \Uparrow\textbf{out\_of\_order'}(d)$ (=**A**)

b. $ct[\mathbf{A}]_{g,t,w} = \{\langle D \cup \{d\}, n+1, r[d/p_n], i \cup \{\langle p_n, a\rangle\}, v\rangle \mid \langle D,n,r,i,v\rangle \in ct \wedge$
$F(\textbf{printer'})(v) = \{a\} \wedge a \in F(\textbf{out\_of\_order'})(v)\}$

c. $\|\Downarrow\mathbf{A}\|_{g,s,w} = 1$ iff $\exists a \in E\ [F(\textbf{printer'})(w) = \{a\} \wedge e \in F(\textbf{out\_of\_order'})(w)]$, 0 else

d. $\exists x[\textbf{printer'}(x) \wedge \neg\exists y[\textbf{printer'}(y) \wedge x \neq y] \wedge \textbf{out\_of\_order'}(x)]$

The truth-conditional content (46c) does not come as a surprise. The sentence is true iff there is exactly one printer and this printer is out of order. This can be expressed by the first-order formula in (46d).

3.4.3 Anaphoric Definites

Now let us turn to the other reading of the definite article.

(47) $[_{+\text{Topic}}\ \text{The}_d\ ]$ student is intelligent.

For reasons not to be discussed here (cf. Jäger['92]), subjects of individual-level predicates (cf. Kratzer['89b], Diesing['92]) like *intelligent* are obligatorily [+Topic]. Hence there is no ambiguity. This predestinates this kind of construction to the investigation of the issue: presupposition or assertion?

(48) a. I cannot believe that the student is intelligent.
b. If the student were intelligent, he would solve the problem.
c. Maybe the student is intelligent.

None of these examples is compatible with the knowledge that there is no student or that there is more than one salient student. Hence we conclude that the Topic-morpheme not only narrows down the domain of interpretation, it also shifts the descriptive content from assertion to presupposition. The operations to be performed by the update are first presented informally:

(49) a. Fix the discourse marker "d" to a familiar peg p_i

b. Check that the value of p_i is a student under each peg-interpretation.
c. Check that there is no other familiar peg p_j such that the value of p_j is a student under each peg-interpretation.
d. Eliminate those possibilities where the value of p_i is not intelligent.

How to formalize the first step? The only way to introduce a new, or to reset a familiar, discourse marker is the application of the dynamic existential quantifier "$\mathcal{E}$d", but this introduces a new peg and fixes "d" to that peg. Here is where our Topic-operator **T** comes into play. **T** deletes the last peg introduced - the value of "d" in the present state - and fixes "d" to a familiar peg. This familiar peg has to be mapped to a student.

(50) $\mathcal{E}$d. **T**⇑**student'**(d)

Note that, although "**T**⇑**student'**(d)" is not an update, "$\mathcal{E}$d.**T** ⇑**student'**(d)" is. The latter's output contains the same number of pegs as the input. But it does not suffice that "d" is mapped to some student-peg in every possibility of the input: it has to be the same one in every possibility. This corresponds to the fact that the existence of a student-peg is presupposed and not merely asserted. This can be done by means of the necessity-operator, what can be taken to be a reconstruction of the intuition that Topics carry "old" information.

(51) $\mathcal{E}$d. **T** □⇑**student'**(d)

This update succeeds if and only if there is a familiar peg in the input that is mapped to a student in every possibility. The uniqueness-requirement is implemented in the same way as before, such that the desired translation of (47) is

(52) $\mathcal{E}$d. **T** □⇑**student'**(d) ∧ ∃x(d=x ∧ ¬($\mathcal{E}$d. **T** □⇑**student'**(d) ∧ d≠x)) ∧ ⇑**intelligent'**(d)

The meaning of the anaphoric definite determiner is again achieved by abstraction over the nominal and the verbal predicate.

Definition 4.2 The Anaphoric Reading of the Definite Determiner
$[_{+Topic}\ the_d]$ ==> λPλQ.$\mathcal{E}$d. **T**□P{^d} ∧ ∃x(d=x ∧ ¬($\mathcal{E}$d. **T**□P{^d} ∧ d≠x)) ∧ Q{^d}

It was mentioned above that these two readings of the definite article are not a matter of lexical ambiguity, but rather are driven by the presence vs. absence of the Topic-feature. Hence there must be a template that corresponds to that feature and that maps the referential to the anaphoric reading. By comparing the referential reading in definition 4.1 and the anaphoric reading in definition 4.2, it becomes clear that the only difference is the prefix "**T**□" preceding every occurrence of "P" in the anaphoric variant. The definition of the Topic-template is thus straightforward.

Definition 4.3 The Topic-Template
Let "top" be a DITT-constant, top $\in$ Exp(<<s, det>,det>>). For every DITT-model $\mathcal{M}$, sequence s, and assignment g, it holds that:
$\|\mathrm{top}\|_{\mathcal{M},g,s,w} =_{def} \|\lambda D_{<s,det>}\lambda P_{<s,pred>}.D\{{}^\wedge\lambda x_{<s,e>}.\mathbf{T}\Box P\{x\}\}\|_{\mathcal{M},g,s,w}$

The referential reading is taken to be the basic one. Topic assignment is done by means of an additional syntactic rule.

Definition 4.4 Topic Assignment
i) $[_{+Topic}\ D]$ ==> D
ii) DP ==> $[_{+Topic}\ D]$, NP
iii) *trans*($[_{+Topic}\ D]$) = top(^*trans*(D))
where *trans* is the translation function from English to DITT

The first line gives the syntactic rule that assigns the Topic-feature to a determiner. The second line indicates that [+Topic]-determiners show the same distribution as [-Topic] ones. The last line gives the translation rule for Topic assignment. The fact that this feature presumably percolates to DP does not matter here. We are now able to derive the translation of (47).

(53) a.
the_d :: D :: $\lambda P\lambda Q.\mathcal{E}d.P\{{}^\wedge d\} \wedge \exists x(d=x \wedge \neg(\mathcal{E}d.\ P\{{}^\wedge d\} \wedge d\neq x)) \wedge Q\{{}^\wedge d\}$ (= **A**)
|
the_d :: $[_{+Topic}\ D]$ :: top(^**A**)
|
| student :: NP :: $\lambda x.\Uparrow\mathbf{student'}(^\vee x)$
| /
the_d student :: DP :: top(**A**)($^\wedge\lambda x.\Uparrow\mathbf{student'}(^\vee x)$)
|
| is intelligent :: VP :: $\lambda x.\Uparrow\mathbf{intelligent'}(^\vee x)$
| /
the_d student is intelligent :: S :: top(^**A**)($^\wedge\lambda x.\Uparrow\mathbf{student'}(^\vee x)$)($^\wedge\lambda x.\Uparrow\mathbf{intelligent'}(^\vee x)$) (=**B**)

b. $\lambda D\lambda P.D\{{}^\wedge\lambda x.\mathbf{T}\Box P\{x\}\}({}^\wedge\lambda R\lambda Q.\mathcal{E}d.R\{{}^\wedge d\} \wedge \exists x(d=x \wedge \neg(\mathcal{E}d.R\{{}^\wedge d\} \wedge d\neq x)) \wedge Q\{{}^\wedge d\})$
$= \lambda P.\lambda R\lambda Q.\mathcal{E}d.R\{{}^\wedge d\} \wedge \exists x(d=x \wedge \neg(\mathcal{E}d.R\{{}^\wedge d\} \wedge d\neq x)) \wedge Q\{{}^\wedge d\}({}^\wedge\lambda x.\mathbf{T}\Box P\{x\})$
$= \lambda P.\lambda Q\mathcal{E}d.\lambda x.\mathbf{T}\Box P\{x\}({}^\wedge d) \wedge \exists x(d=x \wedge \neg(\mathcal{E}d.\lambda x.\mathbf{T}\Box P\{x\}({}^\wedge d) \wedge d\neq x)) \wedge Q\{{}^\wedge d\}$
$= \lambda P.\lambda Q\mathcal{E}d.\mathbf{T}\Box P\{{}^\wedge d\} \wedge \exists x(d=x \wedge \neg(\mathcal{E}d.\mathbf{T}\Box P\{{}^\wedge d\} \wedge d\neq x)) \wedge Q\{{}^\wedge d\}$
= top(^**A**)

c. $\lambda P.\lambda Q.\mathcal{E}d.\mathbf{T}\Box P\{{}^\wedge d\} \wedge \exists x(d=x \wedge \neg(\mathcal{E}d.\mathbf{T}\Box P\{{}^\wedge d\} \wedge d\neq x)) \wedge Q\{{}^\wedge d\}({}^\wedge\lambda x.\Uparrow\mathbf{student'}(^\vee x))$

$= \lambda Q.\mathcal{E}d.\mathbf{T}\Box\Uparrow\mathbf{student'}(d) \wedge \exists x(d{=}x \wedge \neg(\mathcal{E}d.\mathbf{T}\Box\Uparrow\mathbf{student'}(d) \wedge d{\neq}x)) \wedge Q\{{}^\wedge d\}$
$= \text{top}(\mathbf{A})({}^\wedge\lambda x.\Uparrow\mathbf{student'}({}^\vee x))$

d. $\lambda Q.\mathcal{E}d.\mathbf{T}\Box\Uparrow\mathbf{student'}(d) \wedge \exists x(d{=}x \wedge \neg(\mathcal{E}d.\mathbf{T}\Box\Uparrow\mathbf{student'}(d) \wedge d{\neq}x)) \wedge Q\{{}^\wedge d\}$
$({}^\wedge\lambda x.\Uparrow\mathbf{intelligent'}({}^\vee x))$
$= \mathcal{E}d.\mathbf{T}\Box\Uparrow\mathbf{student'}(d) \wedge \exists x(d{=}x \wedge \neg(\mathcal{E}d.\mathbf{T}\Box\Uparrow\mathbf{student'}(d) \wedge d{\neq}x)) \wedge \Uparrow\mathbf{intelligent'}(d)$
$= \mathbf{B}$

e. $ct[\mathbf{B}]_{g,s,w} = \{\langle D\cup\{d\},n,r[d/\alpha],i,v\rangle \mid \langle D,n,r,i,v\rangle \in ct \wedge i(\alpha) \in F(\mathbf{intelligent'})(v)\}$
iff $\alpha = \iota x(x \in \text{Pdom}(ct) \wedge \forall\langle D,n,r,i,v\rangle \in ct{:}\ i(x) \in F(\mathbf{student'})(v))$,
undefined else.

f. $\|\Downarrow\mathbf{B}\|_{g,s,w} =$ 1 iff $F(\mathbf{student'})(w) \subseteq F(\mathbf{intelligent'})(w)$, 0 else

g. $\forall x[\mathbf{student'}(x) \rightarrow \mathbf{intelligent'}(x)]$

The update is not defined in the empty state **1**, which reflects the fact that the Topic has to be linked to the preceding discourse in one way or another. The anaphoric character of the Topic-subject *the student* is reflected by the fact that the truth-conditional content of (47) (given in (53f)) corresponds to an universally quantified first-order formula, namely (53g). Remember that the truth-conditional content of sentences containing free anaphora corresponds to universally quantified formulae, too. Nevertheless, there is no anaphor in (47) in the syntactic sense of the word. This universal force of the Topic is swallowed, if the sentence is preceded by a sentence where a student is mentioned.

(54) a. There is $a_{d'}$ student. (...) [$_{+\text{Topic}}$ The_d] student is intelligent.

b. $\mathcal{E}d'.\Uparrow\mathbf{student'}(d')$[12] $\wedge\ \mathbf{B}$

c. $ct[\mathcal{E}d'.\Uparrow\mathbf{student'}(d') \wedge \mathbf{B}]_{g,s,w} = \{\langle D\cup\{d,d'\},n{+}1,r[d'/p_n][d/p_n],i\cup\{\langle p_n,a\rangle\},v\rangle \mid$
$\langle D,n,r,i,v\rangle \in ct \wedge a \in F(\mathbf{student'})(v) \cap F(\mathbf{intelligent'})(v)\}$
iff $\forall p(p \in \text{Pdom}(ct) \rightarrow \exists\langle D,n,r,i,v\rangle \in ct{:}\ i(p) \notin F(\mathbf{student'})(v))$,
undefined else.

d. $\|\Downarrow\mathcal{E}d'.\Uparrow\mathbf{student'}(d') \wedge \mathbf{B}\|_{g,s,w} =$ 1 iff $F(\mathbf{student'})(w) \cap F(\mathbf{intelligent'})(w) \neq \emptyset$,
0 else

f. $\exists x[\mathbf{student'}(x) \wedge \mathbf{intelligent'}(x)]$

The discourse in (54) introduces two new discourse markers into the context, d and d', but it only introduces one new peg. Both d and d' are mapped to this new peg. The interpretation of the peg has to be an intelligent student in each possibility. Since the definite Topic triggers a uniqueness-presupposition, the discourse is only felicitous in a context that does not contain a student-peg already. More precisely, there must not be any familiar peg that is mapped to a student in **every**

[12]The concrete analysis of *there*-sentences is not at issue here. For a careful discussion in a dynamic setup, cf. Blutner['93].

possibility.

(55) Yesterday, I met Peter. His brother is studying at the university. (...)
The student is intelligent.

It is not excluded in (55) that Peter is a student, too. The uniqueness-presupposition only excludes that Peter is **known** to be a student in the input context.

Accordingly, this version of the uniqueness-presupposition in (54) does not carry over to the truth conditions (54d). They only assert the existence of an intelligent student.

3.4.4 Donkey Sentences with Definite Descriptions and the E-Type Strategy

There is a long tradition in analyzing donkey sentences that is incompatible with the view advocated here (cf. Evans['77], Cooper['79], Heim['90], v. Fintel['94], ...). Its apologists rely on the observation that the sentences in (56a) and (b) are synonymous.

(56) a. If a farmer owns a donkey, he beats it.
b. If a farmer owns a donkey, the farmer beats the donkey.

The core claim of that approach says that the pronouns *he* and *it* in the (a)-example should not be treated as bound variables (or discourse markers respectively) but as disguised definite descriptions (so-called E-type pronouns, cf. Evans['77]). The synonymy is accounted for by the assumption that the pronoun *he* itself is synonymous with *the farmer* or even with *the farmer who owns a donkey*. *It* should be interpreted as *the donkey* or *the donkey a farmer owns*. There are basically two ways to assign such a meaning to the pronoun: either you copy the NP from the antecedent (*farmer* and *donkey* respectively) into the scope of the pronoun at LF, or you make use of some coindexing mechanism that ensures identity of descriptive content between antecedent and pronoun (the attempt to attribute the semantic content of a pronoun to pure pragmatics does not qualify as a serious option in my view). It is obvious that the first option is incompatible with the requirement of S-compositionality. Pronouns - as every lexical entry - denote whatever they denote by means of their lexical information, and that is all there is to be said about this issue. The second option - coindexing - is possible, but it leads to wrong predictions.

(57) a. $^?$If a dog$_i$ meets a dog$_j$, it$_i$ barks at it$_j$.
b. *If a dog$_i$ meets a dog$_j$, the dog$_i$ barks at the dog$_j$.

If the coindexing in (57a) were only to serve to transfer the descriptive content *dog* from the antecedents to the respective pronouns, then (57a) should be semantically identical to (57b). But the latter is completely out, while the former is merely somewhat awkward[13]. Hence we have to conclude that identical indices force coreference, too. This is also assumed in the dynamic approach. But if coreference is necessary anyway, why should we assume identity of descriptive content? By Occam's Razor, this assumption is superfluous and therefore to be denied. I conclude that the E-type strategy is - besides being unavailable in the present approach - also undesirable from the point of view of the empirical predictions it makes[14].

Nevertheless, the synonymy in (56) remains to be explained. Although it does not provide a tool to analyze donkey constructions in general, it is an interesting empirical problem. To put it another way round, instead of being an *explanans*, it is an *explanandum*.

The treatment of definites outlined above predicts both the synonymy in (56) and the contrast in (57), as long as we consider the definites in (56b) as Topics. Before showing this, I introduce an abbreviational convention, since the fully spelled out DITT-translation of the definite determiner is rather intractable.

Definition 4.5 THE

$\mathrm{THE}_d\,(\phi)(\psi) =_{def} \mathcal{E}d.\phi \wedge \exists x(d{=}x \wedge \neg(\mathcal{E}d.\phi \wedge d{\neq}x)) \wedge \psi$

Instead of (58), I have chosen an example with only one donkey pronoun. The analysis carries over to the "classical" donkey sentence.

(58) a. If a_d man walks, he_d moves.

b. $\mathcal{E}d.\ {\Uparrow}\mathbf{man'}(d) \wedge {\Uparrow}\mathbf{walk'}(d) \rightarrow {\Uparrow}\mathbf{move'}(d)$

c. $ct[\mathcal{E}d.\ {\Uparrow}\mathbf{man'}(d) \wedge {\Uparrow}\mathbf{walk'}(d) \rightarrow {\Uparrow}\mathbf{move'}(d)]_{g,s,w}$

$= \{\langle D,n,r,i,v\rangle \mid F(\mathbf{man'})(v) \cap F(\mathbf{walk'})(v) \subseteq F(\mathbf{move'})(v)\}$

d. $\|{\Downarrow}\mathcal{E}d.\ {\Uparrow}\mathbf{man'}(d) \wedge {\Uparrow}\mathbf{walk'}(d) \rightarrow {\Uparrow}\mathbf{move'}(d)\|_{g,s,w}$

$= 1$ iff $F(\mathbf{man'})(w) \cap F(\mathbf{walk'})(w) \subseteq F(\mathbf{move'})(w)$, 0 else

e. $\forall x[\mathbf{man}(x) \wedge \mathbf{walk'}(x) \rightarrow \mathbf{move'}(x)]$

---

[13]Matters do not improve if we choose the more complicated option.

i) *If a dog meets a dog, the dog that met a dog barks at the dog that a dog met.

This sentence is as bad as (57b). In the rest of the paragraph, only the simplified version is discussed, but the argumentation carries over to the more complicated one.

[14]Heim['90] develops a more sophisticated descendant of the "classical" E-type strategy where pronouns are not claimed to be plainly synonymous to definite descriptions sharing the descriptive content with their antecedent. Nevertheless she admits that this construction type is problematic for her approach.

(59) a. If a_d man walks, $[_{+Topic}$ $the_{d'}$] man moves.

b. a_d man walks :: S :: $\mathcal{E}d.\ \Uparrow\mathbf{man'}(d) \wedge \Uparrow\mathbf{walk'}(d)$

|
| if :: C :: $\lambda p\lambda q.{}^{\vee}p \rightarrow {}^{\vee}q$
| /
if a_d man walks :: $\bar{\mathbf{S}}$ :: $\lambda q.\mathcal{E}d.\ \Uparrow\mathbf{man'}(d) \wedge \Uparrow\mathbf{walk'}(d) \rightarrow {}^{\vee}q$
|
| $the_{d'}$ :: $[_{+Topic}$ D] :: $\lambda P\lambda Q.THE_{d'}(\mathbf{T}\Box P\{{}^{\wedge}d\})(Q\{{}^{\wedge}d\})$
| |
| | man :: NP :: $\lambda x.\Uparrow\mathbf{man'}({}^{\vee}x)$
| | /
| $the_{d'}$ man :: DP :: $\lambda Q.THE_{d'}\ (\mathbf{T}\Box\Uparrow\mathbf{man'}(d'))(Q\{{}^{\wedge}d'\})$
| |
| | moves :: IV :: $\lambda x.\Uparrow\mathbf{move'}({}^{\vee}x)$
| | /
| $the_{d'}$ man moves :: S :: $THE_{d'}\ (\mathbf{T}\Box\Uparrow\mathbf{man'}(d'))(\Uparrow\mathbf{move'}(d'))$
| /
if a_d man walks, $the_{d'}$ man moves :: S
:: $\mathcal{E}d.\ \Uparrow\mathbf{man'}(d) \wedge \Uparrow\mathbf{walk'}(d) \rightarrow THE_{d'}\ (\mathbf{T}\Box\Uparrow\mathbf{man'}(d'))(\Uparrow\mathbf{move'}(d'))$ (=**A**)

c. $ct[\mathbf{A}]_{g,s,w} = \{\langle D,n,r,i,v\rangle |\ F(\mathbf{man'})(v) \cap F(\mathbf{walk'})(v) \subseteq F(\mathbf{move'})(v)\}$ iff
$\forall p(p \in Pdom(ct) \rightarrow \exists\langle D,n,r,i,v\rangle \in ct: i(p) \notin F(\mathbf{man'})(v))$,
undefined iff
$\exists p(p \in Pdom(ct) \wedge \forall\langle D,n,r,i,v\rangle \in ct: i(p) \in F(\mathbf{man'})(v))$.

d. $\|\Downarrow\mathbf{A}\|_{g,s,w} = 1$ iff $F(\mathbf{man'}) \cap F(\mathbf{walk'})(w) \subseteq F(\mathbf{move'})(w)$, 0 else

e. $\forall x[\mathbf{man'}(x) \wedge \mathbf{walk'}(x) \rightarrow \mathbf{move'}(x)]$

According to our analysis, (58) and (59) are not completely synonymous. The definite description *the man* in (59) triggers an existential and a uniqueness presupposition. The former is swallowed by the antecedent of the conditional, but the latter is projected to the entire sentence. Accordingly, the update is only defined if there is still no man-peg in the input context. This seems not implausible to me. Nevertheless, the truth-conditions assigned to the sentences (58) and (59) are identical. Hence our approach is no worse than the E-type analysis in this case.

Now let us investigate the contrast in (57). The (a)-example is unproblematic.

(60) a. If a_d dog meets $a_{d'}$ dog, it_d barks at $it_{d'}$

b. $\mathcal{E}d.\ \Uparrow\mathbf{dog'}(d) \wedge \mathcal{E}d'.\ \Uparrow\mathbf{dog'}(d') \wedge \Uparrow\mathbf{meet'}(d,d') \rightarrow \Uparrow\mathbf{bark'}(d,d')$

c. $ct[\mathcal{E}d.\ \Uparrow\mathbf{dog'}(d) \wedge \mathcal{E}d'.\ \Uparrow\mathbf{dog'}(d') \wedge \Uparrow\mathbf{meet'}(d,d') \rightarrow \Uparrow\mathbf{bark'}(d,d')]_{g,s,w}$
$= \{\langle D,n,r,i,v\rangle |\ F(\mathbf{dog'})(v) \times F(\mathbf{dog'})(v) \cap F(\mathbf{meet'})(v) \subseteq F(\mathbf{bark'})(v)\}$

d. $\forall x\forall y[\ \mathbf{dog'}(x) \wedge \mathbf{dog'}(y) \wedge \mathbf{meet'}(x,y) \rightarrow \mathbf{bark'}(x,y)]$

This is the interpretation we expect. Let us turn to the bad example.

(61)

a. If a_d dog meets $a_{d'}$ dog, $[_{+Topic}$ $the_{d''}$] dog barks at $[_{+Topic}$ $the_{d'''}$] dog.

b.

if a_d dog meets $a_{d'}$ dog :: $\bar{\mathbf{S}}$ :: $\lambda q.\mathcal{E}d.\Uparrow\mathbf{dog'}(d) \wedge \mathcal{E}d'.\Uparrow\mathbf{dog'}(d') \wedge \Uparrow\mathbf{meet'}(d,d') \rightarrow {}^{\vee}q$
|
| $the_{d'''}$ dog :: DP :: $\lambda Q.THE_{d'''}\ (\mathbf{T}\Box\Uparrow\mathbf{dog'}(d'''))(Q\{d'''\})$
| |
| | barks at :: TV :: $\lambda T\lambda x.T\{{}^{\wedge}\lambda y.\mathbf{bark'}({}^{\vee}x,{}^{\vee}y)\}$
| | /
| barks at $the_{d'''}$ dog :: VP :: $\lambda x.THE_{d'''}\ (\mathbf{T}\Box\Uparrow\mathbf{dog'}(d'''))(\Uparrow\mathbf{bark'}({}^{\vee}x,d'''))$ (=**A**)
| |
| | $the_{d''}$ dog :: DP :: $\lambda Q.THE_{d''}\ (\mathbf{T}\Box\Uparrow\mathbf{dog'}(d''))(Q\{d''\})$
| | /
| $the_{d''}$ dog barks at $the_{d'''}$ dog :: S :: $THE_{d''}\ (\mathbf{T}\Box\Uparrow\mathbf{dog'}(d''))(\mathbf{A}(d''))$ (=**B**)
| /
if a_d dog meets $a_{d'}$ dog, $the_{d''}$ dog barks at $the_{d'''}$ dog :: S ::
$\mathcal{E}d.\Uparrow\mathbf{dog'}(d) \wedge \mathcal{E}d'.\Uparrow\mathbf{dog'}(d') \wedge \Uparrow\mathbf{meet'}(d,d') \rightarrow \mathbf{B}$ (=**C**)

c. **B** = $\mathcal{E}d''.\mathbf{T}\Box\Uparrow\mathbf{dog'}(d'') \wedge \exists x(x=d'' \wedge \neg(\mathcal{E}d''.\mathbf{T}\Box\Uparrow\mathbf{dog'}(d'') \wedge x\neq d'')) \wedge$
$\mathcal{E}d'''.\mathbf{T}\Box\Uparrow\mathbf{dog'}(d''') \wedge \exists x(x=d''' \wedge \neg(\mathcal{E}d'''.\mathbf{T}\Box\Uparrow\mathbf{dog'}(d''') \wedge x\neq d''')) \wedge$
$\Uparrow\mathbf{bark'}(d'',d''')$

d. $ct[\mathbf{C}]_{g,s,w}$ = undefined

(61a) is undefined in each context, since the antecedent of the conditional introduces two different dog-pegs, while the consequence presupposes that there is exactly one. If we were to analyze the definite DPs in (57b) as being referential, we would get an interpretation, something like *There is no more than one dog all over, and if this dog meets itself, it barks at itself*. This interpretation is excluded by Binding Principle C. Hence the ungrammaticality of (57b) is explained.

Note that (57) cannot be treated in parallel to the famous bishop-sentences which Heim['90] attributes to Hans Kamp:

(62) a. If a bishop meets another man, he blesses him.
b. $^{(?)}$If a bishop meets another man, the bishop blesses the man.

Both (62a) and (b) imply *If two bishops meet each other, they bless each other*. Under a simplistic interpretation of the uniqueness presuppositions triggered by the definites in (62b) (and, under the E-type analysis, in (62a) too), the sentence instead should come out as truth-valueless, if the man who is met is a bishop, too. This is another story than the one told by (57), since (62b) is nearly as acceptable as, and even more or less synonymous to (62a). Under the present approach, the uniqueness-presupposition triggered by *the bishop* only requires that the peg that the definite picks up is not interpreted as a bishop under every peg-interpretation admitted by the context. It does not matter if it happens to do so in one possibility or the other. But (62b) is in fact problematic under the present approach. If we take it for granted that bishops are always men, a violation of the uniqueness presupposition of *the man* results. We either have to admit that bishops are not necessarily men, or we have to refine the interpretation of the definite determiner slightly.

(63) "The P Q" means "There is one individual x that is P and possibly Q, and there are no individuals y different from x that are P and possibly Q, and x is Q"

According to this approach, *the man* in (62b) roughly means *the only man that the bishop could bless*. If we assume that bishops do not bless themselves (as far as I know, religious confessions differ in this respect), (62b) comes out as synonymous to (62a). I refrain from formalizing this idea since it causes quite a lot of technical difficulties that would lead us beyond the scope of this dissertation.

To conclude, if we contrast donkey conditionals with anaphoric pronouns in the consequence to parallel examples with definite descriptions, there are three observations to be accounted for.

(64) a. If a man walks, he talks.
b. If a man walks, the man talks.

(65) a. If a bishop meets a bishop, he blesses him.
b *If a bishop meets a bishop, the bishop blesses the bishop.

To start with, (64b), containing a definite description, does not presuppose or assert the existence and uniqueness of a single man. Even if we know that there is a walking man, there may be other men besides him. A theory of definiteness that requires general existence and uniqueness is unable to account for this observation

Secondly, the pronoun *he* and the definite description *the man* are interchangeable in (64). An adequate theory of definiteness has to predict this. Finally, this interchangeability of pronouns and definites breaks down in examples like (65) where subject and object of the antecedence are syntactically identical. I am not aware of any semantic theory of anaphoricity and definiteness except the one presented here, that is able to account for all these data. (65b) proves that definiteness is connected to uniqueness in a certain sense, but it has to be restricted in an appropriate way such that the uniqueness presupposition cannot project to the top level in (64a). The semantics of Topics given in this chapter is able to fulfill this requirement.

3.4.5 Bridging without Accommodation

Before we start formalizing the strategy to deal with bridging constructions that was informally discussed in paragraph 3.2, let me make two more remarks. To start with, it should be stressed that our mechanism is only intended to account for bridging in connection with **anaphoric** definites. To state this explicitly:

ANAPHORIC Definites trigger an existence and uniqueness presupposition w.r.t. the peg system of the input context.

Referential definites are sometimes related to the linguistic context by means of a kind of bridging too (some examples are discussed in paragraph 3.6.1 below), but there another mechanism is needed.

As a second point, attributing all bridging inferences to Meaning Postulates is a great oversimplification. Look again at the city-hall-example:

(66) In every city, the city hall is near the market place.

The analysis of this example crucially depends on the presence of two Meaning Postulates that ensure that each city has a city hall and a market place. This is of course too strong. Berlin, for example, does not have a market place, but this knowledge failes to make (66) unacceptable. Hence, some Meaning Postulates rather have the status of a generic statement than that of an analytical truth that a Meaning Postulate usually expresses.expresses. It was already mentioned at the end of subsection 3.2.2 that the term "Meaning Postulate" might be somewhat misleading since the information Meaning Postulates encode in our system rather have the status of presuppositions (in the sense that each discourse presupposes the weakest system of Meaning Postulates that makes it acceptable). It is well known that presupposition may be defeasible, but since the underlying logic of the present system is a monotonic one, this cannot be accounted for here. With this proviso, we now can formulate our claim more precisely:

An anaphoric definite is only licensed if its presupposition is supported by contextual information together with analytic and generic knowledge BEFORE the definite is processed.

Now let us work through the examples discussed in paragraph 3.2.

(67) John_d is married. $\text{The}_{d'}$ woman is nice.

Without advocating a particular theory about the semantics of proper nouns, I assume that *John* is just an abbreviation for *the individual called John*.

(68) $\text{John}_d \implies \lambda P.\text{THE}_d(\Uparrow \mathbf{john'}(d))(P\{{}^\wedge d\})$

The static predicate **john'** is intended to denote the set of individuals called John. We might require that it rigidly denotes one and the same singleton set in every world, but this does not matter for our purposes.

(69) a. $[_{+Topic}\ John_d]$ is married.

b. $THE_d(\mathbf{T}\Box\Uparrow\mathbf{john'}(d))(\Uparrow\mathbf{married'}(d))$

c. $ct[THE_d(\mathbf{T}\Box\Uparrow\mathbf{john'}(d))(\Uparrow\mathbf{married'}(d))]_{g,s,w}$ =

$rex(\{<D\cup\{d\},n,r[d/\alpha],i,v>|\ <D,n,r,i,v> \in ct \wedge i(\alpha) \in F(\mathbf{married'})(v)\})$

iff $\alpha = \iota p(p\in P_n \wedge \forall <D,n,r,i,v> \in ct\ [i(p) \in F(\mathbf{john'})(v)])$, undefined else

In the previous section, we ignored the fact that we have to compute the realistic extension of the output since the set of Meaning Postulates was empty and hence *rex* was just the identity function. Now suppose we do have Meaning Postulates.

MP 1 : $\forall x[\Box\mathbf{john'}(x) \rightarrow \Box\mathbf{male'}(x)]$

MP 2: $\forall x[\Box\mathbf{married'}(x) \wedge \Box\mathbf{male'}(x) \rightarrow \exists y[\Box\ \mathbf{woman'}(y) \wedge \Box\mathbf{wife'}(x,y)]]$

According to (69c), after processing the sentence we get a context that contains exactly one peg that is necessarily mapped to John. Let us call this context ct'. Definition 3.12 on page 86 gives us a modal first order model based on this context.

(70) $M_{ct'} =_{def} <P_n,ct',ct'\times ct',G>$, such that:

$G(Q^m)(<D,n,r,i,w>) = \{<q_1, ..., q_m> \in P_n^{\ m} \mid <i(q_1), ..., i(q_m)> \in F(Q^m)(w)\}$

The first Meaning Postulate is valid in $M_{ct'}$. Let us again use α to refer to the one and only peg mapped necessarily to John in ct' again:

(71) $M_{ct} =_{def} <P_n,ct,ct\times ct,G>$, such that:

$G(\mathbf{john'})(<D,n,r,i,v>) = \{q \in P_n \mid i(q) \in F(\mathbf{john'})(v)\} = \{\alpha\}$

$G(\mathbf{male'})(<D,n,r,i,v>) = \{q \in P_n \mid i(q) \in F(\mathbf{male'})(v)\}$

$\alpha \in G(\mathbf{male'})(<D,n,r,i,v>)$

$\|\Box\mathbf{john'}(x) \rightarrow \Box\mathbf{male'}(x)\|_{<D,n,r,i,v>,g[x/\alpha]} = 1$

$\|\forall x[\Box\mathbf{john'}(x) \rightarrow \Box\mathbf{male'}(x)]\|_{<D,n,r,i,v>,g} = 1$

Since the Meaning Postulates must be supported by the DITT-model (definition 3.3), the interpretation of **john'** is a subset of the interpretation of **male'**. This ensures that MP 1 also holds in every context-model.

Things are different w.r.t. MP2. According to (69c), α must be mapped to an element of F(**married'**) in each possibility of ct'. Hence the antecedence of MP2 is fulfilled in every possibility and under each variable assignment, but the consequence is only fullfilled if there is a peg among P_n that is mapped to John's wife in every possibility of ct'.

(72) a. $\alpha \in G(\mathbf{male'})(<D,n,r,i,v>)$

b. $\alpha \in G(\mathbf{married'})(<D,n,r,i,v>)$

c. $\|\forall x[\Box\mathbf{married'}(x) \wedge \Box\mathbf{male'}(x) \rightarrow$
$\exists y[\Box\ \mathbf{woman'}(y) \wedge \Box\mathbf{wife'}(x,y)]]\|_{<D,n,r,i,v>,g} = 1$

iff $\exists\beta \in P_n\ \forall<D,n,r,i,v> \in ct'[i(\beta) \in F(\mathbf{woman'}) \wedge <i(\alpha),i(\beta)> \in F(\mathbf{wife'}))$

Suppose this is not the case. Then ct' is not a realistic context. But on the other hand, since the DITT-model supports MP2, there is a woman that is John's wife in each possible world. The minimal extension of ct' that supports MP2 is the context that is exactly like ct' except it contains a new peg p_n that is mapped to John's wife in each possibility.

(73) a. $rex(ct') = \{<D,n+1,r,i\cup\{<p_n,a>\},v>|<D,n,r,i,v> \in ct' \wedge$
$a \in F(\mathbf{woman'})(v) \wedge$
$<i(\alpha),a> \in F(\mathbf{wife'})(v)\}$

b. $ct[THE_d(\mathbf{T}\Box\Uparrow\mathbf{john'}(d))(\Uparrow\mathbf{married'}(d))]_{g,s,w} =$
$\{<D\cup\{d\},n+1,r[d/\alpha],i\cup\{<p_n,a>\},v>|<D,n,r,i,v> \in ct \wedge$
$i(\alpha) \in F(\mathbf{married'})(v) \wedge$
$a \in F(\mathbf{woman'})(v) \wedge$
$<i(\alpha),a> \in F(\mathbf{wife'})(v)\}$

iff $\alpha = \iota p(p\in P_n \wedge \forall<D,n,r,i,v> \in ct\ [i(p) \in F(\mathbf{john'})(v)])$, undefined else

Note that the value of the newly introduced peg p_n need not be unique. If John is a bigamist, there are possibilities in the ultimate output state that map p_n to his first wife, some that map it to his second wife etc. Nevertheless there is only one **peg** that is always mapped to one of John's wives. This ensures that the uniqueness presupposition of the subsequent sentence is fulfilled.

(74) a. $[_{+Topic}$ The$_{d'}$] woman is nice.

b. $THE_{d'}\ (\mathbf{T}\Box\Uparrow\mathbf{woman'}(d'))(\Uparrow\mathbf{nice'}(d'))$

c. $ct[THE_{d'}\ (\mathbf{T}\Box\Uparrow\mathbf{woman'}(d'))(\Uparrow\mathbf{nice'}(d'))]_{g,s,w}$
$= \{<D\cup\{d'\},n,r[d'/\beta],i,v>|\ <D,n,r,i,v> \in ct \wedge i(\beta) \in F(\mathbf{nice'})(v)\}$
iff $\beta = \iota p(p\in P_n \wedge \forall<D,n,r,i,v> \in ct\ [i(p) \in F(\mathbf{woman'})(v)])$, undefined else

(75) a. John$_d$ is married. The$_{d'}$ woman is nice.

b. $THE_d(\mathbf{T}\Box\Uparrow\mathbf{john'}(d))(\Uparrow\mathbf{married'}(d)) \wedge THE_{d'}\ (\mathbf{T}\Box\Uparrow\mathbf{woman'}(d'))(\Uparrow\mathbf{nice'}(d'))$

c. $ct[THE_d(\mathbf{T}\Box\Uparrow\mathbf{john'}(d))(\Uparrow\mathbf{married'}(d)) \wedge THE_{d'}\ (\mathbf{T}\Box\Uparrow\mathbf{woman'}(d'))(\Uparrow\mathbf{nice'}(d'))]_{g,s,w}$
$= \{<D\cup\{d,d'\},n+1,r[d/\alpha][d'/p_n],i\cup\{<p_n,a>\},v>|\ <D,n,r,i,v> \in ct \wedge$
$i(\alpha) \in F(\mathbf{married'})(v) \wedge$
$a \in F(\mathbf{woman'})(v) \wedge$
$<i(\alpha),a> \in F(\mathbf{wife'})(v)\}$

iff $\alpha = \iota p(p \in P_n \wedge \forall\langle D,n,r,i,v\rangle \in ct\ [i(p) \in F(\mathbf{john'})(v)]) \wedge$
$\neg\exists\beta \in P_n\ \forall\langle D,n,r,i,v\rangle \in ct\ [i(\beta) \in F(\mathbf{woman'})(v)]$, undefined else

d. $\|\Downarrow THE_d(\mathbf{T}\Box\Uparrow\mathbf{john'}(d))(\Uparrow\mathbf{married'}(d)) \wedge THE_{d'}\ (\mathbf{T}\Box\Uparrow\mathbf{woman'}(d'))(\Uparrow\mathbf{nice'}(d'))\|_{g,s,w}$
$= 1$ iff $F(\mathbf{john'})(w) \subseteq F(\mathbf{married'})(w) \wedge$
$\{a|\ F(\mathbf{john'})(w) \times \{a\} \subseteq F(\mathbf{wife'})(w)\} \cap F(\mathbf{woman'})(w) \cap F(\mathbf{nice'})(w) \neq \emptyset$,
0 else

c. $\forall x[\mathbf{john'}(x) \rightarrow \mathbf{married'}(x) \wedge \exists y[\mathbf{wife'}(x,y) \wedge \mathbf{woman'}(y) \wedge \mathbf{nice'}(y)]]$

The most important feature of this treatment of bridging is the fact that the introduction of the peg corresponding to John's wife is not triggered by the DP *the woman*. After processing *John is married*, the wife-peg is introduced, no matter whether or not it is referred to later. This sharply distinguishes this approach from theories that use accommodation. According to such theories, a presupposition trigger ensures itself that its presupposition is fulfilled. As a consequence of this treatment, *the woman* in our example would introduce a woman-peg if there is none, and it would not, if there is one already. It is hard to bring such an approach into line with the idea of compositionality. That this is nevertheless possible is shown by Beaver['92, '93], but it remains unclear in his approach how for instance the presupposition of *the woman* is formally linked to the meaning of *married*. Our Meaning Postulates, stipulative though they may be, establish that link.

The licensing of anaphoric definites in the consequence of conditionals by means of the material in the antecedence is quite similar to dynamic binding of variables/discourse markers in the case of anaphoric pronouns.

(76) a. If John$_d$ is married, the$_{d'}$ woman is nice.

b. $THE_d\ (\mathbf{T}\Box\Uparrow\mathbf{john'}(d))(\Uparrow\mathbf{married'}(d)) \rightarrow THE_{d'}\ (\mathbf{T}\Box\Uparrow\mathbf{woman'}(d'))(\Uparrow\mathbf{nice'}(d'))$
$= \neg(THE_d\ (\mathbf{T}\Box\Uparrow\mathbf{john'}(d))(\Uparrow\mathbf{married'}(d)) \wedge \neg THE_{d'}\ (\mathbf{T}\Box\Uparrow\mathbf{woman'}(d'))(\Uparrow\mathbf{nice'}(d')))$

c. $ct[THE_d\ (\mathbf{T}\Box\Uparrow\mathbf{john'}(d))(\Uparrow\mathbf{married'}(d)) \wedge \neg THE_{d'}\ (\mathbf{T}\Box\Uparrow\mathbf{woman'}(d'))(\Uparrow\mathbf{nice'}(d'))]_{g,s,w}$
$= \{\langle D\cup\{d\},n+1,r[d/\alpha],i\cup\{\langle p_n,a\rangle\},v\rangle|\ \langle D,n,r,i,v\rangle \in ct \wedge i(\alpha) \in F(\mathbf{married'})(v)$
$\wedge\ a \in F(\mathbf{woman'})(v) - F(\mathbf{nice'})(v) \wedge$
$\langle i(\alpha),a\rangle \in F(\mathbf{wife'})(v)\}$

iff $\alpha = \iota p(p \in P_n \wedge \forall\langle D,n,r,i,v\rangle \in ct\ [i(p) \in F(\mathbf{john'})(v)]) \wedge$
$\neg\exists\beta \in P_n\ \forall\langle D,n,r,i,v\rangle \in ct\ [i(\beta) \in F(\mathbf{woman'})(v)]$, undefined else

d. $ct[THE_d\ (\mathbf{T}\Box\Uparrow\mathbf{john'}(d))(\Uparrow\mathbf{married'}(d)) \rightarrow THE_{d'}\ (\mathbf{T}\Box\Uparrow\mathbf{woman'}(d'))(\Uparrow\mathbf{nice'}(d'))]_{g,s,w}$
$= \{\langle D,n,r,i,v\rangle|\ ((F(\mathbf{john'})(v) \cap F(\mathbf{married'})(v)) \times F(\mathbf{woman'})(v)) \cap F(\mathbf{wife'})(v) =$
$((F(\mathbf{john'})(v) \cap F(\mathbf{married'})(v)) \times (F(\mathbf{woman'})(v) \cap F(\mathbf{nice'})(v) \cap F(\mathbf{wife'})(v)$

iff $\alpha = \iota p(p \in P_n \wedge \forall\langle D,n,r,i,v\rangle \in ct\ [i(p) \in F(\mathbf{john'})(v)]) \wedge$
$\neg\exists\beta \in P_n\ \forall\langle D,n,r,i,v\rangle \in ct\ [i(\beta) \in F(\mathbf{woman'})(v)]$, undefined else.

e. $\forall x\forall y[\mathbf{john'}(x) \wedge \mathbf{married'}(x) \wedge \mathbf{woman'}(y) \wedge \mathbf{wife'}(x,y) \rightarrow \mathbf{nice'}(y)]$

The truth-conditions predicted for (76a) are roughly *Every wife of every John is nice*. Besides this, the sentence carries the presuppositions that there is exactly one John-peg, and no woman-peg, in the input context.

3.5 Summary

Among the competing recent approaches to discourse semantics - Discourse Representation Theory, File Change Semantics, and Dynamic Semantics - there is some measure of agreement concerning the semantics of indefinites and anaphoric pronouns. These converging assumptions can be given in a nutshell:

(77) i) Indefinite DPs introduce a novel discourse referent (DRT)/file card (FCS)/ variable (DPL) /discourse marker (DMG).
ii) Anaphoric pronouns pick up a familiar discourse referent/...

The kinds of abstract objects which these theories assign to sentences as meanings are accordingly very similar. The differences mainly concern the way these "meanings" are composed. DRT assumes a mediating level of representation called "Discourse Representation Structures". In the "canonical" version of DRT (Kamp['81], Kamp & Reyle['93]), certain transformations operating on DRS's are a crucial part of the theory. As a consequence, DRT is essentially representational and non-compositional.

At a first glance, FCS is very similar to DRT. The mediating representations are called "files", and utterances perform actions on files. This similarity has led many authors to the conclusion that FCS is nothing more than a variant of DRT (unfortunately, Heim['90] herself supports this view). There is a crucial difference, though. Interpretation rules in FCS only make reference to two aspects of files, namely the domain of a file and its satisfaction set. Both are model-theoretic objects. The former is a set of individuals and the latter a set of sequences. (In Heim['83b], partial functions are used, so that the domain becomes superfluous as an extra component.) Hence it is possible to identify files with model-theoretic objects, and the whole theory proves to be essentially non-representational. It is even compositional, with the one exception that some interpretation rules implicitly make reference to the feature [αdefinite]. Hence, the interpretation of a complex constituent sometimes depends on morphosyntactic information in addition to the interpretations of the subconstituents and the way they are combined. As an additional complication, the input of interpretation is a level of Logical Form that differs substantially from S-structure. For instance, it is assumed that an indefinite as *a dog* has the same LF-category like a sentence (it is claimed to be synonymous to *There is a dog*, and a quantifier like *every cat* does not even form a constituent at LF. This is clearly a disadvantage since these DPs can be conjoined (*a dog and every cat*). It remains unclear how this can be accounted for in FCS.

Dynamic Montague Grammar tries to develop the insights of FCS further (although the relation of Dynamic Semantics to FCS is unfortunately rarely mentioned in the dynamic literature). The most important difference concerns the meaning of indefinite DPs. These are treated on a par with quantifiers, i.e. the indefinite article has a meaning of its own, and maps a predicate expression to a function from predicates to sentence denotations. This move solves the problem of the free conjoinability of DPs. Another, even more important pay-off is that the introduction of a new file card/discourse marker is performed by the semantic counterpart of the indefinite determiner. Thus there is no need to explicitly refer to definiteness any longer, indefinites can be interpreted *in situ*, and, as a consequence, LF can be dispensed with in the dynamic framework (as far as indefinites are concerned).

Although the treatment of indefinites and pronouns in the theories mentioned represents a considerable step forward in comparison to previous approaches such as Montague Grammar, we recognize a regrettable gap as soon as we turn our attention to definite descriptions. In DRT, the issue is not investigated systematically. In the dynamic framework, I am only aware of two proposals. Van Eijck['91] simply adopts the directly referential interpretation (definites presuppose existence and uniqueness globally) into a slightly revised version of Dynamic Predicate Logic. As mentioned above, neither presupposition is always supported by the observations. The relevant examples are repeated here.

(78) a. Peter resembles Mary so closely that he could be the brother of the girl.
b. John is married. The woman is nice.

In (78a), the existence of Mary's brother is neither presupposed nor asserted (neither, by the way, is the uniqueness of *the girl*), and (78b) by no means presupposes that there is only one woman, the quantificational domain being as small as you want, since speaker and hearer need not be able to identify John's wife.

The second dynamic approach to definiteness I am aware of, Beaver['93], is more or less identical to Heim's['82] treatment; hence it will not be discussed independently.

In contrast to DRT and DMG, Heim['82] devotes a lot of space to the investigation of definite descriptions. She does away with the "truth conditional" approaches altogether and sticks to a familiarity theory of definiteness. Put briefly, definite descriptions are treated in parallel to anaphoric pronouns, i.e. they pick up familiar file cards. The descriptive content plays, so to speak, only an auxiliary role: it narrows down the range of file cards the DP is able to pick up. The use of a definite is - according to FCS - only felicitous if the file card picked up is known to refer to an individual satisfying the description in the current state of conversation. As an epiphenomenal consequence, the definite DP is claimed to presuppose existence, but not uniqueness. The sentences in (78) again both provide counterevidence to this view. In (78a), the existence presupposition is violated, and in (78b), there is no file card available that *the woman* could felicitously pick up.

The present chapter tries to fill this gap. There are two related starting points that were used. The first is a possible extension of FCS informally discussed in Heim['82]. To explain the restricted distribution of pronouns in comparison to definite descriptions, she proposes to designate a subset of the domain of file cards as "prominent". Pronouns are only able to pick up prominent file cards, while the entire domain is accessible for definite full DPs. The second proposal elaborated on originates in GSV['93,'94]. These authors assume that a context defines two different domains - variables and pegs. Formulae are directly linked only to variables, while the pegs only copy the information encoded by the variables. Therefore variables become free to lose old information and acquire new information. One might imagine this system as a two-tape Turing Machine, where the first tape operates with the input alphabet and the second one with the output alphabet. Groenendijk (p.c.) once insisted that the proposal does not have any application in natural language semantics, but I hope that I have shown the opposite to be true.

In the present approach, the peg-tape not only serves as a backup copy of the information encoded at the discourse-marker-tape. There are certain inference processes that are largely independent of the referential indices of DPs, but which are triggered by descriptive content of certain linguistic items. A relevant example is (78b). From the descriptive content of the verb *marry,* together with the knowledge that John is a man, it can be inferred that there is a woman who John is married to. This kind of information is stored on the peg-tape directly, without affecting the discourse-marker-tape.

The empirical basis for the analysis of definite descriptions presented here is formed by the insight that **syntactically** they do not form a homogenous class. There are (at least) two different determiners subsumed under the term "definite article". In English, the difference is only indicated by means of different stress patterns, but in standard German, it is expressed by different word order, and in some German and Dutch dialects, even different formatives are used (cf. Ebert['71]). A minimal pair is given in (79).

(79) a. Ich habe gerade den Dekan getroffen.
I have just now the dean met
'I just met the DEAN'
b. Ich habe den Dekan gerade getroffen.
I have the dean just now met
'I just MET the dean'

In (79a), where the definite object is on the right of the adverbial in the German, and is stressed in the English version, *the dean* - in the absence of more specific information - refers to the dean of the department the speaker belongs to. There is a unique referent of the DP identifiable by both speaker and hearer by means of **extralinguistic** information. For this reason, I have called this class of definites "referential".

In (79b), on the other hand, the object is scrambled in German, and deaccented in English. It is only interpretable with a **linguistic** context. Suppose the sentence is preceded by *A: There are several professors from John's department at the party, including the dean. Are they having fun? B: I just MET the dean. He was flirting with a student.* In this context, *the dean* refers to the dean of John's department. Generally, scrambled/deaccented definites refer back to an item from the preceding discourse; and if the referent of the antecedent is not fixed, neither is the referent of the definite. Hence I have called them "anaphoric". As example (78b) shows, there need not be an explicitly mentioned antecedent at all. This observation is easily accounted for if we use the peg-tape for the interpretation of anaphoric definites.

To return to Heim's file metaphor again, we now have two files. In the main file (corresponding to the peg-tape), real, i.e. contentful information is stored (formally: each file card corresponds to an individual property, a function from possible worlds to sets of individuals). Some file cards of this file have a certain label. There is an auxiliary file (the discourse markers), where only the labels of the cards in the main file, together with a pointer to the location of the corresponding file card, are written down. There may be more than one label for one "contentful" file card, and there may be file cards without any label. Anaphoric pronouns are, so to speak, lazy file clerks. They only look into the auxiliary file containing the labels. Hence they have no access to those main file cards lacking a label. Anaphoric definites, on the other hand, are busy file clerks. They look into the main file for a specific content, and if they find a card that meets their requirements, they assign a new label to it (to enable the lazy pronouns to find it later on). If there is no card, or more than one card with the desired content, the file clerk goes on strike.

Referential definites, as well as indefinites, always create a new file card in the main file, and they either assign a new label to it or they recycle an old one which then ceases to refer to the card which it previously referred to. Definite file clerks again are more thorough; they make the entry on the new card as informative as possible (such that the new card denotes either a singleton or the empty set in every world), while indefinites allow for an arbitrary degree of uncertainty.

Items of different morphological and syntactic categories have different access to the files. Anaphoric pronouns only look at the surface-file where the labels are stored. Definite descriptions and indefinites (and probably tense) have to create or recycle labels. Those indefinites that were investigated up to now, and referential definites additionally create new peg-cards. Anaphoric definites are only allowed to **read** in the peg-file. Linguistic items of any category are allowed to write something into it, as long as they are not part of a Topic and they contain descriptive content. This reflects the intuition that Topics carry "old" information while the Comment adds new information. The descriptive content of Topics merely serves to identify certain pegs. Up to this point, anaphoric definites were the only instance of Topics, but in the subsequent chapters, we will see that indefinites and tense may serve this purpose as well.

3.6 Loose Ends

It does not come as a surprise that the analysis proposed here probably raises more questions than it answers. This is not an accident. DITT (or the analysis based on DITT) is intended as a modification of both FCS and Dynamic Montague Grammar. In the best case, it avoids some problems these frameworks are faced with. Nevertheless, DITT inherits most of the problems of its predecessors. Let me mention some of the shortcomings.

3.6.1 Pronouns

Little of what has been said about the interpretation of anaphoric pronouns is new. They are simply assumed to pick up familiar discourse markers, and there are standard counterexamples against this view that I can only list here.

(80) **Pronouns of Laziness** (cf. Karttunen['69])
Every wise man gives his paycheck to his wife. John gives **it** to his mistress.

Obviously, *it* in the second sentence should be interpreted as *John's paycheck*. But no matter how we analyze the semantics of *his paycheck*, the first sentence is unable to introduce any new discourse marker in the present framework, since universally quantified sentences are statically closed. In this case, the E-type strategy is clearly superior to the dynamic account. According to Heim['90], anaphoric pronouns can denote function variables as well as individual variables. Applied to the second sentence of (80), this predicts the following (static) translation:

(81) **give'**(**j'**, f(**j'**), **mistress'**(**j'**))

The instantiation of the variable "f" is somehow governed by the context. In (81), f's value is the function that maps men to their paychecks. The weak point of this analysis is the way in which this instantiation is determined. I think that it is not completely utopian to combine the E-type approach and Dynamic Semantics in such a way that *it* in our example is dynamically bound by *his paycheck*, i.e. to reformulate Heim's version of the E-type approach in an S-compositional and **semantical** way. But it surely will not suffice to allow Skolem functions as values of pegs, since universally quantified sentences always denote purely eliminative updates and hence are unable to license anaphors of any kind. I leave the issue to further research.

Even more problematic for the present account are the different variants of subordination.

(82) a. There is no unified account for anaphoricity yet, but **it** presumably would be a dynamic one.
b. Maybe there is a solution to these problems. Anyway, it would be too difficult to work **it** out now.
c. Most theories have a weak point, although it is sometimes hard to detect **it**.

Here the functions that Heim assumes as interpretation of the pronouns are not even linguistically present in the respective antecedent sentence. There are two options to account for such data in a dynamic framework. The notion of dynamic binding may be extended in such a way that it covers these dependencies as coindexing. This is the strategy Dekker['91] chooses. As a consequence, it is difficult to exclude cases where quantification, negation etc. do block anaphoric dependencies. Chierchia['92] proposes to allow two strategies of anaphoricity simultaneously, dynamic binding and E-types. Here the familiar objections against the latter apply as well, but I have to admit that I am unable to propose any alternative here.

3.6.2 Definite Descriptions and Bridging

It is an obvious fact that the assumed uniqueness condition on the definite article is much too strong in most cases. Hence it has to be relativized to some contextually determined domain. The set of pegs provides this restriction in the case of anaphoric definites, but referential ones range over the whole individual domain of the model. Nevertheless, even linguistic context is able provide domain restriction for referential definites, as the following example (due to Manfred Krifka, p.c.) shows.

(83) Ich habe mir gestern ein Auto gekauft.
I have me yesterday a new car bought
'Yesterday, I bought a new car.'
a. Heute ist bereits die linke Vorderradkappe abgefallen.
Today is already the left front-hub-cap fallen-off
b. ??Heute ist die linke Vorderradkappe bereits abgefallen.
Today is the left front-hub-cap already fallen-off
'The front left hub cap fell off today'

The object *the front left hub cap* preferably remains *in situ*. Hence it is a referential definite. but its interpretation is of course not *the one and only front left hub cap*, but *the front left hub cap of the car just mentioned*. To put it in other terms, there is a kind of bridging between *a car* in the first sentence and *the front left hub cap*, namely a part-of relation, but this bridge is not built by means of Meaning Postulates and pegs. One way to account for this observation is given in Löbner['85]. According to Löbner, the definite article generally selects relational NPs. If the NP happens to denote a one-place property (like *front left hub cap*), it becomes somehow reinterpreted as a relational one, in our case presumably something like ***its*** *front left hub cap*. The new argument place can be interpreted as anaphorically to *a car*. I doubt that this kind of reinterpretation always applies, but maybe it is available as a kind of last-resort mechanism.

Matters are even more complicated with so-called "inalienable" uses of the definite determiner. In some languages like French and German, it is possible to refer to body-parts by singular definite descriptions even if there is more than one possible referent.

(84) a. Hans hat sich wahrscheinlich das Bein gebrochen
Hans has himself presumably the leg broken
b. Hans hat sich das Bein wahrscheinlich gebrochen
Hans has himself the leg presumably broken
'Hans presumably broke his leg'

In (84b) the object *das Bein* (the leg) is scrambled and hence a Topic. Semantically, it behaves just as expected; the sentence is only felicitous if exactly one of Hans's legs is already under debate. The problematic case is (84a). Here the definite is syntactically marked as referential, but nothing like a uniqueness-assertion arises. The meaning is just *Hans broke one of his legs*. The fact that this construction-type is not available in English may be seen as an indication that it is not a proper use of the definite article at all but rather an idiosyncratic and language specific accident. Vergnaud & Zubizarreta['92], who investigate similar examples in French, conclude that the article in these constructions is expletive, i.e. semantically empty.

Presumably the most daring claim made in this chapter concerns the treatment of associative anaphoric definites, and accordingly, the possible counterexamples are most challenging. The proposed strategy to bridging corresponds to a certain strategy of theorem proving called "forward chaining" in the AI-literature (cf. Charniak & McDermott['85]). If an assertion is added to a database, a forward chaining theorem prover draws all inferences that can be drawn from the assertion **at the time it is asserted**. If a query is made later on, the system only has to check whether the required theorem is stored in the database or not. The opposite strategy is called "backward chaining". Here making an assertion simply means to add the assertion itself to the database. **Only when a query is done** that requires theorems proven by means of the assertion, are the inferences actually drawn. This corresponds to the accommodation strategy advocated by Heim['82, '83b].

Instead of assertions, we have pegs and their properties in our model, and the counterparts of queries are anaphoric definites. Our central claim can thus be formulated as:

The processing of ANAPHORIC definites can be done by means of forward chaining only.

The two strategies are indistinguishable in the case of non-associative anaphoric definites.

(85) A farmer owns a donkey. The donkey is grey.

As a consequence of processing *a donkey*, a donkey-peg is introduced. *The donkey* merely requires the presence of such a donkey. Hence no additional inferences are necessary, and the question of when the necessary inferences are drawn does not arise.

(86) A farmer owns a donkey. He bought it last week. The animal is grey.

Here a certain inference is inevitable, namely that a donkey is an animal. Since there is another sentence between the assertion *a donkey* and the query *the animal*, we have a choice about when to draw this inference, but it makes no recognizable difference, since it is reasonable to assume that the inference rule *every donkey is an animal* is always available.

The choice between forward and backward chaining becomes apparently important in the case of so-called epithets (examples from Clark['74]).

(87) a. I met a man yesterday. The bastard stole all my money.
b. I ran two miles the other day. The whole stupid business bored me.
c. Her house was large. The immensity made me jealous.

To interpret *the bastard* in (87a) as anaphoric to *a man* in the preceding sentence, we have to infer that this man is a bastard. If we insist on forward chaining, we have to conclude that there is an inference rule like *every man is a bastard* or *every man I met yesterday is a bastard* or something similar. This is of course not desirable. Here backward chaining seems to be superior. At the time *the bastard* is processed, it is inferred a) that the man previously mentioned **could** be a bastard and b) that he **is** in fact a bastard. But such a strategy is clearly on the wrong track.

(88) I met a man$_i$ yesterday. *The rancher$_i$ stole all my money.

Here coreference between *a man* and *the rancher* is even excluded, although the man of course could be a rancher. Actually, only a small and more or less closed class of NPs is able to figure as epithets. They surely do not form a convincing evidence in favour of backward chaining. Presumably, nouns like *bastard* denote just the same property as *human being*, and the pejorative connotation is nothing more than a conventional implicature[15].

The next example (from Beaver['93]) causes a problem for forward chaining, too.

(89) If I go to a wedding then the rabbi will get drunk.

From the mentioning of *a wedding*, we usually only infer the presence of a clergyman. To utter *the rabbi* felicitously, an additional inference seems to be inevitable. On the other hand, it does not seem implausible to me that the sentence as a whole presupposes the presence of an

[15]Interestingly enough, in certain text sorts examples like (88) occur quite regularly. Consider the discourse fragment in (i) that sounds natural as part of a newspaper article:

i) [One of the organizers of last week's bank robbery]$_i$ was recently put under arrest. [The thirty year old ex-convict]$_i$ had left an ID document containing his photo at the counter.

Informants agree that these constructions are nevertheless excluded in spoken discourse. A proper account to the dependency of acceptability judgments from text sorts could go along the lines of Asher['93] and Lascarides&Asher['93], where sentence meanings are not simply combined by means of function composition but by certain rhetorical relations. The inventary of the latter may differ in different text sorts. However, these questions go far beyond the scope of this dissertation.

inference rule like *the present speaker usually visits Jewish weddings*. The fact that this implicature is triggered by *the rabbi* if the sentence is uttered out of the blue is irrelevant here. If backward chaining were available as a **structural** option, the entire sentence should not have any presupposition of this kind at all. That the repair mechanisms we use in actual conversation do use backward chaining is a different story and does not necessarily matter for structural semantics.

Another argument quoted in favour of backward chaining (cf. Clark['74]) concerns examples similar to the front-left-hub-cap example discussed above.

(90) a. Ich betrat den Raum. Zuerst zündete ich schnell die Kronleuchter an.
I walked-into the room. First lighted I quickly the chandeliers up
'I walked into the room. First I lighted up the CHANdeliers'
b. Ich betrat den Raum. ??Zuerst zündete ich die Kronleuchter schnell an.
I walked-into the room. First lighted I quickly the chandeliers up
'I walked into the room. First I lighted UP the chandeliers'

Here we have to infer from *the room* to a plausible part of it, namely *the chandeliers*. This cannot be done straightforwardly by means of forward chaining. But since in the German example the object *die Kronleuchter* is not scrambled, it is not anaphoric in the technical sense; and that we need additional mechanisms to account for the context dependency of referential definites was already mentioned above. Maybe this is the proper place for backward chaining bridging.

Nevertheless, there are cases in which a definite description that is unequivocally a Topic seems to require backward chaining.

(91) Ich betrat einen Raum. Ich sah, daß die Kerzen schon brannten
that the candles already burned
'I walked into a room. I saw the candles already burning.'

According to my intuitions, this discourse, although it is acceptable as it stands, improves remarkably if you replace *the candles* by *the candles there*. A possible explanation of the pattern in (91) could run along the following lines:

a) The object *the candles* contains a silent modifier *there* (either by means of Löbner's reinterpretation or as a syntactically present empty category[16]).

[16]Similarly, non-Topics may be scrambled because of the presence of a silent possessive modifier, as in:

i) Vorige Woche habe ich mir ein Auto gekauft. Heute ist der Motor (des Autos) schon kaputtgegangen.
Last week I bought a car. Today already the motor (of $_{+T}$the car) stopped working.

b) This local expression is a Topic.

c) The DP *the candles [there]* as a whole is not a Topic.

d) The embedded Topic *[there]* induces scrambling of the entire DP by means of a kind of pied-piping.

If the basic idea of this argumentation is correct, we may conclude that backward chaining is only involved in connection with referential definites.

Although this discussion leaves more questions open than it answers, I hope that I have shown that the assumption: "Bridging to **anaphoric** definites can be done by means of forward chaining only" is defensible.

Chapter Four:
Indefinite Topics

4.1 Partitive Readings

4.1.1 Enç's Proposal

In the last chapter, it was claimed that there are two readings of the definite article, and that these two readings are related to the presence vs. absence of the feature [+Topic]. This feature corresponds to a semantic template that maps the definite article in its referential reading to the determiner with the anaphoric reading. Now, one might hypothesize that this feature/template applies to other determiners as well. As far as the indefinite article is concerned, this is surely the case. Actually, there are a number of recent works that predict the expected ambiguity of the indefinite article, for instance Enç['91], van Deemter['92], and Hoekstra['92]. The common integrator of these proposals lies in the assumption that the discourse referent/file card introduced by an indefinite DP, though novel, may be linked to a familiar one by means of set inclusion. Let me illustrate this by an example.

(1) Several children$_{<i,j>}$ came in. ... John knew a girl$_{<k,i>}$.

According to Enç, both indefinite DPs *several children* and *a girl* introduce their first index (i and k respectively) as new file cards. But matters are different w.r.t. the second index. The index j of *several children* is novel too, but *a girl* has i, i.e. a familiar index at the second place. Simplifying her ideas somewhat, she assumes that the value of the first index has to be a subset or element of the value of the second one. Applied to our example, this represents the fact that the girl is an element of the set of children previously mentioned. Enç calls those indefinites that have a familiar index in the second place [+specific]. I wonder whether this terminology really meets the point since there is much more to say about specific indefinites than just that they are interpreted partitively. Nevertheless, Enç's [+/-specificity]-distinction is descriptively just what we expect to arise from the [+/-Topic]-contrast.

Let me make this more precise. If we apply the Topic-template (2a) to the translation of the indefinite article (2b), we get (2c) as translation of the [+Topic/-definite]-determiner.

(2) a. [+Topic] ==> $\lambda D \lambda R.D\{\hat{}\lambda x.\mathbf{T}\Box R\{x\}\}$
b. a_d ==> $\lambda P \lambda Q.\mathcal{E}d.P\{\hat{}d\} \wedge Q\{\hat{}d\}$
c. $[_{+Topic}\ a_d]$ ==> $\lambda D \lambda R.D\{\hat{}\lambda x.\mathbf{T}\Box P\{x\}\}(\hat{}\lambda P \lambda Q.\mathcal{E}d.P\{\hat{}d\} \wedge Q\{\hat{}d\})$
= $\lambda R \lambda Q.\mathcal{E}d.\mathbf{T}\Box R\{\hat{}d\} \wedge Q\{\hat{}d\}$

This is used in the translation of the second sentence of (1).

(3) a. John$_{d'}$ knew [$_{+Topic}$ a$_d$] girl.

b. a$_d$ :: [$_{+Topic}$ D] :: $\lambda R\lambda Q.\mathcal{E}d.\mathbf{T}\Box R\{^\wedge d\} \wedge Q\{^\wedge d\}$

|

| girl :: NP :: $\lambda x.\Uparrow\mathbf{girl'}(^\vee x)$

| /

a$_d$ girl :: DP :: $\lambda Q.\mathcal{E}d.\mathbf{T}\Box\Uparrow\mathbf{girl'}(d) \wedge Q\{^\wedge d\}$

|

| knew :: TV :: $\lambda T\lambda x.T\{^\wedge\lambda y.\Uparrow\mathbf{know'}(^\vee x,^\vee y)\}$

| /

knew a$_d$ girl :: VP :: $\lambda x..\mathcal{E}d.\mathbf{T}\Box\Uparrow\mathbf{girl'}(d) \wedge \Uparrow\mathbf{know'}(^\vee x,d)$

|

| John$_{d'}$ :: DP :: $\lambda P.THE_{d'}(\Uparrow\mathbf{john'}(d'))(P\{^\wedge d'\})$

| /

John$_{d'}$ knew a$_d$ girl :: S :: $THE_{d'}(\Uparrow\mathbf{john'}(d'))(\mathcal{E}d.\mathbf{T}\Box\Uparrow\mathbf{girl'}(d) \wedge \Uparrow\mathbf{know'}(d',d))$

c. $ct[THE_{d'}(\Uparrow\mathbf{john'}(d'))(\mathcal{E}d.\mathbf{T}\Box\Uparrow\mathbf{girl'}(d) \wedge \Uparrow\mathbf{know'}(d',d))]_{g,s,w}$

$$
\begin{aligned}
= \{<D\cup\{d,d'\},n+1,r',i[p_n/a],v>| \quad & <D,n,r,i,v> \in ct \wedge \\
& \exists i\ [\ 0 \leq i \leq n \wedge \\
& r' = r \cup \{<d',p_n>,<d,p_i>\} \wedge \\
& F(\mathbf{john'})(v) = \{a\} \wedge \\
& i(p_i) \in F(\mathbf{girl'})(v) \wedge \\
& <a,i(p_i)> \in F(\mathbf{know'})(v)]\}
\end{aligned}
$$

d. $\|\Downarrow THE_{d'}(\Uparrow\mathbf{john'}(d'))(\mathcal{E}d.\mathbf{T}\Box\Uparrow\mathbf{girl'}(d) \wedge \Uparrow\mathbf{know'}(d',d))\|_{g,s,w} = 1$ iff

$\exists a[F(\mathbf{john'})(v) = \{a\} \wedge$

$\{a\} \times F(\mathbf{girl'})(w) \cap F(\mathbf{know'})(w) \neq \emptyset]$

e. $\exists x\exists y[\mathbf{john'}(x) \wedge \forall z[\mathbf{john'}(z) \rightarrow x = z] \wedge \mathbf{girl'}(y) \wedge \mathbf{know'}(x,y)]$

As can be seen from (3d,e), the truth conditions are not affected by the presence of the Topic-feature. The sentence is true iff there is a girl such that John knows it. But the context change potential is quite different from the counterpart without the Topic-feature. Let me illustrate this by means of CRS-boxes.

(4)

p_i
$\mathbf{girl'}(p_i)$

==>

d, d'
p_i, p_n
$d \rightarrow p_i$, $d' \rightarrow p_n$
$\mathbf{girl'}(p_i)$ $\mathbf{john'}(p_n)$ $\mathbf{know'}(p_i, p_n)$

The output of the update is a context containing a John-peg and a girl-peg, such that the former "knows" the latter. But since *a girl* is a Topic, it has to pick up a familiar peg. Accordingly, the girl-peg has already to be present in the input, while the John-peg and the information about the knowing-relation is added by the update. This is just the same process that is performed by *John knew* ***the*** *girl* too. But since the object is indefinite in (3), it is not excluded that there are many girl-pegs in the input.

(5)

p_i, p_j
girl'(p_i) **girl'**(p_j)

==>

d, d'
p_i, p_j, p_n
$d \to p_i$, $d' \to p_n$
girl'(p_i) **girl'**(p_j) **john'**(p_n) **know'**(p_i, p_n)

According to the Gricean Quantity Maxim, you have to be as informative as possible. Since in (4) both the definite and the indefinite article is possible and the definite is more informative, the indefinite article is pragmatically excluded if there is exactly one girl-peg in the input. Hence there **has** to be more that one girl-peg in the input to felicitously utter (3a). This is just the first part of Enç's prediction, namely that *a girl* refers to an element of a set of contextually salient entities. Note that we derived this without stipulating an else unmotivated second kind of syntactic index.

But this is only the first half of the story. Additionally, we have to face two problems. Firstly, we have to clarify how the link is made between *several children* and *a girl* in the example. Secondly, although the partitive interpretation of a common singular indefinite is rather marked, it is strongly preferred in the case of weak quantifiers where the NP complement is deaccented.

(6) Several children came in. ... TWO children were blond.

In this example, a non-partitive interpretation of *two children* is even excluded.

To account for these observations formally, we have to enrich DITT in such a way that we can translate plurals in a satisfactory way. This will be done in the next paragraph.

4.1.2 Plural

We adopt the basic ideas of Link['83] here, but we use a very much simplified version. It is assumed that plural entities belong to the same type as singular ones, namely individuals. The only modification we have to make is the designation of three constants, the sortal predicates "*sing*" and "*plural*", and the sum operator "$\oplus$".

Definition 1.1 Singular, Plural, and Sum Operator
sing $=_{def}$ $c_{<e,t>}$
plural $=_{def}$ $c'_{<e,t>}$
$\oplus$ $=_{def}$ $c_{<e,<e,e>>}$

The sum operation has the well-known properties of commutativity, associativity, and idempotence. This is ensured by Meaning Postulates.

Definition 1.2 Properties of $\oplus$

$MP_{\oplus}1$:	$\forall x \forall y[\Box\ x \oplus y = y \oplus x]$	% Commutativy
$MP_{\oplus}2$:	$\forall x \forall y \forall z[\Box\ ((x \oplus y) \oplus z) = (x \oplus (y \oplus z))]$	% Associativity
$MP_{\oplus}3$:	$\forall x[\Box\ x \oplus x = x]$	% Idempotence

Remember that each conjunct in the Meaning Postulates has to be prefixed with the necessity operator to ensure that not only the model have the desired properties but the realistic contexts too. It follows from these postulates that the extension of "$\oplus$" forms a join semilattice in every possible world. The corresponding partial order is easily definable.

Definition 1.3 $\leq$
"$a \leq b$" abbreviates "$a \oplus b = b$".

It is reasonable to assume that it is even the same semilattice in every world. (Suppose both *John* and *Mary* are rigid terms. Than *John and Mary* is surely rigid too.)

Definition 1.4 Rigidity of $\oplus$
For every DITT-Model $\mathcal{M}$ = <E, W, F, MP>, there is a two-place operation "+" in E such that:

$\forall w \in W[F(\oplus)(w) = +]$

Another important property of the sum operation that is needed for the treatment of plurals is the absence of an identity element.

Definition 1.5 Absence of an Identity Element
$MP_{\oplus}4$: $\forall x \forall y[\Box x \leq y \wedge \Box\ x \neq y \rightarrow \exists z[\ \Box\ y \neq z \wedge \Box\ y = x \oplus z]]$

This formulation looks more complicated than necessary at first glance, but it has an important and desirable consequence as soon as we look at realistic extensions. Suppose we have exactly two pegs in our context, and the only thing that we know is that the one is a proper part of the other. This situation is illustrated in the left-hand CRS.

(7)

	==>	
p_i, p_j		p_i, p_j, p_k
$p_i \leq p_j$ $p_i \neq p_j$		$p_i \leq p_j$ $p_i \neq p_j$ $p_j \neq p_k$ $p_i \oplus p_k = p_j$

According to $MP_{\oplus}4$, this context is not realistic, since there is no peg p_k different from p_j such that $p_i \oplus p_k = p_j$. Hence, we have to introduce such a peg to make the context realistic. To put it another way round, we always have to introduce the algebraic complement into the context as soon as we know that two familiar pegs stand in a proper part-of-relation. That the complement in fact has to be available as a peg (but not as a discourse marker) is illustrated by the famous marble-examples.

(8) a. I lost ten marbles and found only nine of them. ???It is probably under the sofa.
b. I lost ten marbles and found only nine of them. The missing one is probably under the sofa.

The tenth marble is available as a peg. Therefore the anaphoric definite in (8b) is okay. The pronoun in (8a) is unacceptable, since the newly created peg does not correspond to a discourse marker.

The characteristic properties of singular and plural entities are that they do not or do have proper parts, respectively. As long as we do not take mass terms into account, we may additionally assume that every individual that has proper parts is a plural individual. This is again reflected by Meaning Postulates.

Definition 1.6 Singular and Plural

MP_{sing} : $\forall x \forall y[\Box \mathit{sing}(x) \wedge \Box\, y \leq x \rightarrow \Box x=y]$

$MP_{plural}1$: $\forall x[\Box \mathit{plural}(x) \rightarrow \exists y[\Box y \neq x \wedge y \leq x]]$

$MP_{plural}2$: $\forall x \forall y[\Box x \neq y \rightarrow \exists z[\Box \mathit{plural}(z) \wedge \Box\, x \oplus y = z]]$

Note that $MP_{plural}1$ and $MP_{plural}2$ again may involve the introduction of new pegs. Firstly, the peg system of each realistic context is closed under the sum operation. Secondly, suppose that a context contains a peg p_i that is known to be plural, and that the same context does not contain any peg p_j that is known to be a proper part of p_i. In this case, such a p_j has to be introduced to make the context realistic, and according to $MP_{\oplus}4$, the complement to p_j has to be introduced too. Let me briefly illustrate this with an example. I assume that bare plurals are indefinites with silent articles. Additionally, I assume that the number-information of a DP is semantically always delivered by the determiner, while the number-information at the NP is a consequence of syntactic agreement.

(9) a. There are $[_{DP}\ Ø_d$ children]
b. children ==> $\lambda x.\Uparrow$**child'**$(^{\vee}x)$
$Ø_d$ ==> $\lambda P \lambda Q.\mathcal{E}d.\ P\{^{\wedge}d\} \wedge$ *plural*$(d) \wedge Q\{^{\wedge}d\}$
c. $\mathcal{E}d.\ \Uparrow$**child'**$(d) \wedge$ *plural*(d)
d.

==>

d
p_i, p_j, p_k
$d \rightarrow p_i$
plural(p_i) **child'**(p_i) $p_i \neq p_j$ $p_i \neq p_k$ $p_j \oplus p_k = p_i$

The processing of the update in (9c) involves the introduction of the discourse marker d together with the peg p_i and the information that p_i is a plurality of children (I assume for the moment that all predicates except *sing* and *plural* are both cumulative and distributive). But since this intermediate context contains the information that p_i is a plural entity, $MP_{plural}1$ triggers the introduction of another peg p_j that is a proper part of this group of children, and $MP_{\oplus}4$ subsequently requires the introduction of the complement of p_j modulo p_i, called p_k in the CRS.

These new pegs p_j and p_k are now available as anchors for subsequently processed Topics like *a child* in (10) in its partitive reading. For simplification, we make the assumption that there are no child-pegs available in the input context yet.

(10) a. There are $Ø_d$ children. $[_{+Topic}\ A_{d'}]$ child is blond.
b. $a_{d'}$ ==> $\lambda P \lambda Q.\mathcal{E}d'.P\{^{\wedge}d'\} \wedge$ *sing*$(d) \wedge Q\{^{\wedge}d'\}$

c. $\mathcal{E}d.\ \Uparrow\mathbf{child'}(d) \wedge \mathit{plural}(d) \wedge \mathcal{E}d'.\mathbf{T}\Box\Uparrow\mathbf{child'}(d') \wedge \mathit{sing}(d') \wedge \Uparrow\mathbf{blond'}(d')$

d. $ct[\mathcal{E}d.\ \Uparrow\mathbf{child'}(d) \wedge \mathit{plural}(d) \wedge \mathcal{E}d'.\mathbf{T}\Box\Uparrow\mathbf{child'}(d') \wedge \mathit{sing}(d') \wedge \Uparrow\mathbf{blond'}(d')]_{g,s,w}$
$= \{\langle D\cup\{d,d'\},n+3,r[d/p_n][d'/p],i\cup\{\langle p_n,a\rangle,\langle p_{n+1},b\rangle,\langle p_{n+2},c\rangle\},v\rangle \mid$
$\langle D,n,r,i,v\rangle \in ct \wedge$
$a \in F(\mathit{plural})(w) \wedge b+c=a \wedge a \in F(\mathbf{child'})(w) \wedge$
$[p = p_{n+1} \wedge b \in F(\mathit{sing})(w) \wedge b \in F(\mathbf{blond'})(w) \vee$
$p = p_{n+2} \wedge c \in F(\mathit{sing})(w) \wedge c \in F(\mathbf{blond'})(w)]\}$
provided that $ct[\mathcal{E}d'.\mathbf{T}\Box\Uparrow\mathbf{child'}(d')]_{g,s}$ is undefined.

e. $\exists x\exists y[\mathbf{child'}(x) \wedge \mathit{plural}(x) \wedge y \leq x \wedge \mathit{sing}(y) \wedge \mathbf{blond'}(y)]$

The output context is underspecified w.r.t. the peg that is associated with the discourse marker d' that is introduced by *a child*. It may be assigned either to p_{n+1} or p_{n+2}, since these two pegs have exactly the same properties. It is known that they are parts of the child-peg introduced by the first sentence, and that their sum is just this child-peg, and nothing else. Hence the processing of *a child* involves a nondeterministic choice.

4.1.3 Weak Quantifiers

4.1.3.1 Syntax

Now let us turn to those constructions where the partitive reading is not only possible but strongly favoured: weak quantifiers with deaccented head noun.

(11) There are several children. ... THREE children are blond.

First let me say a few words about the syntax of these constructions. Numerals like the cardinal numbers or *many*, *some* etc. are usually treated as determiners, on a par with *every*, *most* etc. In my view, this assumption should be reconsidered. Distributionally, numerals pattern more closely with adjectives than with determiners. For instance, they can be combined with the definite article.

(12) a. the red books
b. the three books
c. *the most books

In German, there is even morphological evidence that numerals are in fact adjectives. There is a strong and a weak inflectional paradigm for adjectives in German, depending on the determiner of the entire DP.

(13) a. die kleinen Kinder

the little$_{weak}$ children
b. kleine Kinder
little$_{strong}$ children

If weak determiners show overt inflection[1] (for example *viele* "many" or *wenige* "few"), they follow the same paradigm as adjectives.

(14) a. die vielen Kinder
the many$_{weak}$ children
b. viele Kinder
many$_{strong}$ children

This leads to the conclusion that weak quantifiers are simply plural indefinites, just like bare plurals. The numeral is an NP-adjunct like any attributive adjective.

(15) $[_{DP}\ [_{D}\ \emptyset]\ [_{NP}\ [_{AP}\ \text{three}]\ [_{NP}\ \text{children}]]]$

4.1.3.2 Semantics

As far as the semantics is concerned, I take adjectives (including numerals) to be simple predicates.

(16) a. red ==> $\lambda x.{\Uparrow}\mathbf{red'}({}^{\vee}x)$
b. three ==> $\lambda x.{\Uparrow}\mathbf{three'}({}^{\vee}x)$

The quantificational impact of numerals is ensured by Meaning Postulates. There are two Meaning Postulates for every cardinal number. I illustrate this with the example *three*.

Definition 1.7 Three

MP_{three} 1: $\forall x[\Box\mathbf{three'}(x) \rightarrow \exists y\exists z\exists w[\Box \mathit{sing}(y) \wedge \Box \mathit{sing}(z) \wedge \Box \mathit{sing}(w) \wedge \Box\ x = y\oplus z\oplus w \wedge \Box y\neq z \wedge \Box y \neq w \wedge \Box z\neq w]]$

MP_{three}2: $\forall x\forall y\forall z[\Box\ \mathit{sing}(x) \wedge \Box\ \mathit{sing}(y) \wedge \Box\ \mathit{sing}(z) \wedge \Box\ x\neq y \wedge \Box x\neq z \wedge \Box\ y\neq z \rightarrow \mathbf{three'}(x\oplus y\oplus z)]$

Actually, we should have a biconditional. A plural entity has the cardinality three if and only if there are three distinct singular entities such that their sum is the plural entity. But since only Inference Rules are admitted as Meaning Postulates, we have to state the two implications independently. Note that lexical decomposition of numerals like *three* would not be equivalent.

[1] The cardinal numbers do not inflect at all.

This would involve discourse markers for the atomic parts of the plural entity, which is not supported by the facts. Hence Meaning Postulates are the only option.

Since both NPs and APs are taken to denote predicates, the semantic operation corresponding to adjunction cannot be function application, but has to be generalized conjunction.

Definition 1.8 Attributive Modification
Syntax: NP_1 ==> AP, NP_2
Semantics: $[NP_1] = \lambda x.[AP](x) \wedge [NP_2](x)$
where [X] denotes the DITT-translation of X.

With these background assumptions, the existential, i.e. non-partitive reading does not cause major problems.

(17) a. Two CHILDren are in the garden.

b. two :: AP :: $\lambda x.{\Uparrow}\mathbf{two'}(\check{}x)$
|
| children :: NP :: $\lambda x.{\Uparrow}\mathbf{child'}(\check{}x)$
| /
two children :: NP :: $\lambda x.{\Uparrow}\mathbf{two'}(\check{}x) \wedge {\Uparrow}\mathbf{child'}(\check{}x)$
|
| $\emptyset_d$ :: D :: $\lambda P\lambda Q.\mathcal{E}d.P\{{}^\wedge d\} \wedge \mathit{plural}(d) \wedge Q\{{}^\wedge d\}$
| /
two children :: DP :: $\lambda Q.\mathcal{E}d.{\Uparrow}\mathbf{two'}(d) \wedge {\Uparrow}\mathbf{child'}(d) \wedge \mathit{plural}(d) \wedge Q\{{}^\wedge d\}$
|
| are in the garden :: VP :: $\lambda x.{\Uparrow}\mathbf{in\_the\_garden'}(\check{}x)$
| /
two children are in the garden :: S ::
$\mathcal{E}d.{\Uparrow}\mathbf{two'}(d) \wedge {\Uparrow}\mathbf{child'}(d) \wedge \mathit{plural}(d) \wedge {\Uparrow}\mathbf{in\_the\_garden'}(d)$

c. $ct[\mathcal{E}d.{\Uparrow}\mathbf{two'}(d) \wedge {\Uparrow}\mathbf{child'}(d) \wedge \mathit{plural}(d) \wedge {\Uparrow}\mathbf{in\_the\_garden'}(d)]_{g,s,w}$
$= \{\langle D\cup\{d\},n+3,r[d/p_n],i\cup\{\langle p_n,a\rangle,\langle p_{n+1},b\rangle,\langle p_{n+2},c\rangle\},v\rangle |$
$\langle D,n,r,i,v\rangle \in ct \wedge$
$\{b,c\} \subseteq F(\mathit{sing})(v) \cap F(\mathbf{child'})(v) \wedge b+c = a$
$a \in F(\mathbf{in\_the\_garden'})(v)\}$

d. $\|{\Downarrow}\mathcal{E}d.{\Uparrow}\mathbf{two'}(d) \wedge {\Uparrow}\mathbf{child'}(d) \wedge \mathit{plural}(d) \wedge {\Uparrow}\mathbf{in\_the\_garden'}(d)\|_{g,s,w} = 1$ iff
$|F(\mathbf{child})(w) \cap F(\mathit{sing})(w) \cap F(\mathbf{in\_the\_garden'})(w)| \geq 2$

e. $\exists x\exists y[x\neq y \wedge \mathit{sing}(x) \wedge \mathit{sing}(y) \wedge \mathbf{child'}(x\oplus y) \wedge \mathbf{in\_the\_garden'}(x\oplus y)]$

Generalizing from the example (10), where the singular indefinite Topic *a child* received a partitive reading, we expect the same result with a plural indefinite Topic. The only difference with respect to (17) is the fact that the translation of the NP *two children* is in the scope of

"**T**□".

(18) a. There are $Ø_d$ children. [$_{+Topic}$ $Ø_{d'}$] Two children are in the garden.

b. $\mathcal{E}d.\Uparrow\mathbf{child'}(d) \wedge \mathit{plural}(d) \wedge \mathcal{E}d'.\ \mathbf{T}\Box(\Uparrow\mathbf{two'}(d') \wedge \Uparrow\mathbf{child'}(d')) \wedge$
$\mathit{plural}(d') \wedge \mathbf{in\_the\_garden'}(d')$ (= $\mathbf{A}$)

c. $\mathbf{1}[\mathbf{A}]$ = undefined

Surprisingly, the discourse in (18a) is predicted to be infelicitous as an out-of-the-blue utterance. In particular, the bare plural *children* in the first sentence is unable to licence the partitive reading of *two children.* The update is only defined if the input already contains at least two singular child-pegs. Presumably this effect becomes more obvious with the help of a CRS. Suppose we start with the empty context and process the first sentence of (18). As output, we get the context that is represented in (19).

(19)

d
p_0, p_1, p_2
$d \rightarrow p_0$
$\mathbf{child'}(p_0)$ $p_1 \oplus p_2 = p_0$ $\mathit{plural}(p_0)$ $p_0 \neq p_1$ $p_0 \neq p_2$

Besides the peg p_0 that is introduced explicitly by *children*, we have two other pegs that are known to be proper parts of p_0. That is all we know about them. Now consider the update that is defined by the second sentence. Since the Ø-determiner is [+Topic], the information carried by the NP *two children* has to be presupposed. Hence every input where this update is defined has to contain a plural peg carrying these properties.

(20) [$_{+Topic}$ $Ø_{d'}$] Two children are in the garden.

p_i
$\mathbf{child'}(p_i)$ $\mathbf{two'}(p_i)$

==>

d'
p_i
$d \rightarrow p_i$
child'(p_i) **two'**(p_i) **in_the_garden'**(p_i)

The context represented in (19) does not fulfill the requirements that (20) needs in order to be processed since neither of the pegs in (19) is **known** to have the cardinality two. Hence a presupposition failure results.

4.1.3.3 Intonation and Focus

The fact that the partitive reading of (20) is predicted to be unavailable is not such a bad result after all. If the sentence is uttered with unmarked intonation, i.e. with the nuclear stress at the head noun *children*, a partitive reading is in fact impossible. This reading becomes marginally possible if the sentence is uttered with a hat contour, i.e. a rising prenuclear accent on *children* and a falling nuclear accent on *garden*. If the prenuclear accent is shifted backward from *children* to *two*, the partitive reading is even strongly preferred (rising tones are indicated by "/" and falling tones by "\" in the examples).

(21) a. There are many people all around. Two CHILDren \ are in the garden.
  ==> only existential reading, people and children disjoint
 b. There are many people all around. Two CHILDren / are in the GARden \.
  ==> partitive reading
 c. There are many children all around. Two CHILDren / are in the GARden \.
  ==> marginally acceptable in the partitive reading
 d. There are many children all around. TWO / children are in the GARden \.
  ==> only partitive reading

Interestingly, the location of the prenuclear accent interacts with the presupposition of the sentence. If the head-noun is stressed as in (21b), the contextually present superset must not consist of children only. If the numeral is accented, it is just the other way round. It is most important to note that partitivity of weak quantifiers is **not** tied to the stressing of the numeral expressions. Both (21b), where *children*, and (21d), where *two* is stressed, are acceptable in a partitive reading. This is in sharp contrast to what is usually assumed in the literature (cf. Löbner['90], Hoekstra['92], Jäger['94]). On the other hand, there is an intonational pattern which partitive weak quantifiers have to meet, namely they must always bear a prenuclear rising accent. Whether this accent is realized on the quantifying adjective or on the head noun makes a difference in interpretation, but the partitivity as such is not affected.

Nevertheless constructions like (21d) are the most clear-cut instances of partitive indefinites, and hence we start analyzing them first. It is argued elsewhere (Jäger['94, '95b]) that both accents in (21d) are exponents of a syntactic feature [+Focus]. The realization as a rising or falling tone respectively reflects the fact that the focus on *two* belongs to the Topic-part of the sentence (literally: it is c-commanded by a [+Topic]-determiner), while the VP-focus belongs to the Comment (i.e. is not c-commanded by [+Topic]). I assume that the focus-assignment inside the Topic-part is optional[2]. If there is no Topic-focus, the entire Topic-DP is deaccented. If the focus is present, it is realized as a prenuclear rising tone. The assignment of the Comment-focus, on the other hand, is presumably obligatory, and is realized as a nuclear falling tone. These assumptions are more or less identical to the claims made in Krifka['92]. Applied to (21d), we get this structure:

(22) [$_{\mathrm{DP}}$ [$_{\mathrm{D,+Topic}}$ Ø$_{\mathrm{d}}$] [$_{\mathrm{NP}}$ [$_{\mathrm{AP,+Focus}}$ two] [$_{\mathrm{NP}}$ children]]] [$_{\mathrm{VP,+Focus}}$ are in the garden][3]

These assumptions can straightforwardly be tied to the misprediction of a presupposition failure in (21d). The clash arose since - according to the semantics of Topic which we have assumed until now - the first sentence introduces three child-pegs, but only gives the information that one of them is plural and that the sum of the second and the third equals the first peg. The second sentence, on the other hand, is wrongly claimed to presuppose the existence of a child-peg **with cardinality two**. Focus structure helps us to weaken this presupposition. Intuitively, only the non-focused part of the Topic-DP is presupposed. In our example, only the existence of a child-peg is required, and this condition is met. The fact that this peg has the cardinality two is part of the assertion of the sentence, not of its presupposition. In a sense, the focus *two* has to be extracted out of the scope of the presuppositional operator "**T**□".

Since the semantics of focus in general is here of secondary interest, I leave the technical details of the implementation to the appendix and present only the result of the composition. Following Krifka['92], I assume that the only semantic impact of the focus-feature is the

[2]In Jäger[94, 95a,b], I claimed that the Topic-focus is obligatory, but this is surely wrong. Compare (21b) to (i):

i) [$_{\mathrm{+Topic}}$ The] children are in the GARden \

There is a clear-cut intonational difference between the respective subjects. The most plausible explanation for this observation is the assumption that in (21c) the NP *two children* as a whole is focused, while there is no focus on the subject in (i).

[3]Since the issue does not matter here, I assume that the stress on *garden* is an exponent of a focus on the entire VP without further argumentation.

structuring of meaning. (Similar ideas can be found in von Stechow['90] and Jacobs['91].) The basic idea is rather simple. I try to explain it in a nutshell. The interpretation of a constituent containing a focus is an ordered pair. Its second element is the interpretation of the focused constituent itself (simply "focus" for short). The first element - sometimes called "background" - is a certain function. It is characterized by the fact that applying the focus to it yields just the interpretation of the constituent without focus. Let us apply this to the NP *TWO*$_F$ *children*. In DITT, we write structured meaning in angeled brackets indexed with "F".

(23) a. $[_{NP}\ [_{AP}\ \text{two}]\ [_{NP}\ \text{children}]]$ ==> $\lambda x.{\Uparrow}\mathbf{two'}({}^{\vee}x) \wedge {\Uparrow}\mathbf{child'}({}^{\vee}x)$
b. $[_{AP}\ \text{two}]$ ==> $\lambda x.{\Uparrow}\mathbf{two'}({}^{\vee}x)$
c. $[_{NP}\ [_{AP,+Focus}\ \text{two}]\ [_{NP}\ \text{children}]]$ ==> $\langle_F\ \lambda T\lambda x.T\{{}^{\vee}x\} \wedge {\Uparrow}\mathbf{child'}({}^{\vee}x),\ \lambda x.{\Uparrow}\mathbf{two'}({}^{\vee}x)\rangle$

As a consequence of meaning structuring, we have separate access to the background *children* and the focus *two*, when the NP *two children* is semantically combined with the zero-determiner. Now there are two options. The focus-background structure may be transferred further to the DP-node, or focus and background are combined at this stage in such a way that the interpretation of the DP is an unstructured meaning. Generally, only focus-sensitive operators have access to the parts of a structured meaning. Most prominent examples are particles like *only* or *even*. One of the crucial claims to be made in this chapter is the following:

(24) **Topic is a focus-sensitive operator.**

More thoroughly, we have to say that the Topic-template transforms ordinary determiners to focus-sensitive operators. The modified version of the template is again given in the appendix. We may summarize it informally as follows:

(25) If the head of a DP is [+Topic], the interpretation of the DP
i) picks up a familiar peg,
ii) presupposes the background of the NP, and
iii) asserts the focus of the NP.

In DITT, this modified semantics of the DP *TWO children* looks as follows.

(26) $[_{DP}\ [_{D,+Topic}\ \varnothing_d]\ [_{NP}\ [_{AP,+Focus}\ \text{two}]\ [_{NP}\ \text{children}]]]$ ==>
$\lambda Q.\mathcal{E}d.\ \mathbf{T}\Box{\Uparrow}\mathbf{child'}(d) \wedge {\Uparrow}\mathbf{two'}(d) \wedge \mathit{plural}(d) \wedge Q\{{}^{\wedge}d\}$

The only (but crucial) difference compared to the version without focus lies in the fact that the conjunct "${\Uparrow}\mathbf{two'}(d)$" is "moved" to the right in such a way that it is not in the scope of the presuppositional operator "$\mathbf{T}\Box$" any longer.

The focus on the VP in *TWO children are in the GARden* is not at issue here; according to Krifka, it is bound by an illocutionary operator "assert". We simply ignore it. Now we are able to derive the meaning of the entire sentence.

(27) a. $[_{DP}\ [_{D,+Topic}\ Ø_d]\ [_{NP}\ [_{AP,+Focus}\ \text{two}]\ [_{NP}\ \text{children}]]]$ are in the garden ==>
$\mathcal{E}d.\ \mathbf{T}\square\Uparrow\mathbf{child'}(d) \wedge \Uparrow\mathbf{two'}(d) \wedge \mathit{plural}(d) \wedge \Uparrow\mathbf{in\_the\_garden'}(d)$

b. $ct[\mathcal{E}d.\ \mathbf{T}\square\Uparrow\mathbf{child'}(d) \wedge \Uparrow\mathbf{two'}(d) \wedge \mathit{plural}(d) \wedge \Uparrow\mathbf{in\_the\_garden'}(d)]_{g,s,w}$
$= \{<D\cup\{d\},n,r[d/p],i,v>| \quad <D,n,r,i,v> \in ct \wedge$
$p \in Pdom(ct) \wedge$
$i(p) \in F(\mathbf{child})(v) \cap F(\mathit{plural})(v) \wedge$
$|\{a|\ a \neq i(p) \wedge a+i(p) = i(p)\}| = 2\}$
iff $\exists p \in Pdom(ct) \forall <D,n,r,i,w> \in ct$: $i(p) \in F(\mathbf{child'})$, undefined else.

c. $\|\Downarrow\mathcal{E}d.\ \mathbf{T}\square\Uparrow\mathbf{child'}(d) \wedge \Uparrow\mathbf{two'}(d) \wedge \mathit{plural}(d) \wedge \Uparrow\mathbf{in\_the\_garden'}(d)\|_{g,s,w} = 1$ iff
$|F(\mathbf{child'})(w) \cap F(\mathit{sing}) \cap F(\mathbf{in\_the\_garden'})(w)| \geq 2$

d. $\exists x \exists y[x \neq y \wedge \mathit{sing}(x) \wedge \mathit{sing}(y) \wedge \mathbf{child'}(x \oplus y) \wedge \mathbf{in\_the\_garden'}(x \oplus y)]$

The sentence is only felicitous if there is at least one child-peg available in the context. Insofar it differs from (17), which is the same sentence without Topic and focus. Nevertheless the truth-conditions are completely identical.

If the sentence is embedded into a linguistic context where children are mentioned, the partitive reading is correctly predicted.

(28) a. There are $Ø_d$ children playing. $[_{+Topic}\ Ø_{d'}]$ TWO_F children are blond.

b. $\mathcal{E}d.\Uparrow\mathbf{child'}(d) \wedge \mathit{plural}(d) \wedge \Uparrow\mathbf{play'}(d) \wedge$
$\mathcal{E}d'.\mathbf{T}\square\Uparrow\mathbf{child'}(d) \wedge \Uparrow\mathbf{two'}(d) \wedge \mathit{plural}(d') \wedge \Uparrow\mathbf{blond'}(d')$ (=**A**)

c. $\mathbf{1}[\mathbf{A}]_{g,s,w} = \{<\{d,d'\},3,r,i,v>|\ r(d) = p_0 \wedge$
$i(p_0) \in F(\mathbf{child'})(v) \cap F(\mathit{plural})(v) \cap F(\mathbf{play'})(v) \wedge$
$i(p_0) = i(p_1)+i(p_2) \wedge i(p_0) \neq i(p_1) \wedge i(p_0) \neq i(p_2) \wedge$
$r(d') \in P_3 \wedge$
$i(r(d')) \in F(\mathbf{child'})(v) \cap F(\mathbf{two'})(v)$

d. $\|\mathbf{A}\|_{g,s,w} = 1$ iff $F(\mathbf{child'})(w) \cap F(\mathit{plural}) \cap F(\mathbf{play'})(v) \neq Ø \wedge$
$|F(\mathbf{child'})(w) \cap F(\mathit{sing})(w) \cap F(\mathbf{blond'})(w)| \geq 2$

Note that the discourse in (28) does not entail *There are blond children playing*. Hence the partitive interpretation is not a matter of truth conditions. On the other hand, if the discourse is uttered out of the blue, the resulting context (given in (28c)) does entail it. If there are no other child-pegs available, the blond children mentioned in the second sentence have to be linked to the playing children by means of the part-of-relation.

The treatment of the instances of partitive weak quantifiers where the head noun is stressed runs completely in parallel fashion, once we assume that here the whole NP is in focus.

(29) a. There are children all around. Two GIRLS / are in the GARden \.
. b. $[_{DP} [_{D,+Topic} Ø_{d'}] [_{NP,+Focus}$ two girls]] are in the garden
c. $\mathcal{E}$d.⇑**child'**(d) ∧ *plural*(d) ∧ ⇑**around'**(d) ∧
$\mathcal{E}$d'.**T**□∃P.P(d') ∧ ⇑**two'**(d') ∧ ⇑**girl'**(d') ∧ ⇑**in_the_garden'**(d') (=**A**)
d. $\mathbf{1}[\mathbf{A}]_{g,s,w} = \{<\{d,d'\},3,r,i,v>|\ r(d) = p_0 \wedge$
$i(p_0) \in F(\mathbf{child'})(v) \cap F(plural) \cap F(\mathbf{around'})(v) \wedge$
$i(p_0) = i(p_1)+i(p_2) \wedge i(p_0) \neq i(p_1) \wedge i(p_0) \neq p(p_2) \wedge$
$r(d') \in P_3 \wedge$
$i(r(d')) \in F(\mathbf{girl'})(v) \cap F(\mathbf{two'})(v)$
e. $\|\mathbf{A}\|_{g,s,w} = 1$ iff $F(\mathbf{child'})(w) \cap F(plural) \cap F(\mathbf{around'})(v) \neq Ø \wedge$
$|F(\mathbf{girl'})(w) \cap F(sing)(w) \cap F(\mathbf{blond'})(w)| \geq 2$

The focus-structure ensures that the update in the scope of the presuppositional operator ("∃P.P(d')") is just the tautology. Hence, the only effect of the Topic-feature is the fact that the peg linked to d' is a familiar one. No further restrictions are made.

4.1.4 Summary and Discussion

There are two descriptive generalizations in connection with the partitive reading(s) of weak quantifiers which a suitable explanation has to accomplish:

I If in a weak-quantifier-DP $[_{DP}$ Ø $[_{NP}$ $[_{AP}$ Q] NP]] the quantifying expression "Q" is exponent of a prenuclear rising accent, the antecedent which the partitive interpretation relies on has the property defined by "NP".

II If in a weak-quantifier-DP $[_{DP}$ Ø $[_{NP}$ $[_{AP}$ Q] NP]] the head of "NP" is the exponent of such an accent, the antecedent which the partitive interpretation relies on must not be known to have the property defined by "NP".

These points are illustrated by the following examples.

(30) a. (I have bought some books yesterday). THREE / books are on the SHELF \.
b. (I have bought some presents for you). Three BOOKS / are on the SHELF \.

In (30a) where *three* is stressed, the superset falls under the description *books*, while in (30b), where *books* bears the accent, the superset does not only consist of books; at least it is not known to do so. This pattern is predicted by our theory if we accept a further assumption concerning the syntax-phonology-interface:

A focus feature c-commanded by [+Topic] is realized prosodically as a rising tone.

The essentials of our treatment of partitive indefinites, in particular weak quantifiers, can be summarized as follows.

i) A Topic-DP may contain a focus.
ii) Topic is a focus-sensitive operator
iii) Indefinite Topics pick up a familiar peg.
iv) This peg must satisfy the description corresponding to the background-part.
v) The choice of this peg may be non-deterministic (and, according to the Gricean Quantity Maxim, it even has to be so).
vi) The information corresponding to the focus part is asserted.
vii) Plural DPs that are not Topic introduce three novel pegs: one that is known to be pluralic, and two proper parts of the first.
viii) Plural [-Topic]-DPs thus provide the proper antecedents for indefinite Topics.,

It is of particular importance that the semantic counterpart of the focused item is asserted while the nonfocused material in the Topic-DP is presupposed ((iv), (vi)). These assumptions explain the pattern in (30).

There are three residual points to be discussed briefly. First, our treatment of partitive weak quantifiers does not predict that the referent of the partitive phrase is a **proper** part of its antecedent.

(31) A: There are some students at the party. TEN students are DANcing.
B: Actually, these ten are the only students here.

Although an interpretation as proper part is usually preferred, in special contexts an identity-reading is possible. The implicature that we are talking about proper parts is presumably a consequence of the opposition with the definite article together with the Gricean Quantity Maxim.

Secondly, one might wonder whether our approach is really all that different from Enç's proposal after all. Superficially, there is a kind of trade-off between these options. Enç complicates syntax in assuming that each DP bears two indices instead of one. This allows her to keep semantics rather simple. We refrain from stipulating invisible information in the syntax, but as a consequence, our semantics is pretty complex. But this picture is incomplete. Enç (and the same objections apply to van Deemter['92] and Hoekstra['92]) does not say a single word on how the choice of the second index is restricted. In our approach, however, it is completely determined by the semantics of the Topic-DP at hand, what entities may serve as antecedents of a partitive indefinite or an anaphoric definite. Hence our approach is more restrictive, and the empirical facts seem to favour it.

(32) There were [many PEOple]$_{<i,j>}$ \ in front of the wrapped Reichstag.

[Twenty DUTCHmen]$_{<k,i>}$ / sang a SONG \.
[Two muSIcians]$_{<l,\{i/*k\}>}$ / played the guiTAR \.

Enç's proposal admits that this discourse has a reading where *two musicians* is partitive to *twenty Dutchmen*. This is indicated by the fact that the second index of *two musicians* ("k") picks up the first index of *twenty Dutchmen*. There is nothing in Enç's theory that excludes this indexing. Nevertheless, this reading is impossible. The only interpretation available is the one where *two musicians* is partitive to *many people*. This is predicted by our approach. Let me briefly explain why. The first sentence introduces three novel pegs, the many-people-peg and two of its parts. *Twenty Dutchmen* in the second sentence picks up one of them and asserts that its interpretation consists of twenty Dutchmen. But the choice of this peg is non-deterministic. In the context achieved after the second sentence, there are possibilities where the first peg that is a part of the many-people-peg is unified with *twenty Dutchmen*, there are possibilities where the second part plays this role (the two part-of-many-people-pegs are semantically undistinguishable but nevertheless distinct), and there are even possibilities where the peg corresponding to *many people* is equated with the peg corresponding to *twenty Dutchmen*. Hence there is no particular peg in this context that is known to be a twenty-Dutchmen-peg. We know that there are twenty Dutchmen, but we do not know which peg is to be identified with them. Accordingly, we are not allowed to create twenty singular-Dutchman-pegs. The Meaning Postulates only give rise to peg-generation if one and the same peg has a special property **in every possibility**. This situation is not given here. Hence there are no part-of-twenty-Dutchmen-pegs available and *ceteris paribus*, *two musicians* can only pick up a part-of-many-people-peg. This property of DITT seems to me to be a proper advantage over more syntax-oriented approaches.

Last but not least, the treatment of Topic-internal focus proposed here helps to explain some data that are *prima facie* counterexamples to the assumption that anaphoric definites only make use of forward chaining.

(33) Two men came in. The LARGE$_F$ / man wore a HAT \.

The first sentence only provides the information that there are two men. Nothing is said about their height. But according to the analysis proposed in the last chapter, the second sentence presupposes that there is exactly one peg in its input context that is known to be a large man. If we take focus into account, the presupposition becomes much weaker.

(34) a. [$_{+Topic}$ The$_d$] [$_{+Focus}$ large] man wore a hat.
b. THE$_d$ (**T**□ ⇑**man'**(d) ∧ ⇑**large'**(d))(⇑**wore_a_hat'**(d)) (=**A**)
c. ct[**A**]$_{g,s,w}$ = {<D∪{d},n,r[d/p],i,v>| <D,n,r,i,v> ∈ ct ∧ p ∈ Pdom(ct) ∧
F(**man'**)(v) ∩ F(**large'**)(v) = {i(p)} ∧
i(p) ∈ F(**wore_a_hat'**)(v)}
iff ∀<D,n,r,i,v> ∈ ct ∃p∈Pdom(ct): i(p) ∈ F(**man'**)(v), undefined else.

The sentence now only requires that there is at least one man-peg in the input context, and it asserts a) that he is large and wore a hat and b) that all man-pegs eventually present in the input are not large. This is in accordance with intuitions. From (33) one can in fact infer that the other man is not large. Hence the treatment of Topic-internal focus leads to predictions that are supported by the facts not only in connection with weak quantifiers but in other domains too.

4.1.5 Appendix

<u>DITT with Structured Meanings (DITTSM)</u>

Definition A1: Types

$TYPE_{DITTSM}$ is the smallest set such that

i) Every type of DITT is a type of DITTSM (simply "type" henceforth).

ii) If τ is a type of DITT, $sm(\tau)$ is a type.

iii) If σ and τ are types, $<\sigma,\tau>$ is a type.

Definition A2: Domains

i) If τ is a type of DITT, its domain is as under DITT

ii) If τ is a type, $Dom(sm(\tau)) =_{def} \bigcup_{\sigma \in TYPE} (Dom(<\sigma,\tau>) \times Dom(<s,\sigma>))$

iii) If σ and τ are types, $Dom(<sm(\sigma),\tau>) =_{def} Dom(<\sigma,\tau>) \cup Dom(\tau)^{Dom(sm(\sigma))}$

Definition A3: Syntax of DITTSM

Exp(DITTSM) is the smallest set such that

i) If α is subject to the combinatory rules of DITT, $\alpha \in Exp$.

ii) If $\alpha \in Exp_{<\sigma,\tau>}$ and $\beta \in Exp_{\sigma}$, $<_F \alpha,\beta> \in Exp_{sm(\tau)}$

iii) If $\alpha \in Exp_{<\sigma,\tau>}$ and $\beta \in Exp_{sm(\sigma)}$, $\alpha(\beta) \in Exp_{sm(\tau)}$

iv) If $\alpha \in Exp_{sm(<\sigma,\tau>)}$ and $\beta \in Exp_{\sigma}$, $\alpha(\beta) \in Exp_{sm(\tau)}$

v) If $\alpha \in Exp_{<sm(\sigma),\tau>}$ and $\beta \in Exp_{\sigma}$, $\alpha(\beta) \in Exp_{\tau}$

vi) If $\alpha \in Exp_{sm(\tau)}$, $^\wedge\alpha \in Exp_{sm(<s,\tau>)}$

vii) If $\alpha \in Exp_{sm(<s,\tau>)}$, $^\vee\alpha \in Exp_{sm(\tau)}$

viii) If $\alpha \in Exp_{sm(\tau)}$ and $v \in Var_{\sigma}$, $\lambda v.\alpha \in Exp_{sm(<\sigma,\tau>)}$

ix) If $\phi \in Exp_{sm(t)}$, $\Uparrow\phi \in Exp_{sm(up)}$

x) If $\psi \in Exp_{sm(up)}$, $\Downarrow\phi \in Exp_{sm(t)}$

xi) If $\alpha \in Exp_{sm(\tau)}$ and $\beta \in Exp_{\tau}$, $(\alpha=\beta)$, $(\beta=\alpha) \in Exp_{sm(up)}$

xii) If $\phi \in Exp_{sm(up)}$,$\psi \in Exp_{up}$,$d \in DM$ and $v \in VAR$,
$(\neg\phi)$, $(\mathbf{T}\phi)$, $(\phi\wedge\psi)$, $(\psi\wedge\phi)$, $(\mathcal{E}d.\phi)$, $(\Diamond\phi)$, $(\exists v.\phi)$, and $(\forall v.\phi) \in Exp_{sm(up)}$

xiii) If $\alpha \in Exp_{\tau}$, $\alpha \in Exp(DITTSM)$.

Definition A4: Semantics of DITTSM

i) If α is an expression of DITT, its interpretation is the same as under DITT.

ii) $\|<_F \alpha, \beta>\| =_{def} <\|\lambda v.\alpha(v)\|, \|\beta\|>$,

iii) If $\alpha \in Exp_{<\sigma,\tau>}$ and $<_F \beta, \gamma> \in Exp_{sm(\sigma)}$, $\|\alpha(<_F \beta,\gamma>)\|$
$=_{def} \|<\lambda v.\alpha(\beta(v)), \gamma>\|$

iv) If $<_F \alpha,\beta> \in Exp_{sm(<\sigma,\tau>)}$ and $\gamma \in Exp_{\sigma}$, $\|<_F \alpha, \beta>(\gamma)\| =_{def} \|<_F \lambda v.(\alpha(v)(\gamma)), \beta>\|$;

v) If $\alpha \in Exp_{<sm(\sigma),\tau>}$ and $\beta \in Exp_{\sigma}$, $\|\alpha(\beta)\| =_{def} \|\alpha\|(\|\beta\|)$

vi) $\|{}^\wedge\!<_F \alpha,\beta>\| =_{def} \|<_F \lambda v.{}^\wedge\alpha,\ \beta>\|$

vii) $\|{}^\vee\!<_F \alpha,\beta>\| =_{def} \|<_F \lambda v.{}^\vee\alpha,\ \beta>\|$

viii) $\|<_F \alpha,\beta> \wedge \phi\| =_{def} \|<_F \lambda v.(\alpha(v)\wedge\phi),\ \beta>\|$

ix) $\|\phi \wedge <_F \alpha,\beta>\| =_{def} \|<_F \lambda v.(\phi\wedge\alpha(v)),\ \beta>\|$

x) $\|\neg<_F \alpha,\beta>\| =_{def} \|<_F \lambda v.(\neg\alpha(v)),\ \beta>\|$

xi) $\|\mathcal{E}d.<_F \alpha,\beta>\| =_{def} \|<_F \lambda v.(\mathcal{E}d.\alpha(v)),\ \beta>\|$

xii) $\|\exists x.<_F \alpha,\beta>\| =_{def} \|<_F \lambda v.(\exists x.\alpha(v)),\ \beta>\|$

xiii) $\|\forall x.<_F \alpha,\beta>\| =_{def} \|<_F \lambda v.(\forall x.\alpha(v)),\ \beta>\|$

xiv) $\|\Uparrow<_F \alpha,\beta>\| =_{def} \|<_F \lambda v.(\Uparrow\alpha(v)),\ \beta>\|$

xv) $\|\Downarrow<_F \alpha,\beta>\| =_{def} \|<_F \lambda v.(\Downarrow\alpha(v)),\ \beta>\|$

xvi) $\|<_F \alpha,\beta> = \gamma\| =_{def} \|<_F \lambda v.(\alpha(v) = \gamma),\ \beta>\|$

xvii) $\|\gamma = <_F \alpha,\beta>\| =_{def} \|<_F \lambda v.(\gamma = \alpha(v)),\ \beta>\|$

xviii) $\|\Diamond<_F \alpha,\beta>\| =_{def} \|<_F \lambda v.(\Diamond\alpha(v)),\ \beta>\|$

Definition A5: Extension of the Syntax of English
$C \Longrightarrow [_{+Focus}\, C] :: \mathit{trans}([_{+Focus}\, C]) =_{def}\ <_F \lambda X.X,\ \mathit{trans}(C)>$

Definition A6: The Topic-Template, Revised Version
Let "top" be a DITTSM-constant, top $\in$ Exp(<<s, det>,<sm(<s,pred>),<<s,pred>,up>>>>). For every DITT-model $\mathcal{M}$, sequence s, world w, and assignment g, it holds that:

i) If $P \in Exp_{<s,pred>}$ and $D \in Exp_{det}$,
$\|top(D)(P)\|_{\mathcal{M},s,g,w} = D\{{}^\wedge\lambda x.\mathbf{T}\Box P\{x\}\}\|_{\mathcal{M},s,g,w}$

ii) If $<_F \lambda X.B(X), F> \in Exp_{sm(<s,pred>)}$ and $D \in Exp_{det}$,
$\|top(D)(<_F B, F>)\|_{\mathcal{M},s,g,w} = \|D\{{}^\wedge\lambda x.(\mathbf{T}\Box\exists v.B(v)\{x\} \wedge B({}^\vee F)\{x\})\}\|_{\mathcal{M},s,g,w}$

4.2 The Proportion Problem

4.2.1 Ambiguities in Donkey Sentences

In chapter two, we pretended that there are clear-cut intuitions about the interpretation of donkey sentences, and that the only problem is the compositional derivation of this interpretation. This is a fresh oversimplification. There are at least two sources of ambiguity, and in some cases, the predicted truth-conditions are plainly the wrong ones. Look at the following example (from Strigin['85]).

(35) a. Every$_d$ woman who has a$_{d'}$ hat wears it$_{d'}$.
b. $\neg(\mathcal{E}d.{\Uparrow}\textbf{woman'}(d) \wedge \mathcal{E}d'.{\Uparrow}\textbf{hat'}(d') \wedge {\Uparrow}\textbf{have'}(d,d') \wedge \neg{\Uparrow}\textbf{wear'}(d,d'))$
c. $\forall x \forall y(\textbf{woman'}(x) \wedge \textbf{hat'}(y) \wedge \textbf{have'}(x,y) \rightarrow {\Uparrow}\textbf{wear'}(x,y))$

Our analysis predicts the truth-conditions given in (35c). This roughly says that each hat-owning woman wears every hat she owns. This is surely not the meaning of (35a). What we want is that each hat-owning woman wears **one** of her hats.

The fundamental mistake we did in the treatment of *every* lies in the fact that we defined it in terms of dynamic existential quantification and dynamic negation. Chierchia['92] proposes that instead we should take the corresponding static Generalized Quantifier as starting point.

Definition 2.1 Static **every'**
Let **every'** be a DITT-constant of type <<e,t>,<<e,t>,t>>
For each <e,t>-expressions P and Q, it holds that:
$\|\textbf{every'}(P,Q)\| = 1$ iff $\{e \mid \|P\|(e) =1\} \subseteq \{e \mid \|Q\|(e) =1\}$

(36) Every$_d$ man is mortal.

To make the dynamic properties corresponding to *man* and *is mortal* in (36) applicable, we have to transform them into static predicates.

(37) a. $^\wedge\lambda x.{\Uparrow}\textbf{man'}(^\vee x)$ % dynamic property
b. $^\wedge\lambda x.{\Uparrow}\textbf{man'}(^\vee x)\{^\wedge y\}$ % update
$= {\Uparrow}\textbf{man'}(y)$
c. ${\Downarrow}{\Uparrow}\textbf{man'}(y)$ $(=\textbf{man'}(y))$ % static formula
d. $\lambda y.\textbf{man'}(y)$ % static predicate
e. $\lambda P \lambda y.{\Downarrow}P\{^\wedge y\}$ % template

The meaning of the English determiner *every* is now easily derivable.

Definition 2.2 *every*

every_d ==> $\lambda P\lambda Q.\Uparrow\mathbf{every'}(\lambda y.\Downarrow\mathcal{E}d.d=y \wedge P\{^\wedge d\})(\lambda y.\Downarrow\mathcal{E}d.d=y \wedge P\{^\wedge d\}\wedge Q\{^\wedge d\})$

(38) a. Every_d woman who has $a_{d'}$ hat wears $it_{d'}$.

b. $\lambda P\lambda Q.\Uparrow\mathbf{every'}(\lambda y.\Downarrow\mathcal{E}d.d=y \wedge P\{^\wedge d\})(\lambda y.\Downarrow\mathcal{E}d.d=y \wedge P\{^\wedge d\}\wedge Q\{^\wedge d\})$
$(^\wedge\lambda x.\Uparrow\mathbf{woman'}(^\vee x) \wedge \mathcal{E}d'.\ \Uparrow\mathbf{hat'}(d') \wedge \Uparrow\mathbf{have'}(^\vee x,d'))(^\wedge\lambda x.\ \Uparrow\mathbf{wear'}(^\vee x,d'))$
$= \Uparrow\mathbf{every'}(\lambda y.\Downarrow\mathcal{E}d.d=y \wedge \Uparrow\mathbf{woman'}(d) \wedge \mathcal{E}d'.\ \Uparrow\mathbf{hat'}(d') \wedge \Uparrow\mathbf{have'}(d,d'))$
$(\lambda y.\Downarrow\mathcal{E}d.d=y \wedge \lambda x.\Uparrow\mathbf{woman'}(^\vee x) \wedge \mathcal{E}d'.\ \Uparrow\mathbf{hat'}(d') \wedge \Uparrow\mathbf{have'}(^\vee x,d')(^\wedge d)\wedge \Uparrow\mathbf{wear'}(d,d'))$
(= **A**)

c. $ct[\mathbf{A}]_{g,s,w} = \{\langle D,n,r,i,v\rangle \mid \langle D,n,r,i,v\rangle \in ct \wedge$
$\{a \mid a\in F(\mathbf{woman'})(v) \wedge \{a\} \times F(\mathbf{hat'})(v) \cap F(\mathbf{have'})(v) \neq \emptyset\}$
$\subseteq \{a \mid a\in F(\mathbf{woman'})(v) \wedge \{a\} \times F(\mathbf{hat'})(v) \cap F(\mathbf{have'})(v) \cap F(\mathbf{wear'})(v) \neq \emptyset\}\}$

d. $\forall x[\mathbf{woman'}(x) \wedge \exists y[\mathbf{hat'}(y) \wedge \mathbf{have'}(x,y)] \rightarrow \exists y[\mathbf{hat'}(y) \wedge \mathbf{have'}(x,y) \wedge \mathbf{wear'}(x,y)]]$

The truth-conditions are *Every woman that has a hat wears one of her hats*. This is just what we expect. This treatment has the additional advantage that it is straightforwardly extrapolable to other Generalized Quantifiers like *most*, *few* etc.

Definition 2.3 *most*

i) Let **most'** be a DITT-constant of type <<e,t>,<<e,t>,t>>
For each <e,t>-expressions P and Q, it holds that:
$\|\mathbf{most'}(P,Q)\| = 1$ iff $|\{a \mid \|P\|(a) =1 \wedge \|Q\|(a) = 0\}| < |\{a \mid \|P\| = 1 \wedge \|Q\|(a) =1\}|$

ii) $\textit{most}_d$ ==> $\lambda P\lambda Q.\Uparrow\mathbf{most'}(\lambda y.\Downarrow\mathcal{E}d.d=y \wedge P\{^\wedge d\})(\lambda y.\Downarrow\mathcal{E}d.d=y \wedge P\{^\wedge d\}\wedge Q\{^\wedge d\})$

Nevertheless, this treatment does not cover all cases.

(39) Most persons that use a windows application have difficulties with it.

The semantics of *most* given above predicts that the sentence means *Most windows-users have difficulties with one of their programs*, yet the intended interpretation is *Most windows-users have difficulties with all their programs*. This reading is sometimes called the "strong" reading in contrast to the "weak" one described above. This reading can be described by necessitating the matrix of the dynamic generalized quantification.

Fact 2.1 Weak and Strong Readings

Let D be a static Generalized Quantifier (Type <<e,t>,<<e,t>,t>>). Then D^- is the translation of the corresponding determiner in its weak and D^+ in its strong reading.

i) $D^-_d =_{def} \lambda P\lambda Q.\Uparrow D(\lambda y.\Downarrow\mathcal{E}d.d=y \wedge \Uparrow P\{^\wedge d\})(\lambda y.\mathcal{E}d.d=y \wedge P\{^\wedge d\} \wedge Q\{^\wedge d\})$

ii) $D^+_d =_{def} \lambda P\lambda Q.\Uparrow D(\lambda y.\Downarrow\mathcal{E}d.d=y \wedge \Uparrow P\{^\wedge d\})(\lambda y.\mathcal{E}d.d=y \wedge P\{^\wedge d\} \wedge \Box Q\{^\wedge d\})$

The question which of these readings is enforced in a given construction and a given context depends on a lot of factors, including monotonicity of the quantifier, focus structure, encyclopedic knowledge etc. Topic-Comment-articulation has an influence too, but it is by no means dominant. Therefore this is not the proper place to investigate the issue any further.

Things are different as soon as we turn to conditional donkey sentences. They are ambiguous too, although in a different sense than donkey sentences involving adnominal quantification. If the antecedence of the conditional contains a transitive verb and two indefinite arguments, there are even three different readings. This ambiguity is usually called the **proportion problem** in the literature (the term is due to Kadmon['87], but the fact was to my knowledge firstly noted in Partee['84, p.282, fn. 12]). The usually most prominent reading is the **subject-asymmetric** one.

(40) If a woman has a HAT, she wears it

In its most obvious reading, the sentence is synonymous to (35), i.e. it claims that each hat-owning woman wears one of her hats.

(41) If an ITAlian has made a pizza, he has put twenty different spices on it.

Suppose commercially sold Italian pizzas are made by a team of Italians, but only the boss is allowed to put the spices on it. Although under the analysis given in chapter two, this case should falsify (41) (provided that *make a pizza* is distributive here), it doesn't. This reading is called **object-asymmetric**, since we asymmetrically quantify over pizzas instead of Italians or Italian-pizza-pairs.

Finally, there is a reading where we quantify over instances of the subject and the object simultaneously. It is called the **symmetric** reading.

(42) If a man OWNS a car, he has to pay taxes for it.

In the most prominent reading, (42) says that every car-owner has to pay for each of his cars.

In chapter two, we reduced *if*-conditionals to dynamic negation and dynamic conjunction. This analysis only accounts for the symmetric reading. But besides this, there is again a still more fundamental shortcoming of this analysis. Lewis['75] notes that plainly any attempt to explain *if*-conditionals by means of some kind of implication is doomed to failure, if we take conditionals containing adverbs of quantification into account.

(43) {always, usually, sometimes, mostly, ...}if ϕ, ψ

If we analyze the *if*-conditional as implications, we only get reasonable truth-conditions in the case of *always*. If the sentence is modified by *sometimes*, conjunction seems to be the correct relation between the antecedence and the consequence, but neither implication nor conjunction account for the interpretation of the sentences with *usually* or *mostly*. Generally, it is impossible to analyze the *if*-conditional as one propositional constituent if we aim at compositionality. Lewis instead proposes to treat adverbs of quantification as two-place operators and the antecedence and the consequence of the conditional as the respective arguments. Bare conditionals, i.e. those lacking a quantificational adverb, are not the basic cases any longer but rather accidental constructions now. They should be analyzed "as if" they were modified by *always*.

Although this move provides a fundamental insight into the nature of conditionals, it does not offer a solution to the proportion problem *per se*. The claim that conditionals are somehow quantificational structures does not tell us what to quantify over. Lewis himself makes two very influential proposals that in some sense form the basis both for DRT and FCS:

i) Indefinites are to be translated as open formulae containing a free variable, and
ii) adverbs of quantification quantify over (partial) assignment functions.

Let me illustrate this by an example.

(44) a. Mostly, if a linguist goes to a party, he enjoys it
b. $\text{most}_{x,y}$ [**linguist'**(x) ∧ **party'**(y) ∧ **goes_to'**(x,y)] [**enjoys'**(x,y)]
c. most({g|g(x) is a linguist and g(y) is a party and g(x) goes to g(y)})
({g|∃h: g ⊆ h ∧ h(x) enjoys h(y)})

Both the antecedence and the consequence of the conditional are translated as open formulae, where the indefinites as well as the pronouns provide free variables. These open formulae each define a set of partial assignment functions that a) verify the respective formula and b) are minimal in the sense that they do not assign values to variables not occurring free in the formula. *Mostly* is interpreted as a Generalized Quantifier taking these two sets as arguments. Superficially, *most* therefore binds unselectively all variables occurring free in its arguments. Therefore this treatment is usually called **unselective-binding approach**.

Unfortunately, this accounts only for the symmetric reading of donkey conditionals, just as our previous analysis did. There is a huge amount of proposals suggesting how this shortcoming of the unselective-binding-approach can be overcome. Basically, two strategies are possible. Either we have to refine it in such a way that not every free variable is bound by the adverb. Let me call this the **selective-binding approach**. As a second option, we may assume that adverbs of quantification do not quantify over assignment functions at all but over situations (whatever this might be). I call it the **situation-based approach**. In the following paragraphs, we will briefly present a representative of each strategy. Finally, it will be shown that DITT lends itself quite naturally to a synthesis of these two proposals.

4.2.2 A Situation-based Approach: Berman['87]

Berman['87] gives as his starting point an example where the unselective-binding approach goes terribly wrong.

(45) a. Usually, if a letter arrives for me, I am at home.
b. most_x [**letter'**(x) ∧ **arrives_for'**(x,**I'**)] [**at_home'**(**I'**)]

Simplifying somewhat, we assume that *usually* is synonymous to *mostly*. Now suppose there were just one occasion when I missed the postman, but this was just the day when 100 letters arrived. On the 50 other days when always only one letter arrived, I was at home. Intuitively, the sentence is true in this setup, but under unselective binding, it is predicted to be false, since 100 letters reached me when I was out and only 50 when I was at home. The first mistake of the formalization in (45b) is the fact that the points in time when a letter arrived and I was or was not at home are not taken into account. This can easily be incorporated.

(46) $\text{most}_{x,t}$ [**letter'**(x) ∧ **arrives_for'**(x,**I'**,t)] [**at_home'**(**I'**,t)]

Now we quantify over letter-time pairs. But since there is exactly one time for each letter arrived when it arrived, the predicted truth-conditions are exactly the same as before. Especially, there are 100 letter-time-pairs such that I was not at home at this time, corresponding to the 100 letters arriving at once. But intuitively, these 100 letters should count only once as an element of the set we quantify over. On an intuitive level, we quantify over occasions where at least one letter arrived, no matter whether there were other letters that arrived simultaneously. Berman identifies these "occasions" with situations in the sense of (an earlier version of) Kratzer['89a].

We cannot go into technical detail here, but we only give the basic ideas of this theory. According to Kratzer, situations instead of possible worlds are the basic entities interpretation relies on. Situations are ontologically primitive entities. They are partially ordered by means of a kind of inclusion relation. For instance, a minimal situation characterized by the sentence *It rains* is a proper part of a situation to be described by *It rains and I am wet*. There are maximal elements of this partial ordering. These maximal elements correspond to possible worlds in traditional semantics, i.e. they contain total information about the state of the world. Accordingly, non-maximal situations can be thought of as parts of the world. Natural language sentences still denote propositions, but propositions are thought of as sets of situations here.

Since a) a proposition is a set of situations and b) situations are partially ordered, every proposition contains a subset of minimal situations. This might be a singleton set, but it need not. According to Berman, adverbs of quantification quantify over minimal situations. Take (45a). The antecedence, *a letter arrives for me,* defines a set of situations, those situations where it is true that at some time, some letter arrives for me. The antecedence together with the consequence defines another set, situations where it is true that at some time some letter reaches me and I am at home. The latter set is a subset of the former.

The set of situations where some letter reached me at some time contains a subset of minimal elements. This subset serves as restriction of the quantifier. Now there are two extreme options. There is a situation where I received 100 letters at the same time. Either this situation contains 100 parts where I received one letter each, or the 100-letter-situation is, so to speak, compact in that it does not contain proper parts that are letter-arriving-situations. In the first case, those truth-conditions result that were predicted by unselective binding (i.e. (45a) is predicted to be false in the described situation), in the second case the sentence comes out as true. I give a semiformal formulation here:

(47) *Usually, if a letter arrives for me, I am at home* is true in situation s iff
MOST({s'| s' ≤ s ∧ *a letter arrives for me* is true in s' ∧
¬∃s''[*a letter arrives for me* is true in s'' ∧ s''≤s']})
({s'| s' ≤ s ∧ *a letter arrives for me* is true in s' ∧
¬∃s''[*a letter arrives for me* is true in s'' ∧ s''≤s'] ∧
∃s'''[s' ≤ s''' ≤ s ∧ *a letter arrives for me and I am at home* is true in s''']})

In prose: Most parts of the evaluation situation where a letter arrived for me and that are minimal in this respect can be extended to another part of the evaluation situation where a letter reaches me at home.

This proposal has the major advantage that the intuitively correct truth-conditions are predicted to be possible. But this is its major disadvantage at the same time. What truth-conditions a conditional actually possesses depends completely on the nature of the ordering relation over situations. Hence donkey-conditionals are not predicted to be ambiguous but to be extraordinarily vague. This goes against intuition (at least against my own intuition). Consider an instance of an object-asymmetric reading.

(48) If a PAINter lives in a village, it is usually pretty. (Kadmon['90])

In its preferred reading, it claims that most villages that are the residence of a painter are pretty. To derive this reading, Berman has to assume that twenty painters living in a particular village constitutes a somehow compact situation that cannot be split into twenty one-painter-living-in-a-village-situations. On the other hand, if we stress *village*, the subject-asymmetric reading results, and here we have to allow for such a partition. It is unclear how this can be done within one and the same model.

4.2.3 Selective Binding: Chierchia['92]

Another objection concerns the linguistic status of the proportion-ambiguities. Which reading a particular donkey-conditional receives is linguistically much more determined than Berman's proposal leads us to expect. It was already noted by Kratzer['89b] that donkey conditionals are not as ambiguous as one might expect at first glance. The English language is a little misleading here, but in German, the different readings are syntactically distinguished to a great extent. Let us take the German translations of the three examples we used above to illustrate the different readings.

(49) a. Wenn eine Frau (stolz) einen Hut besitzt, trägt sie ihn.
If a woman (proudly) a hat owns, wears she it
'If a woman (proudly) owns a hat, she wears it' : subject-asymmetric
b. Wenn eine Pizza (wirklich) ein Italiener gemacht hat, hat er zwanzig Gewürze
If a pizza_{ACC} (really) an Italian_{NOM} made has, has he twenty spices
hinzugegeben
put-on-it
'If (really) an ITALian made a pizza, he has put twenty spices on it' : object-asym.
c. Wenn ein Mann ein Auto (legal) besitzt, muß er Steuern dafür bezahlen.
If a man a car (legally) owns, must he taxes for-it pay
'If a man (legally) owns a car, he has to pay taxes for it.' : symmetric

The generalization to be made is pretty obvious: If the subject is scrambled (i.e. [+Topic]), the subject-asymmetric reading results, scrambling of the object forces the object-asymmetric reading, and scrambling of both arguments results in a symmetric reading. Descriptively, the adverb of quantification quantifies over the Topics of the antecedent only, not over any indefinite there. Kratzer, elaborating on the work of Diesing['88], tries to implement this interdependence between scrambling and selective binding directly into the syntax-semantics-interface, but this leads to serious difficulties as soon as we try to extrapolate the analysis to English. She therefore has to assume LF-scrambling in English, and it remains unclear how these constructions have to be dealt with in non-configurational languages. I doubt if the strategy of extrapolating idiosyncratic properties of one particular language to the LF-syntax of any language does really lead to new insights concerning the relation between syntax and semantics. We have to argue on a more abstract level if we aim at a general solution. Chierchia['92] is much more modest here. He assumes - as we did - that there is a syntactic feature [+T](opic) that determines whether an indefinite is accessible for quantification or not. Since he does not investigate the peculiarities of German syntax, he does not explicitly state a relation between topicality and scrambling, but most likely he would agree with our assumption that [+Topic] triggers scrambling (and in fact, his work did - among others - inspire this assumption). This strategy has the advantage that we can leave it to language-specific investigations how this feature realizes in syntax.

The main shortcoming of the unselective-binding-approach is the fact that the adverb, so to speak, sometimes binds too many variables. Chierchia is confronted with the opposite problem. He uses a framework called "Dynamic Type Theory", which is an independently developed variant of G&S's DMG. In this framework, indefinites are assumed to be interpreted as existential quantifiers. I again illustrate this by an example. Since DITT shares all features relevant here with Chierchia's Dynamic Type Theory, I use a DITT-formalization for convenience. For ease of exposition, Chierchia's proposal is also simplified somewhat, but the basic idea remains unchanged.

(50) a. Always, if a map is old, it is useless.
b. $\textbf{always'}\ [\mathcal{E}d.\ {\Uparrow}\textbf{map'}(d) \wedge {\Uparrow}\textbf{old'}(d)]\ [{\Uparrow}\textbf{useless'}(d)]$

If we assume that *always* should be analyzed as a kind of quantifier, it has to bind some free variable, but there is none in the arguments. It is just the function of the (semantic counterpart of the) Topic-feature to provide these variables. Chierchia adopts an idea brought up by Dekker['90], so-called **existential disclosure**. The idea quite simple: the discourse markers we want to quantify over (those that are introduced by a Topic) are equated with a free static variable, and the quantifier unselectively binds any free variable made accessible by this process. To provide that this variable is also available in the second argument of the quantifier, the second argument is assumed to be the conjunction of the translation of antecedence and consequence. If we assume that *a man* in (49a) is a Topic, the formalization is roughly:

(51) $\textbf{always'}_x\ [\mathcal{E}d.\ {\Uparrow}\textbf{map'}(d) \wedge d{=}x \wedge {\Uparrow}\textbf{old'}(d)]$
$[\mathcal{E}d.\ {\Uparrow}\textbf{map'}(d) \wedge d{=}x \wedge {\Uparrow}\textbf{old'}(d) \wedge {\Uparrow}\textbf{useless'}(d)]$

This turns out to be equivalent to

(52) $\textbf{always'}_x\ [{\Uparrow}\textbf{map'}(x) \wedge {\Uparrow}\textbf{old'}(x)]\ \ [{\Uparrow}\textbf{useless'}(x)]$

Up to this point, there is no difference to unselective binding. The picture changes if we consider proper donkey sentences.

(53) a. Usually, if [$_{+T}$ a$_d$] farmer owns a$_{d'}$ donkey, he$_d$ beats it$_{d'}$
b. $\textbf{most'}_x\ [\mathcal{E}d.{\Uparrow}\textbf{farmer'}(d) \wedge d = x \wedge \mathcal{E}d'.{\Uparrow}\textbf{donkey'}(d') \wedge {\Uparrow}\textbf{owns'}(d,d')]$
$[\mathcal{E}d.{\Uparrow}\textbf{farmer'}(d) \wedge d = x \wedge \mathcal{E}d'.{\Uparrow}\textbf{donkey'}(d') \wedge {\Uparrow}\textbf{owns'}(d,d') \wedge {\Uparrow}\textbf{beats'}(d,d')]$
c. $\textbf{most'}_x\ [{\Uparrow}\textbf{farmer'}(x) \wedge \exists y({\Uparrow}\textbf{donkey'}(y) \wedge {\Uparrow}\textbf{owns'}(x,y))]$
$\exists y[{\Uparrow}\textbf{farmer'}(x) \wedge {\Uparrow}\textbf{donkey'}(y) \wedge {\Uparrow}\textbf{owns'}(x,y) \wedge {\Uparrow}\textbf{beats'}(x,y)]$
(subject-asymmetric reading)

(54) a. Usually, if a$_d$ farmer owns [$_{+T}$ a$_{d'}$] donkey, he$_d$ beats it$_{d'}$
b. $\textbf{most'}_y\ [\mathcal{E}d.{\Uparrow}\textbf{farmer'}(d) \wedge \mathcal{E}d'.{\Uparrow}\textbf{donkey'}(d') \wedge d' = y\ \wedge {\Uparrow}\textbf{owns'}(d,d')]$
$[\mathcal{E}d.{\Uparrow}\textbf{farmer'}(d) \wedge \mathcal{E}d'.{\Uparrow}\textbf{donkey'}(d') \wedge d' = y \wedge {\Uparrow}\textbf{owns'}(d,d') \wedge {\Uparrow}\textbf{beats'}(d,d')]$
c. $\textbf{most'}_y\ [{\Uparrow}\textbf{donkey'}(y) \wedge \exists x({\Uparrow}\textbf{farmer'}(x) \wedge {\Uparrow}\textbf{owns'}(x,y))]$

$\exists x[\Uparrow\mathbf{donkey'}(y) \wedge \Uparrow\mathbf{farmer'}(x) \wedge \Uparrow\mathbf{owns'}(x,y) \wedge \Uparrow\mathbf{beats'}(x,y)]$
(object-asymmetric reading)

(55) a. Usually, if $[_{+T}\ a_d]$ farmer owns $[_{+T}\ a_{d'}]$ donkey, he_d beats $it_{d'}$
b. $\mathbf{most'}_{x,y}\ [\mathcal{E}d.\Uparrow\mathbf{farmer'}(d) \wedge d=x \wedge \mathcal{E}d'.\Uparrow\mathbf{donkey'}(d') \wedge d' = y \wedge \Uparrow\mathbf{owns'}(d,d')]$
$[\mathcal{E}d.\Uparrow\mathbf{farmer'}(d) \wedge d=x \wedge \mathcal{E}d'.\Uparrow\mathbf{donkey'}(d') \wedge d' = y \wedge \Uparrow\mathbf{owns'}(d,d') \wedge \Uparrow\mathbf{beats'}(d,d')]$
c. $\mathbf{most'}_{x,y}\ [\Uparrow\mathbf{farmer'}(x) \wedge \Uparrow\mathbf{donkey'}(y) \wedge \Uparrow\mathbf{owns'}(x,y))]\ [\Uparrow\mathbf{beats'}(x,y)]$
(symmetric reading)

Depending on which argument is marked as Topic, the respective b-readings result, each of which in turn is equivalent to the formula in (c).

This approach is also able to deal with the letter-example discussed above that provided the motivation for Berman's proposal, if we make one additional assumption. The example is repeated for convenience.

(56) Usually, if a letter arrives for me, I am at home.

If we would analyze *a letter* in (55) as Topic, the wrong reading with quantification over letters results[4]. As we know, we have to quantify over something like occasions instead. Chierchia only says that verbs have "Davidsonian" occasion-arguments that a) are bound by a dynamic existential quantifier and b) can be selected as Topics.

I think that this can be made more precise. Since Partee['84], it is a widely hold observation that tense behaves like a DP in many respect. Nevertheless, its concrete status is somewhat unclear. On the one hand, tense can serve as antecedent for subsequent temporal anaphora like *then*. On the other hand, tense itself often behaves anaphorically, yet in another sense than pronominal anaphors.

(57) a. John went in. He opened the window.

The reference time of the second sentence immediately follows the reference time of the first one, but they are not identical. This kind of dependency - I would like to claim - is just another instance of bridging. Hence it should be analyzed in parallel. This implies a) that tense introduces new discourse entities like definite and indefinite descriptions do, and b) that anaphoric instances of tense should be analyzed as Topics, similar to anaphoric definites and partitive indefinites. That verbal predicates are relativized to a temporal parameter is a safe assumption. Hence the formalization of (55) should look as follows.

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[4]This reading is, by the way, possible if we stress the verb *arrives*.

(58) a. $\mathbf{most'}_t\ [\mathcal{E}d.\ \Uparrow\mathbf{tense'}(d) \wedge d=t \wedge \mathcal{E}d'.\Uparrow\mathbf{letter'}(d') \wedge \Uparrow\mathbf{arrives'}(d', \mathbf{I'},d)]$[5]

$[\mathcal{E}d.\ \Uparrow\mathbf{tense'}(d) \wedge d=t \wedge \mathcal{E}d'.\Uparrow\mathbf{letter'}(d') \wedge \Uparrow\mathbf{arrives'}(d', \mathbf{I'},d) \wedge \Uparrow\mathbf{at\_home'}(\mathbf{I'},d)]$

b. $\mathbf{most'}_t\ [\Uparrow\mathbf{tense'}(t) \wedge \exists x(\Uparrow\mathbf{letter'}(x) \wedge \Uparrow\mathbf{arrives'}(x, \mathbf{I'},t))]$

$\exists x[\Uparrow\mathbf{tense'}(t) \wedge \Uparrow\mathbf{letter'}(x) \wedge \Uparrow\mathbf{arrives'}(x, \mathbf{I'},t) \wedge \Uparrow\mathbf{at\_home'}(\mathbf{I'},t)]$

If I receive 100 letters at once, there is only one time slice when this happens. Since we quantify over time slices here, the sentence is correctly predicted to be true in the example situation described above.

This is not the place to discuss eventual empirical mispredictions of Chierchia's proposal to solve the proportion problem. As far as I can see, it is clearly the best one that is on the market at present time. Nevertheless, it is somehow unsatisfactory from a conceptual point of view. The category "Topic" remains totally unrelated to all the phenomena discussed in the preceding chapters or other empirical domains. Therefore in the next paragraph, an attempt is made to incorporate this proposal into our general theory of topicality. It provides in some sense a synthesis of Berman's situation-based and Chierchia's selective-binding-approach.

4.2.4 A Synthesis: Proportions in DITT

We adopt the basic idea of Chierchia's proposal, namely that adverbs of quantification quantify over instances of the Topic(s) of the antecedent. But technically, we have to choose another strategy since our Topic-template as it was defined above does not provide free variables of any kind. Instead of pursuing the more syntax-oriented approach used by Chierchia (syntax of the logical language), we follow Berman in quantifying over model-theoretic entities. According to him, quantification takes minimal situations as arguments. There is a straightforward counterpart to situations in the ontology used in DITT, namely possibilities[6]. Absolutely minimal possibilities are those containing neither discourse markers nor pegs.

Definition 2.4 Absolutely Minimal Possibilities
A possibility k is absolutely minimal iff there is a world $w \in W$, such that:

$k = \langle \emptyset,0,\emptyset,\emptyset,w \rangle$

Please note that "**1**", the state of complete ignorance, is just the set of all absolutely minimal possibilities. Each minimal possibility defines a certain context, namely its singleton set. These contexts are, so to speak, maxi-minimal in that they contain complete factual knowledge about

[5]The actual descriptive content of tense morphemes is a highly complicated matter that I cannot pursue here. To get an impression of the complexity of the issue, see Lascarides & Asher['93].

[6]Of course the philosophical background is completely different. Firstly, DITT uses a possible-world semantics, while worlds are derived entities in Kratzer's situation-based approach. Secondly, situations are intended to be realistic entities, while DITT-possibilities are to be interpreted epistemically.

the world but complete ignorance about discourse entities like discourse markers and pegs. Accordingly, sentences containing anaphors or Topics are not defined in such a context. This leads us to a relativized notion of minimality. Roughly, a possibility is minimal w.r.t. an update if the update is defined in the singleton context corresponding to the possibility, and there are no parts of the possibility that fulfill this requirement. Let us take an example. Consider the sentences *A firemen is altruistic.* For some reasons, this sentence is only acceptable if the subject is interpreted specifically, i.e. if it is a Topic (ignoring the generic reading). Hence the corresponding update is only defined in contexts that contain at least one fireman-peg. A possibility is minimal w.r.t. this update if it contains just exactly one fireman-peg and no discourse markers. To make this idea precise, we first need some auxiliary definitions.

Definition 2.5 Minimality

i) Let P be a set of possibilities (that need not constitute a context).

$\mathit{MIN}(P) =_{def} \{k|\ k \in P \wedge \forall l[\ l \in P \wedge l \leq k \rightarrow l=k]\}$

ii) Let ϕ be an update. Its **precondition** is the set of contexts where ϕ is defined.

$PC(\phi,g,s,w) =_{def} \{ct|\ ct[\phi]_{g,s,w} \text{ is defined}\}$

iii) Let ϕ be a type-up formula. The set of possibilities **minimal w.r.t. ϕ** is defined as follows:

$\mathit{MIN}(\phi,g) =_{def} \{k| \forall <s,w> \in compl(k): \{k\} \in \mathit{MIN}(PC(\phi,g,s,w))\}$

iv) Let ϕ be a type-up formula and l a possibility.

$\mathit{MIN}(\phi,l,g) =_{def} \{k|\ k \in \mathit{MIN}(\phi,g) \wedge compl(l) \subseteq compl(k)\}$

In iv), minimality is additionally relativized to a particular possiblitiy, something like the counterpart of Bermans evaluation situation. Now we can give the set of possibilities minimal w.r.t. *A fireman is altruistic*.

(59) a. $[_{+Topic}\ A_d\ ]$ fireman is altruistic.

b. $\mathcal{E}$d. **T**□⇑**fireman'**(d) ∧ **altruistic'**(d)

c. ct[$\mathcal{E}$d. **T**□⇑**fireman'**(d) ∧ **altruistic'**(d)]$_{g,s,w}$ =
{<D∪{d},n,r[d/p],i,v>| <D,n,r,i,v> ∈ ct ∧ p ∈ Pdom(ct) ∧ i(p) ∈ F(**altruistic'**)(v)}
iff ∀<D,n,r',i',v'> ∈ ct: i'(p) ∈ F(**fireman'**)(v'), undefined else

d. PC(($\mathcal{E}$d. **T**□⇑**fireman'**(d) ∧ **altruistic'**(d)),g,s,w) =
{ct| ∃p ∈ Pdom(ct) ∀<D,n,r,i,v> ∈ ct: i(p) ∈ F(**fireman'**)(v)}

e. *MIN*(($\mathcal{E}$d. **T**□⇑**fireman'**(d) ∧ **altruistic'**(d)),g) =
{<Ø,1,Ø,{<p_0,a>},w>| a ∈ F(**fireman'**)(w)}

f. *MIN*(($\mathcal{E}$d. **T**□⇑**fireman'**(d) ∧ **altruistic'**(d)),l,g) =
{<Ø,1,Ø,{<p_0,a>},w>|Wdom({l}) = {w} ∧ a ∈ F(**fireman'**)(w)}

Note that the sets of possibilities given in (59e) and (f) each constitute a context. The context given in (59f) is particularly interesting. It contains exactly as many possibilities as there are firemen in the respective world of evaluation.

Fact 2.1
Let a possibility l = <D,n,r,i,w> be given. Then it holds that

$$|MIN((\mathcal{E}d.\ \mathbf{T}\Box\Uparrow\mathbf{fireman'}(d) \wedge \mathbf{altruistic'}(d)),l,g)| = |F(\mathbf{fireman'})(w)|$$

This observation can be generalized. The set of possibilities minimal w.r.t. an update and a possibility of evaluation always has the same cardinality as the set of instances of the Topic-part of the update.

Fact 2.2
Let a possibility l = <D,n,r,i,w>, a discourse marker d, and a predicate P be given. Then it holds for all sequences s such that $r°i \subseteq s$ that:

$$|MIN((\mathcal{E}d.\mathbf{T}\Box\Uparrow P(d)),l,g)| = |\|P\|_{g,s,w}|$$

Suppose (59a) is the antecedence of a conditional.

(60) Usually, if a fireman is altruistic, he saves lives.

Intuitively, the sentence is true in a world if most individuals that are altruistic firemen in that world save lives in that world. If we update the context given in (59f) (that has the same cardinality as the set of firemen) with the static closure of the antecedence, we get a context that is isomorphic to the set of altruistic firemen.

Fact 2.3
Let a possibility l = <D,n,r,i,w> be given. Then it holds for all sequences s such that $r°i \subseteq s$ that:

$$|MIN((\mathcal{E}d.\ \mathbf{T}\Box\Uparrow\mathbf{fireman'}(d) \wedge \mathbf{altruistic'}(d)),l,g)[\Uparrow\Downarrow(\mathcal{E}d.\ \mathbf{T}\Box\Uparrow\mathbf{fireman'}(d) \wedge \mathbf{altruistic'}(d))]| = |F(\mathbf{fireman'})(w) \cap F(\mathbf{altruistic'})(w)|$$

If we apply the same procedure to the conjunction of the antecedence and the consequence, we get a context that has the same cardinality as the set of altruistic firemen that save lives. Hence we can use these two contexts as arguments of the Generalized Quantifier MOST (as an expression of the metalanguage). The quantity-requirement on Generalized Quantifiers ensures that truth-conditions are not affected by this move. This gives us a first approximation to the meaning of the adverb of quantification *usually*.

Definition 2.6 "usually", Preliminary Version

$$ct[\mathbf{usually'}\ (\phi)(\psi)]_{g,s,w} =_{def} \{k \in ct|\ \textsc{most}(MIN(\phi,k,g)[\Uparrow\Downarrow\phi]_{g,s,w})(MIN(\phi,k,g)[\Uparrow\Downarrow(\phi\wedge\psi)]_{g,s,w})\}$$

where MOST(A)(B) means $|A| < 2*|A\cap B|$.

This definition is not completely what we want. Until now, we have ignored the possibility that conditionals may contain anaphoric pronouns. If an anaphor occurs in the antecedence part, this does no harm, since the way minimality was defined ensures that the corresponding discourse marker receives the appropriate value. But according to the definition given above, an anaphor in the consequence would result in undefinedness. This is surely wrong.

(61) A_{d} friend of mine really loves Christo.
Usually, if $[_{\text{+Topic}}\ \text{a}_{\text{d'}}]$ new book about Christo is not too expensive, he_{d} buys $\text{it}_{\text{d'}}$.

The anaphor *he* in the consequence is completely acceptable, and it is anaphoric to *a friend* in the preceding sentence. Hence we have to modify the meaning rule for *usually* somewhat. It does not suffice to ensure that the antecedence of the conditional is minimally defined in the possibilities we quantify over; it is the conjunction of antecedence and consequence that has to be defined.

Definition 2.7 "usually", Final Version

$$\text{ct}[\textbf{usually'}\ (\phi)(\psi)]_{g,s,w} =_{def} \{k\in \text{ct} \mid \text{MOST}(\mathit{MIN}((\phi\wedge\psi),k,g)[\Uparrow\Downarrow\phi]_{g,s,w})\ (\mathit{MIN}((\phi\wedge\psi),k,g)[\Uparrow\Downarrow(\phi\wedge\psi)]_{g,s,w})\}$$

This makes sure that the unbound discourse marker "d" in the translation of (61) is interpreted as a friend of mine in any minimal situation we quantify over.

Up to now, this looks very similar to Berman's idea, but we preserve the important features of Chierchia's proposal as well. The first argument of the quantifier is isomorphic to the set of those instances of the Topic-part the Comment is true of. We'll illustrate this with the respective antecedences of the subject-asymmetric, the object-asymmetric, and the symmetric reading of the classical donkey conditional.

(62) a. He_{d} beats $\text{it}_{\text{d'}}$
b. $\Uparrow\textbf{beat'}(d,d')$ (=**C**)

(63) a. $[_{\text{+Topic}}\ \text{A}_{\text{d}}\ ]$ farmer owns $\text{a}_{\text{d'}}$ donkey.
b. $\mathcal{E}d.\ \mathbf{T}\Box\Uparrow\textbf{farmer'}(d) \wedge \mathcal{E}d'.\Uparrow\textbf{donkey'}(d') \wedge \Uparrow\textbf{own'}(d,d')$ (=**A1**)
c. $\mathit{MIN}((\mathbf{A1}\wedge\mathbf{C}),\langle D,n,r,i,w\rangle,g) = \{\langle\varnothing,1,\varnothing,\{\langle p_0,e\rangle\},w\rangle \mid e \in F(\textbf{farmer'})(w)\}$
d. $\mathit{MIN}((\mathbf{A1}\wedge\mathbf{C}),\langle D,n,r,i,w\rangle,g)[\Uparrow\Downarrow\mathbf{A1}]_{g,s,w} =$
$\{\langle\varnothing,1,\varnothing,\{\langle p_0,a\rangle\},w\rangle \mid a \in F(\textbf{farmer'})(w) \wedge$
$\exists b[b \in F(\textbf{donkey'})(w) \wedge \langle a,b\rangle \in F(\textbf{own'})(w)]\}$

(64) a. A_{d} farmer owns $[_{\text{+Topic}}\ \text{a}_{\text{d'}}\ ]$ donkey.
b. $\mathcal{E}d.\Uparrow\textbf{farmer'}(d) \wedge \mathcal{E}d'.\mathbf{T}\Box\Uparrow\textbf{donkey'}(d') \wedge \Uparrow\textbf{own'}(d,d')$ (=**A2**)
c. $\mathit{MIN}((\mathbf{A2}\wedge\mathbf{C}),\langle D,n,r,i,w\rangle,g) = \{\langle\varnothing,1,\varnothing,\{\langle p_0,a\rangle\},w\rangle \mid a \in F(\textbf{donkey'})(w)\}$

d. $MIN((\mathbf{A2} \wedge \mathbf{C}),\langle D,n,r,i,w\rangle,g)[\Uparrow\Downarrow\mathbf{A2}]_{g,s,w} =$
$\{\langle \varnothing,1,\varnothing,\{\langle p_0,a\rangle\},w\rangle \mid a \in F(\mathbf{donkey'})(w) \wedge$
$\exists b[b \in F(\mathbf{farmer'})(w) \wedge \langle b,a\rangle \in F(\mathbf{own'})(w)]\}$

(65) a. $[_{+Topic}\ A_d\ ]$ farmer owns $[_{+Topic}\ a_{d'}\ ]$donkey.
b. $\mathcal{E}d.\ \mathbf{T}\Box\Uparrow\mathbf{farmer'}(d) \wedge \mathcal{E}d'.\Uparrow\mathbf{donkey'}(d') \wedge \Uparrow\mathbf{own'}(d,d')$ (=**A3**)
c. $MIN((\mathbf{A3} \wedge \mathbf{C}),\langle D,n,r,i,w\rangle,g) = \{\langle \varnothing,2,\varnothing,\{\langle p_0,a\rangle,\langle p_1,b\rangle\},w\rangle \mid$
$a \in F(\mathbf{farmer'})(w) \wedge b \in F(\mathbf{donkey'})(w)\}$
d. $MIN((\mathbf{A3} \wedge \mathbf{C}),\langle D,n,r,i,w\rangle,g)[\Uparrow\Downarrow\mathbf{A3}]_{g,s,w} =$
$\{\langle \varnothing,2,\varnothing,\{\langle p_0,a\rangle,\langle p_1,b\rangle\},w\rangle \mid a \in F(\mathbf{farmer'})(w) \wedge b \in F(\mathbf{donkey'})(w) \wedge$
$\langle a,b\rangle \in F(\mathbf{own'})(w)\}$

In (63d), we have one and only one possibility for every donkey-owning farmer, in (64d) for every donkey owned by a farmer, and in (65d) for every farmer-donkey-pair that stands in the ownership-relation. It is obvious that this yields just the respective readings Chierchia predicts if we apply the meaning rule for *usually* given above.

To incorporate adverbs of quantification into our fragment of English, we have to slightly modify the syntax. Actually, both quantificational adverbs and *if*-clauses should be treated as modifiers, with the consequence of the conditional as matrix clause. Still we do not intend to analyze the behaviour of sentences modified by a quantificational adverb but lacking an *if* clause. Thus we pretend a) that these adverbs subcategorize for conditionals, and b) that they only occur in clause initial position.

Definition 2.8 The Syntax of Adverbs of Quantification
i) S ==> Qadv, Cond
ii) Cond ==> $\bar{S}$, S
iii) $\bar{S}$ ==> C, S

Definition 2.9 Extension of the Lexicon
i) Qadv ==> {usually, always, sometimes, rarely, frequently, ...}
ii) usually --> **usually'**
iii) if --> $\lambda p \lambda q \lambda Q.Q\{{}^\vee p\}({}^\vee q)$

I refrain from stating the meaning rules for *always, rarely,* etc. explicitly; you simply have to replace MOST in definition 2.7 by EVERY, FEW, etc. As a sample sentence, the derivation of the object-asymmetric reading of the donkey-conditional is given.

(66) a. Usually, if a_d farmer owns $[_{+Topic}\ a_{d'}\ ]$ donkey he_d beats $it_{d'}$

b. a_d farmer owns [$_{+Topic}$ $a_{d'}$] donkey :: S ::
$\mathcal{E}d.{\Uparrow}\mathbf{farmer'}(d) \wedge \mathcal{E}d'.\mathbf{T}\Box{\Uparrow}\mathbf{donkey'}(d') \wedge {\Uparrow}\mathbf{owns'}(d,d')$
|
| if :: C :: $\lambda p\lambda q\lambda Q.Q\{{}^{\vee}p\}({}^{\vee}q)$
| /
if a_d farmer owns [$_{+Topic}$ $a_{d'}$] donkey :: $\bar{S}$ ::
$\lambda q\lambda Q.Q\{\mathcal{E}d.{\Uparrow}\mathbf{farmer'}(d) \wedge \mathcal{E}d'.\mathbf{T}\Box{\Uparrow}\mathbf{donkey'}(d') \wedge {\Uparrow}\mathbf{owns'}(d,d')\}({}^{\vee}q)$
|
| he_d beats $it_{d'}$ :: S :: ${\Uparrow}\mathbf{beat'}(d,d')$
| /
if a_d farmer owns [$_{+Topic}$ $a_{d'}$] donkey he_d beats $it_{d'}$ :: Cond ::
$\lambda Q.Q\{\mathcal{E}d.{\Uparrow}\mathbf{farmer'}(d) \wedge \mathcal{E}d'.\mathbf{T}\Box{\Uparrow}\mathbf{donkey'}(d') \wedge {\Uparrow}\mathbf{owns'}(d,d')\}({\Uparrow}\mathbf{beat'}(d,d'))$
|
| usually :: Qadv :: **usually'**
| /
Usually, if a_d farmer owns [$_{+Topic}$ $a_{d'}$] donkey he_d beats $it_{d'}$ :: S ::
$\mathbf{usually'}(\mathcal{E}d.{\Uparrow}\mathbf{farmer'}(d) \wedge \mathcal{E}d'.\mathbf{T}\Box{\Uparrow}\mathbf{donkey'}(d') \wedge {\Uparrow}\mathbf{owns'}(d,d'))({\Uparrow}\mathbf{beat'}(d,d'))$ (=**A**)

c. $ct[\mathbf{A}]_{g,s,w} = \{\langle D,n,r,i,v\rangle |$ $\langle D,n,r,i,v\rangle \in ct \wedge$
MOST $(\{a|\ a \in F(\mathbf{donkey'})(v) \wedge \exists b[b \in F(\mathbf{farmer'})(v) \wedge \langle b,a\rangle \in F(\mathbf{own'})(v)]\})$
$(\{a|\ a\in F(\mathbf{donkey'})(v) \wedge \exists b[b \in F(\mathbf{farmer'})(v) \wedge \langle b,a\rangle \in F(\mathbf{own'})(v) \cap F(\mathbf{beat'})(v)]\})$

d. $\|{\Downarrow}\mathbf{A}\|_{g,s,w} = 1$ iff MOST $(\{a|\ a\in F(\mathbf{donkey'})(w) \wedge \exists b[b \in F(\mathbf{farmer'})(w) \wedge \langle b,a\rangle \in F(\mathbf{own'})(w)]\})$
$(\{a|\ a\in F(\mathbf{donkey'})(w) \wedge \exists b[b \in F(\mathbf{farmer'})(w) \wedge \langle b,a\rangle \in F(\mathbf{own'})(w) \cap F(\mathbf{beat'})(w)]\})$

e. $most_y\ [\mathbf{donkey'}(y) \wedge \exists x[\mathbf{farmer'}(x) \wedge \mathbf{own'}(x,y)]]$
$\exists x[\mathbf{farmer'}(x) \wedge \mathbf{own'}(x,y) \wedge \mathbf{beat'}(x,y)]$

It is worth noticing that Berman has difficulties to predict the correct truth-conditions to the already mentioned bishop-sentences, while both Chierchia's and our approach can cope with it.

(67) Always, if a bishop meets another man, he blesses him.

Suppose that two bishops meet each other but only one blesses the other. Then the sentence is false in either reading. To predict this, Berman would have to assume that a situation of bishop A and bishop B meeting each other can be partitioned into two smaller situations, namely bishop A meeting bishop B and vice versa, and that in the first of these situations the proposition *Bishop A meets bishop B* is false. This is against any intuition about situations. But there are unequivocally two different minimal possibilities, each containing one bishop-peg, and in the first one, this peg is mapped to bishop A and in the second one to bishop B. More generally, although the basic strategy of the proposal presented here is very much reminiscent to Berman's, its empirical coverage is completely identical to Chierchia's approach. This implies that notoriously difficult donkey-conditionals like sage-plant sentences etc. which Chierchia deals well with do not cause any harm here either. Besides this, our approach has the major conceptual advantage over Chierchia's in that the notion of Topic used here is brought in accordance with generalizations about seemingly unrelated phenomena like the (non-)anaphoric behaviour of definite descriptions and the partitive reading of weak quantifiers.

Of course the discussion in this paragraph can only be seen as a first step towards a sufficient characterization of the semantics of adverbs of quantification. A more suitable one has to incorporate the modal aspect of these items. Nevertheless, it possibly helps to clarify the question "What do adverbs of quantification quantify over?". Possibilities (in our technical sense) are surely better candidates than assignment functions, and in some respects, they are also superior to the quite vague notion of "situations".

4.3 Conclusion and Desiderata

To sum up, the investigations made in the last two chapters lead us to a new classification of DPs where definiteness only plays a marginal role. The two major distinctions are a) the opposition between third person definite pronouns on the one hand and descriptions on the other, and b) the Topic/non-Topic-dichotomy. The first one corresponds to the issue: picking up an old **discourse marker** or creating a new one, the second one distinguishes between picking up an old vs. creating a new **peg**.

(68)

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">Discourse Marker</td></tr>
<tr><td>old without resetting</td><td>new/ resetting</td></tr>
<tr><td rowspan="2">Pegs</td><td>old</td><td>Third Person Definite
Pronouns</td><td>Anaphoric Definites
Partitive Indefinites</td></tr>
<tr><td>new</td><td></td><td>Referential Definites
Non-Specific Indefinites</td></tr>
</table>

It is obvious that the third cell has to remain empty. If a DP picks up an old discourse marker, it has either to reset it or not. If the latter is the case, the corresponding peg cannot be new.

This chart of course leaves a lot of questions unresolved. One important issue concerns the status of [+Topic]-indefinites. There are two groups of clear cases, namely partitive indefinites that are unequivocally [+Topic], and non-specific "novel" indefinites that introduce new pegs and are not Topics. But some questions arise. If Enç['91] is right with her assumption that partitivity coincides with specificity, one might wonder why specifics/ Topics always favour a wide-scope reading. I have to admit that I have plainly no idea about this. Although it is arguable that specifics are always Topics, I doubt whether this is everything that is to be said about them. Likely, you have to distinguish between hearer-knowledge and speaker-knowledge if you want to account for specificity, something that cannot be expressed in our framework.

The treatment of personal pronouns is very much simplified here, too. Some inadequacies like paycheck pronouns or subordination phenomena were already discussed at the end of chapter three. Besides this, there is another unresolved problem. Cardinaletti & Starke['94] show convincingly that there is a strong tendency crosslinguistically to distinguish between "strong" and "weak" pronominal forms morphosyntactically, and they give good arguments to assume that this distinction is even a language universal. In certain contexts like coordination or focus, only the strong form is possible. As it turns out, strong pronouns do not follow the characterization given above.

(69) Two friends of mine will get married next week. SHE / is HAPpy \.

Since the pronoun *she* is in focus here, it is a strong one in Cardinaletti & Starke's terminology. It is completely acceptable in (69), although there is no familiar singular discourse marker that is ready to be picked up. One might hypothesize that strong pronouns are in fact disguised definite descriptions like *the female person* in the case of strong *she*.

Another shortcoming of our theory is the fact that it sometimes predicts too many readings w.r.t. to partitive indefinites.

(70) a. TWO / children are in the GARden \
b. LITTle / children are in the GARden \

While in (69a), a partitive, i.e. a [+Topic]-interpretation, is strongly preferred, no such reading is available for (69b)[7]. As far as I can see, this is an instance of a more general problem, namely that partitive/specific readings of plural indefinites are only available if they are modified by some quantifying expression. There is superficially no essential difference in the meaning of *some students* and *students* as a bare plural as far as the dynamic behaviour is concerned. Nonetheless, only (70a) has a wide-scope-reading of the embedded object.

(71) a. Harry denied the rumour that he KISSed some students.
b. Harry denied the rumour that he KISSed students.

[7]I thank Kai von Fintel (p.c.) for drawing my attention to this flaw in the argument.

Again, I have not the slightest idea what is going on here.

The treatment of partitive weak quantifiers still offers a quite fundamental problem. Remember that plural indefinites introduce three pegs, where the latter two are parts of the first one. This leads to the wrong conclusion that subsequent partitive expressions may only involve two distinct parts of the sum individual introduced by the plural expression. In contrary, the number of available part-of pegs is virtually unrestricted:

(72) a. Germany consists of 16 states.
 b. THREE / states border on Poland.
 c. TWO/ states are are situated at the border to the Czech Republic.
 ...
 z. THREE/ states are situated inland.

In contrast to what is predicted, the different parts neither have to be mutually identical nor complementary. As far as I can see, a proper solution to this puzzle has to take discourse structure into account. The sentences (72b-z) each are an elaboration to (72a) in the sense of Asher['93]. Insofar they are each subordinated to (72a). As such, they are each interpreted directly with respect to (72a), i.e. in parallel fashion. A formal explication of this idea would offer a whole new branch of dynamic semantics, namely the incorporation of the concept of concurrency from theoretical computer science (cf. Reisig['86]). This obviously has to be left to another occasion.

This list of shortcomings and possible objections is by no means intended to be exhaustive. Nevertheless, I hope to have convinced the gentle reader of four essentials:

I Dynamic Semantics forms an adequate framework for Natural Language Semantics.

II Topic-Comment-Articulation is a matter of semantics and not of pragmatics.

III To account for anaphoricity phenomena in a wide sense, we need more than just one layer of discourse referents.

IV Although writing sometimes was great fun, I am extraordinarily happy about having finished this dissertation

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