Paul Dekker

Institute for Language, Logic and Information

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Jeroen Groenendijk
Martin Stokhof
Frank Veltman

University of Amsterdam

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Preface

From April 13-16, 1987 the Sixth Amsterdam Colloquium was held. It was organized by the Institute for Language, Logic and Information (ITLI), founded by the Departments of Philosophy and Mathematics of the University of Amsterdam.

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This volume contains 18 of the 24 contributed talks that were delivered at the Colloquium.They appear as the authors prepared them.

Jeroen Groenendijk
Martin Stokhof
Frank Veltman

Contents

A Unification-Based Analysis of Unbounded Dependencies in Categorial Grammar.

Gosse Bouma

Institut für Maschinelle Sprachverarbeitung
Universität Stuttgart

Abstract
It is argued that the standard categorial theory of unbounded dependencies is empirically inadequate. An alternative is developed, in terms of Categorial Unification Grammar. This alternative analysis is able to account for island constraints, extraposition, and the interaction of coordination and unbounded dependencies.

0. Introduction*

In Ades & Steedman (1982) and Steedman (1985), a categorial theory of unbounded dependency constructions has been developed,in which functional composition plays a crucial role.

In section 1 we will argue that this theory encounters two empirical difficulties. First, it is forced to introduce certain liberalizations on word order, especially in the case of Dutch, which lead to overgeneration. Second, Steedman's (1985) analysis of 'Right Node Raising' incorrectly predicts that this process will, by and large, be subject to the same island-constraints as leftward extraction. We conclude that the source of these problems is the fact that constraints on word order and coordination cannot be distinguished from constraints on unbounded dependency constructions.

In section 2 an alternative account of unbounded dependency constructions is developed. Categorial Grammar is reformulated in terms of unification. This allows us to incorporate a feature-based theory of 'gap-percolation'. As a result, we arrive at a theory of Categorial Grammar, which treats unbounded dependencies by means of a special module in the grammar.

In the final section we show that this theory is able to account for island-phenomena, the fact that RNR does not obey island constraints, and extraposition.

1. The Functional Composition Approach to Unbounded Dependencies

The standard categorial theory of unbounded dependencies, introduced in Ades & Steedman (1982) (A&S, hereafter), has been worked out in detail in Steedman (1985) (D&C, hereafter). In our discussion of this theory, we will concentrate on the latter, and only indicate that similar points can be made with respect to Steedman (1987) as well.

The categorial grammar for English used in D&C consists of Rightward Application (RA) and Rightward Composition (RC)[1] (in the very general sense, as first introduced in A&S). The core idea behind the treatment of unbounded dependencies is (1).

(1) <u>The Adjacency Property</u>
The combination rules are unable to combine two non-adjacent items, unless the intervening item(s) can

first be combined with one or the other of them.
(D&C:533)

This works fine for a language such as English, which consists mainly of rightward-combining functors:

```
(2) Apples,    I     believe she    will   eat    ø
    T/(S/NP) S/FVP  FVP/S   S/FVP  FVP/VP VP/NP
             ____________RC
                  S/S
                  _______________RC
                       S/FVP
                       ________________RC
                            S/VP
                            _______________RC
                                  S/NP
    __________________________________F
                  T
```

Extracted elements[2] are assumed to be of a raised type T/(S/X), where X is their original type, and T stands for a category S, with the additional feature-specification [+TOPIC].

For languages such as Dutch and German, which contain leftward-combining as well as rightward-combining functors, a problem arises.

```
(3) het meisje,  aan wie    Henk   een nijlpaard   ø     gaf
    the  girl    to which   Henk   a   hippo            gave
                 R/(S/PP)   S/FVP      NP        (FVP/NP)/PP
                                   _______________________LA
                                              *
```

In (3), the extracted PP aan wie ought to be combined with the verb gaf, but the intervening material cannot be combined with one of both parts first. (The grammar for Dutch does contain Leftward Application (LA) and Leftward (see note 1), but this does not solve the problem.) This means that the Adjacency Property cannot be fulfilled. Steedman solves this problem by allowing Category Raising (CR) for NPs :

```
(3) .....aan wie  Henk   een nijlpaard   ø        gaf
        R/(S/PP)  S/FVP      NP              (FVP/NP)/PP
                          __________CR
                          v$/(v$/NP)
                               ______________________FC
                                      FVP/PP
```

The symbol v$ is a variable ranging over verbal categories. However, an immediate consequence of this move is that arguments of the verb (or verb complex) can now 'scramble' in the VP[3]:

```
(4)  a. (dat Henk)  Cecilia een   nijlpaard     overhandigde
        that Henk   Cecilia a     hippo         presented
                    NP_io         NP_o          (FVP/NP_io)/NP_o
                                  ______________________________LA
                                           FVP/NP_io
                    ______________________________LA
                                 FVP

     b. *(dat Henk)  een nijlpaard  Cecilia          overhandigde
                         NP_o       v$/(v$/NP_io)    (FVP/NP_io)/NP_o
                                    _________________________________RC
                                              FVP/NP_o
                         ______________________________LA
                                    FVP
```

(4b) is ungrammatical, but cannot be excluded by means of a restriction on RC, since otherwise (3) would no longer be derivable. Therefore, the following restriction cannot be correct:

(5) $X/Y \quad Y\$/Z \implies X\$/Z$, where $X \neq v\$$, or $Y = v\$$ (D&C:557)

In D&C it is claimed that this restriction excludes (6), since the starred application of RC can no longer take place:

```
(6)   *dat ik    de nijlpaarden    Cecilia          zag voeren
          S/FVP  v$/(v$/NP_2)      v$/(v$/NP_1)     (FVP/NP_1)/NP_2
          ______________________RC ____________________________RC*
              S/(FVP/NP_2)                  FVP/NP_2
              _________________________________________RA
                                 S
```

If this were true, (6) would be excluded at the cost of no longer being able to derive (3). However, notice that things are in fact just the other way around. In the starred application of RC in (6), Y = FVP. FVP is an instance of v$, since it is a verbal category, and therefore (5) would in fact admit (6), and also (3) and (4a,b). Thus it seems that extraction out of VPs can only be accounted for, if certain constraints on word order are ignored[4].

Since non-directional systems, containing Category Raising and Composition, tend to overgenerate, no matter what restrictions one formulates, Steedman (1987) contains a reformulation of A&S and D&C in terms of a directional categorial grammar. The main innovation (apart form the treatment of parasitic gaps) is the introduction of so called 'slash-mixing' instances of Composition. Specifically, Steedman poposes the following rule for English (We are omitting semantics, and rewriting Steedman's notation into the standard Lambek-notation):

(7) $Y/Z \quad Y\backslash X \implies X/Z$ (LC)

This rule is needed for the derivation of (8):

```
(8)  This book,  I    put          ∅       on the table
       S/(S/NP)  S/VP  (VP/PP)/NP          PP
                                           ___________CR
                                           (VP/PP)\VP
                                 ___________________________LC
                                         VP/NP
                          _________________RC
                                S/NP
                 ________________RA
                        S
```

However, this rule will also allow:

```
(9)  I put on the table this book
     _________________  _________
           S/NP            NP
          __________________RA
                   S
```

Of course, there are instances of 'Heavy NP Shift', in which such word orders are acceptable, but in Steedman's system there is no possibility to distinguish such marked orders from the normal ones.

Consider also the consequences it would have for Dutch. Since Dutch contains left-directional as well as right-directional functors, slash-mixing will occur on a large scale here. In order to derive (10a), for instance, forward 'slash-mixing' has to be allowed, which implies that (10b) is admitted as well. For (10b), however, not even the excuse of 'Heavy NP Shift' is available:

```
(10) a.  het boek   dat         ik          verkoop
         the book   which       I           sell
                    R/(S/NP)    S/VP         NP\VP
                                ________________RC
                                       S/NP
                    ___________________RA
                              R

     b. *dat ik   verkoop een boek geschreven door Vestdijk
         that I   sell     a  book written     by  Vestdijk
                          ________________________________
            S/VP    NP\VP            NP
          _____________RC
              S/NP
            _____________________RA
                     S
```

It is not at all clear therefore, that using directional categorial grammar is an improvement of the earlier proposals.

The source of the problems noted above lies in the fact that the treatment of unbounded dependencies requires the introduction of highly general composition and category raising rules. Such extensions are innocent as long as one works with a strictly directional grammar (since it adds strong, not weak, generative capacity). What we have demonstrated above, however, is that as soon as directionality is given up (or 'slash-mixing' is allowed), some nasty side-effects on possible word orders arise. This interference is a consequence of the fact that word order and UDCs are accounted for by means of the same rules. Thus, the only way to avoid it, is to seperate these components somehow.

There is also another way of looking at the facts. In the D&C analysis complex categories lead a somewhat ambiguous life. First, a category X/Y can be considered as a functor which combines with some category Y to form a phrase of category X. However, they can also be phrases of category X, from which an element of category Y is missing. Although these two points of view will often be equivalent (for instance in semantics), there are cases where the difference is important. Take, for instance example (10). The phrase <u>ik verkoop</u> is not a functor of category S/NP, since then one would expect it to be able to combine with an NP either to its left, or to its right. (10b) and (10c) show that neither is possible.

(10) c. *dat een boek ik verkoop
that a book I sell

This shows that we are not dealing with a functor here, but rather with a category containing a gap (which can only be 'filled' once a particular 'landing site' is reached). Again, given the problems we encountered above, it seems advisable to distinguish functor categories from incomplete constituents somehow.

The treatment of 'Right Node Raising' (RNR) and 'Non-Constituent Conjunction' (NCC), presented in D&C, and elaborated in Dowty (1985), raises a second problem for the compositional approach to unbounded dependencies.

RNR and NCC can be accounted for in a categorial framework, if one assumes the following rule schema:

(11) Coordination (C) : X^+ Conj X ==> X

The analyis of RNR and NCC does not require any extension of the already existing framework. In the categorial theory of coordination, it is assumed that these are in fact instances of ordinary constituent conjunction, albeit that the coordinated constituents are somewhat unconventional:

```
(12)  Harry cooked  and  Mary  ate  the beans I bought from
                                                       Alice
      S/FVP FVP/NP CONJ  S/FVP FVP/NP ______________________
      ____________RC     ____________RC          NP
         S/NP               S/NP
         _________________________C
                   S/NP
                   _____________________________________RA
                                    S
```

```
(13) John    gave        Mary a book and Susan a record
     S/FVP  (FVP/NP)/NP  ________________________________
                               ((FVP/NP)/NP)\FVP
            ___________________________________________LA
                 FVP
     ____________RA
          S
```

That Mary a book and Susan a record can indeed be analyzed as a coordination of two constituents of category ((FVP/NP)/NP)\FVP is illustrated in (14).

```
(14)     Mary                      a   book
           NP                          NP
      _________________________CR  ______________CR
      ((FVP/NP)/NP)\(FVP/NP)       (FVP/NP)\FVP
      ___________________________________________LC
                   ((FVP/NP)/NP)\FVP
```

A second attractive aspect of this analysis is that the 'Across the Board'- facts (ATB) of Williams (1978) are accounted for:

```
(15)  a.  beans  which      Harry  cooked   and  Mary  ate
                R/(S/NP)    S/FVP  FVP/NP  CONJ S/FVP FVP/NP
                            ______________RC     _____________RC
                                S/NP                S/NP
                                ___________________________C
                                        S/NP
                 ___________________________RA
                              R

      b. *beans  which Harry    cooked curry   and   Mary ate
              R/(S/NP) ______________________  CONJ  ________
                          S                             S/NP
                       ______________________________________C
                                      *
```

The fact that flexible categorial grammars account for RNR, NCC, and ATB, without introducing any new rules, is one of the strongest arguments for flexibility in phrase structure, that one can imagine[5].

However,the interaction with unbounded dependency phenomena raises a problem. RNR and NCC are accounted for by means of the same rules which also used for UDCs. This leads to the following prediction:

"where leftward extraction is impossible -because partial combination is prohibited from forming a constituent by the island constraints, as in [16a]- RNR is also prohibited, as [16b] shows" (D&C:542)

(16) a. *This picture [I know the woman who painted]
b. *[I know the woman who painted and you met the man who stole], the picture that Harry was so fond of

This claim is in conflict with a considerable amount of literature on the subject. Wexler & Culicover (1980:299ff), McCawley (1982) and Levine (1985) contend that RNR out of a complex NP is grammatical:

(17) a. Mary knows a man who buys, and Bill knows a man who sells, pictures of Fred. (Wexler &Culicover:299)
b. John gave a briefcase, and Harry knows someone who had given a set of steak knives, to Bill (Levine:492)

Furthermore, RNR out of WH-islands is grammatical:

(18) I have been wondering whether, but wouldn't want positively to state that, your theory is correct. (Bresnan, 1974:618)

In D&C it is claimed that the grammaticality of (18) is predicted. Notice however, that the first conjunct of (18) is in fact a WH-island (see (19)). Therefore, (18) can no longer be derived once some version of the WH-island constraint (for instance (20)) is incorporated.

(19) *Who have I been	wondering	whether	Bill	likes
	FVP/S[WH]	S[WH]/S	S/FVP	FVP/NP

(20) RC : X/Y Y$/Z ==> X/Z , where Y ≠ S[WH]

Thus, accounting for (18) is not as unproblematic as it seems.

That not every restriction on leftward extraction, formulated as a restriction on RC, should hold for RNR as well, is confirmed by Zwarts (1986:16 ff.), who not only presents Dutch equivalents of (17) and (18) as grammatical, but also shows that in Dutch the PP-island Condition does not hold for RNR:

(21) Ot stemde voor, maar Sien stemde tegen de ondoordachte
Ot vote for but Sien voted against the unwise
voorstellen.
proposals

These observations effectively falsify the claim that UDCs and RNR are subject to the same constraints. As long as they are accounted for by means of the same rules, however, it seems unlikely that a solution to this problem can be found[6].

To summarize, both the interaction of UDCs with word order, and the interaction of constraints on UDCs with RNR and NCC seem to suggest that the mechanisms used in constructing UDCs must be distinguished from other rules in the grammar.

2. A Unification Approach to Extraction

In this section we present the outlines of an alternative approach to unbounded dependency constructions, formulated in terms of Categorial Unification Grammar (CUG) (Uszkoreit (1986), Zeevat (1986), Wittenburg (1986)). The combination of unification and categorial grammar techniques enables us to incorporate an account of unbounded dependencies based on feature-percolation, which at the same time preserves many of the attractive aspects of Categorial Grammar.

The first step from Categorial Grammar to Categorial Unification Grammar is relatively small[7]. First, we have to express categories as feature-matrices. This is illustrated for NPs and determiners in (22). Cat, val, arg and dir have been used as abbreviations for category, value, argument and directionality, respectively.

```
(22)  a.   [ cat : np ]

      b.  [ cat : [ val : [ cat : np ] ] ]
          [       [ dir : right        ] ]
          [       [ arg : [ cat : n  ] ] ]
```

Second, reduction and category-changing rules are represented as a combination of CF-rules and corresponding feature matrices. This is illustrated below for RA, and one version of CR:

```
(23)  a. Value --> Functor Argument          ( A --> A/B  B)

         [ value    : <1>                              ]
         [ functor  : [ cat : [ val : <1>   ] ]        ]
         [            [       [ dir : right ] ]        ]
         [            [       [ arg : <2>   ] ]        ]
         [ argument : <2>                              ]

      b.   Out --> In                        ( (B/A)\B --> A )

         [ out : [ cat : [ val : [ cat :<1> ]                        ] ] ]
         [       [       [ dir : left                                ] ] ]
         [       [       [ arg : [ cat : [ val :<1>   ] ]            ] ] ]
         [       [       [       [       [ dir : right ] ]           ] ] ]
         [       [       [       [       [ arg : <2>   ] ]           ] ] ]
         [ in  : [ cat : <2> ]                                           ]
```

It should be noted that the symbols appearing in the CF-rules always match with the upper-most attributes in the corresponding feature-matrix.

Once we have taken this first step, there is no need to restrict ourselves to the well-known rules of Categorial Grammar. Indeed, one could even say that crossing the boundaries of traditional Categorial Grammar into the land of unification formalisms, is linguistically interesting only if one exploits the expressive power of unification to establish new and better accounts of natural language phenomena.

Notice that our formulation of CR is in fact an example of this process. In categorial terms, the definition in (23b) amounts to:

(24) a --> (X/a)\X,

where X is a variable over categories. Thus, the application of CR results in what might be called a 'partially specified category'. The effect of this modification is that derivations involving CR are greatly simplified:

```
(25)   (FVP/NP)/NP        NP                  NP
                     ____________CR      ____________CR
                       (X/NP)\X            (Y/NP)\Y
                     _________________________________LC   X = Y/NP
                            ((Y/NP)/NP)\Y
       ___________________________________LA               Y = FVP
                       FVP
```

The constituent structure in (25) is needed to derive the NCC construction in (13). The fact that the value of a partially specified category need not be determined beforehand, but that this will take place during the process of reduction (as illustrated by the equations added to LA and LC in (25)), makes an efficient implementation of such rules feasible[8].

A second extension, on which we will concentrate here, is the incorporation of a treatment of UDCs based on feature-percolation. This approach to UDCs is reminiscent of the slash-feature mechanism used in GPSG (Gazdar et al., 1985) and HPSG (Pollard, 1986).

It is assumed that the mechanism accounting for UDCs consists of three parts: a rule introducing incomplete constituents, rules accounting for the percolation of the information that a 'gap' of a certain category is present, and rules for elimination of 'gaps' (cf. Gazdar et al. 1985:137)[9].

Information about 'gaps' is encoded in a feature <u>gap</u>. It is assumed that all lexical categories will have the specification [gap : nil]. The following rule enables the introduction of incomplete constituents:

(26) **Incomplete Constituent Introduction (ICI)**

```
a.      X     -->     X/Y,    Y\X
       [Y]

b.     Out   --> In

   [in  : [cat  : [val  :  [ cat : <1> ]]]
   [        [      [arg  :  [ cat : <2> ]]]
   [        [gap  : nil                    ]
   [                                       ]
   [out : [cat  :  <1>]                    ]
   [      [gap  :  <2>]                    ]
```

(26a) presents the rule for incomplete constituent introduction in a pseudo-categorial notation. We have adopted the convention that the specification [gap:nil] can be omitted, and that [gap:Y] is abbreviated to [Y]. (26b) presents the unification version of this rule.

For 'gap-percolation' we use a feature-percolation mechanism, not Composition. Feature-percolation in Categorial Grammar will usually be based on something like the 'Functor Feature Convention', saying that the features of a mother-node are inherited from the functor-daughter (see Bach, 1983). The gap-feature is different however, since a mother node must be able to inherit a gap-feature specification from either the functor-daughter, or from the argument-daughter (thus it is a foot-feature in the sense of Gazdar et al, 1985:79 ff.):

```
(27) het meisje, aan wie   Henk   een nijlpaard   ϕ     gaf
     the girl    to  whom  Henk   a   hippo            gave
                           S/FVP  NP               PP\(NP\FVP)
                                                   ___________ICI
                                                     NP\FVP
                                                      [PP]
                                  ______________________________B
                                             FVP
                                             [PP]
                           ______________________F
                                      S
                                     [PP]
```

The correct percolation of the information that a PP is missing, requires that the FVP-node inherits this information from its functor-daughter, whereas the S-node inherits this information from its argument-daughter. This means that the reduction rules RA, RC, LA and LC must be extended with the following disjunctive condition[10].

```
(28) [value   : [ gap  : <1> ]]  or  [value   : [ gap : <1> ]]
     [functor : [ gap  : <1> ]]      [functor : [ gap : nil ]]
     [argument: [ gap  : nil ]]      [argument: [ gap : <1> ]]
```

Notice that in case no 'gap' is present, all values will simply be nil. Therefore, this case can simply be considered as a trivial instance of gap-percolation. This means that no distinction has to be made between instances of application and composition involving gaps versus those not involving gaps.

There will be two rules for 'gap-elimination', one for WH-questions and topicalization, and one for relative clauses (the unification version of that rule closely resembles that for WH):

(29) Gap-elimination:

a. S_{main} --> Y $S_{main\,[Y]}$ (WH)

Value --> Argument Functor

```
┌                                    ┐
│ Value :    ┌cat  : S   ┐           │
│            │main : +   │           │
│            └gap  : nil ┘           │
│            ┌cat  : S   ┐           │
│ Functor :  │main : +   │           │
│            └gap  : <1> ┘           │
│ Argument : [cat  : <1> ]           │
└                                    ┘
```

b. R --> Y_{rel} $S_{sub\,[Y]}$ (R)

An example of the application of R is presented in (27):

```
(27)  het meisje, aan wie Henk  een nijlpaard   ∅    gaf
      the girl,   to  whom Henk a   hippo            gave
                      PPrel S/FVP   NP          PP\(NP\FVP)
                            ____________________________
                                  S
                                 [PP]
                      _______________R
                              R
```

The treatment of unbounded dependencies as presented above has the advantage that it forms a seperate module within the grammar, and, consequently, that no interference with word order constraints will arise. This enables us, for instance, to use a strictly directional grammar in which sentences such as (3) (repeated here as (27)), can be derived without (non-directional) raising of NPs, or using 'slash-mixing'. Thus, we avoid the word order problems of D&C or Steedman (1987).

In the next section we argue that the present system can be extended with an empirically adequate theory of bounding as well, which not only avoids the problems with RNR we noted before, but also is able to distinguish between leftward and rightward movement.

3. Empirical Considerations

In this section, we will illustrate how our approach deals with island-constraints, the interaction between coordination and island-constraints, and extraposition.

Island-constraints are most naturally represented in a unification-based framework if one adds a feature-specification , for instance [island:+] (abbreviated as <u>isl</u>), to those categories which form an island-boundary. Non-island categories will simply be left unspecified for this feature.

The second step is to require that certain rules used for UDCs are made sensitive to this feature. There are two options here. In D&C, and also in GPSG (Gazdar,1982:174 ff.), island-constraints are evaluated locally. That is, being an island means that nothing whatsoever can be moved out of this domain. Such an approach can be incorporated in the framework outlined in the previous section, if gap-introduction and gap-percolation is made sensitive to the island-character of certain constituents. This is illustrated for gap-introduction in (28).

```
(28)      X     -->     X/Y
         [Y]          [isl:-]
```

The alternative, which we will adopt here, is to evaluate island-constraints non-locally, which amounts to making gap-elimination sensitive to island-constraints:

(29) Gap-elimination:

```
          S_main  ==>     Y        S
                               [Y,isl:-]
```

This approach presupposes that if gap-percolation involves crossing an island-boundary, this information is preserved and available at the top-level. Although this process requires a rather delicate interaction between island-feature percolation, and the distribution of gap-features, we think it has the advantage, that leftward movement (WH-sentences, topicalization) can be distinguished from rightward movement (extraposition). This will be illustrated below.

First, however, it will be necessary to say something about the exact rules for <u>isl</u>-percolation. Since UDCs are accounted for by means of a feature, rather than by means of (a chain of) traces, we have to reformulate what it means to cross an island-boundary. In (30), we certainly do not want that the island character of PPs blocks the extraction of an NP out of VP:

```
(30)          put      ∅          on   the  table
              VP/PP                     PP
              [NP]                      [isl]
              _________________________________F
                           VP
                          [NP]
```

This suggests that isl should be treated as a head-feature, that is, as a feature which percolates from functor to value. The general picture is different, however. In case a gap is located in an argument ((31)), or in case composition, rather than application is used ((32)), island-constraints of both functor and argument should be respected.

```
(31) a.       put          the book   on         ∅
              (VP/PP)/NP     NP       PP
              __________________RA   [NP, isl]
                    VP/PP
                    _________________________________RA
                           VP
                       [NP,isl]

     b.       the fact     that  Bill    loves  ∅
              ________     ___________________
              NP/S               S
              [isl]             [NP]
              __________________________
                      NP
                  [NP,isl]

(32) a.       the fact   that Bill loves    (Mary)
              ________   _______________
              NP/S             S/NP
              [isl]
              _____________________RC
                      NP/NP
                      [isl]

     b.       deny  the fact (that... )
              FVP/NP  NP/S
                      [isl]
              _____________RC
                  FVP/S
                  [isl]
```

Thus, we arrive at the conclusion that isl should always be considered a foot-feature in case of composition, and also in case of application with a gap located in the argument-category. This can be expressed as an extension of the general rules for application and composition again, which can simply be expressed as:

```
(33)   ┌value    : [ isl : <1> ] ┐
       │functor  : [ isl : <1> ] │
       └argument : [ isl : <1> ] ┘
```

Only in case application is used, and no gap is present in the argument, will the following constraint suffice:

(34) [value : [isl : <1>]
     functor : [isl : <1>]]

Notice that we are able to treat <u>isl</u> as a foot feature, without using disjunction (as was the case for <u>gap</u>). This is so because the default option for <u>isl</u> is to be unspecified, rather than to be <u>nil</u>.

The most important innovation, as compared to most other theories of bounding, is that we are now able to formulate rules for rightward-extraction, which are not subject to island-conditions. For extraposition of relatives, for instance, the following rule can be formulated:

(35) Extraposition (E) : S --> S R
                                [R]

Since (35) does not refer to <u>isl</u>, we predict that relatives can be extraposed out of island-domains. An example of such an extraposition is (36):

```
(36)  dat ik over een nijlpaard  ∅  droomde, dat kon praten
      that I about a  hippo         dreamed which could talk
          PP/NP  ____________           __________________
          [isl]    NP/R                         R
                   [isl]
                 _________ICI
                    NP
                  [R,isl]
           _______________RA
   .......          PP              ........
                  [R,isl]
      _____________________________________
                    S
                  [R,isl]
                _____________________________________________E
                                  S
```

In (36), at least one, and probably two (depending on the exact formulation of the (Complex)-NP-Constraint that is adopted) island-constraints have been violated. Nevertheless (36) is perfectly grammatical. The approach opted for here is able to account for such phenomena, without banning them into some stylistic component. It should be noted as well, that any theory which evaluates island-constraints locally (as is the case in the compositional analysis of UDCs) will have serious problems with sentences as (36).

The second main advantage of combining categorial techniques with a unificational account of UDCs, is that a wide range of facts concerning the interaction of UDCs and coordination is accounted for.

First, it should be noticed that all the positive points of the D&C and Dowty (1985) analysis are preserved. That is, since the grammar contains raising and composition, all the normal cases of RNR and NCC are derivable as in the D&C approach. Furthermore, the ATB-facts are predicted. This is so because coordination is accounted for by means of a schematic PS-rule, which requires unifiability of the conjuncts. Thus, (37a) will be an admitted instance of rule C, but (37b) is not. (It should be noted that the default option for gap is nil.)

(37) a. X --> X Conj X
[Y] [Y] [Y]

b. X --> X Conj X
[Y] [Y]

The fact that coordination is accounted for by means of a PS-rule, rather than by means of a functor-category (for instance (X\X)/X), also predicts such instances of the Coordinate Constraint as (38a), where one of the conjuncts has undergone RNR, or (38b), where extraction would have applied to one of the conjuncts as a whole.

(38) a. *Bill gave Mary a record and, and Peter gave her a book and, a bunch of flowers

b. *The Pre-Raphaelites, we found and books about. (Sag, 1982:332)

Since the special form of rule C prevents either composition or ICI from applying to it, none of these sentences will be derivable.

A clear difference with the D&C/Dowty approach is that island-constraints no longer constrain the applicability of RNR (since the latter involves composition only).

Thus, the grammaticality of (17a,b) and (18) is predicted.

(17) a. Mary knows a man who buys, and Bill knows a man who sells, pictures of Fred.

(18) I have been wondering whether, but wouldn't want positively to state that, your theory is correct.

Finally, we are also able to account for a somewhat different interaction of RNR and island-constraints, which is illustrated in (39).

```
(39) *Who does Mary buy,
     and Bill know a man who sells,  pictures of ∅

          ___________  ______  _________    _______________
          S/NP         NP/R    R/NP          NP
                       [isl]                [NP]
          _________________RC
           S/R
          [isl]
          ______________________________RC
                  S/NP
                  [isl]
```

That is, if one of both conjuncts of a RNR construction is an island, the use of composition will preserve this information. (Notice that coordination of an island with a non-island conjunct is possible, since the default for isl is to be unspecified.) In Wexler & Culicover (1980), it is observed that this state of affairs is rather embarrasing for any theory which treats UDCs and RNR by means of the same mechanisms.

To summarize this section: we have extended the unificational analysis of UDCs with a mechanim accounting for island-constraints. Thus, leftward- and rightward-extractions could be distinguished. Furthermore, exactly the right predictions are made with respect to the interaction of UDCs, island-constraints and coordination.

Notes

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1. They are defined as:

RA :	X/Y	Y	==>	X
RC :	X/Y	Y$/Z	==>	X$/Z

In A&S and D&C these rules are called 'Forward Combination' and 'Forward Partial Combination', respectively. For Dutch and certain cases of Right Node Raising, Leftward Application (LA) -or 'Backward Combination'- and Leftward Composition (LC) -or 'Backward Partial Combination'- is needed as well:

LA :	Y	X/Y	==>	X
LC :	Y$/Z	X/Y	==>	X$/Z

Notice that the slash is to be read non-directional here. In the discussion of Steedman (1987), and in sections 2 and 3, a directional notation is used, where X/Y is a right-directional functor cancelling to X, and Y\X is a left-directional functor cancelling to X.

2. Terminology taken from transformational grammar, is used for reasons of convenience only, and does not express any theoretical commitments. The same holds for the use of empty elements ($\emptyset$), i.e. they play no role in the theory discussed here, nor in that proposed in section 2.

3. The indices <u>io</u> and <u>o</u> stand for 'indirect object' and 'direct object'. They have only been added to make the intended interpretation explicit.

4. Note that this has consequences for the D&C treatment of verb comlexes in Dutch as well. That is, the fact that NPs can be extracted from VPs containing a verb complex, means that the system cannot prevent NPs from 'scrambling' inside the VP. Thus, the prediction that only the correct, crossing dependency, word orders are generated, is in danger.

5. It is not the only argument, however. The GPSG-account of Topicalization in German, for instance, as presented in Nerbonne (1986) and Johnson (1986) also suggests the kind of flexibility which is natural in Categorial Grammar.

6. Note also that the situation described above is in some sense similar to that in early transformational grammar, where both UDCs and RNR were considered to be transformational processes. That there are essential differences between both phenomena, however, has been demonstrated in, for instance, Williams (1978), Wexler & Culicover (1980) and Levine (1985).

7. For an introduction to and overview of unification formalisms, see Shieber (1986).

8. In fact, we strongly suspect that restricting CR to apply only once to a given category (this will prevent the parser from looping) suffices to account for all instances of RNR and NCC.

9. The fact that we look at UDCs from a bottom up perspective, does not imply that an actual parsing algoritm would have to use the same strategy.

10. Henk Zeevat pointed out that the Gap-threading mechanism introduced by Pereira, and described in Karttunen (1985), would do without disjunction. The reason for not adopting this mechanism is that it doesn't allow for the non-local evaluation of island-constraints, described in the last section.

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A THEORY OF DISTRIBUTIVITY

Jae-Woong Choe
SoongSil University
Department of English
Sangdo-dong 1-1, Dongjak-ku
Seoul, Korea

ABSTRACT:

This paper deals with distributivity (or quantifier scope interactions) in English, and proposes a theory of distributivity. The theory is based on morphological patterns of each phrases, but it intends to present a coherent view of distributivity in general.

0. Introduction

In this paper,[1] I propose a particular view of distributivity in English evidenced by the following pair of sentences:

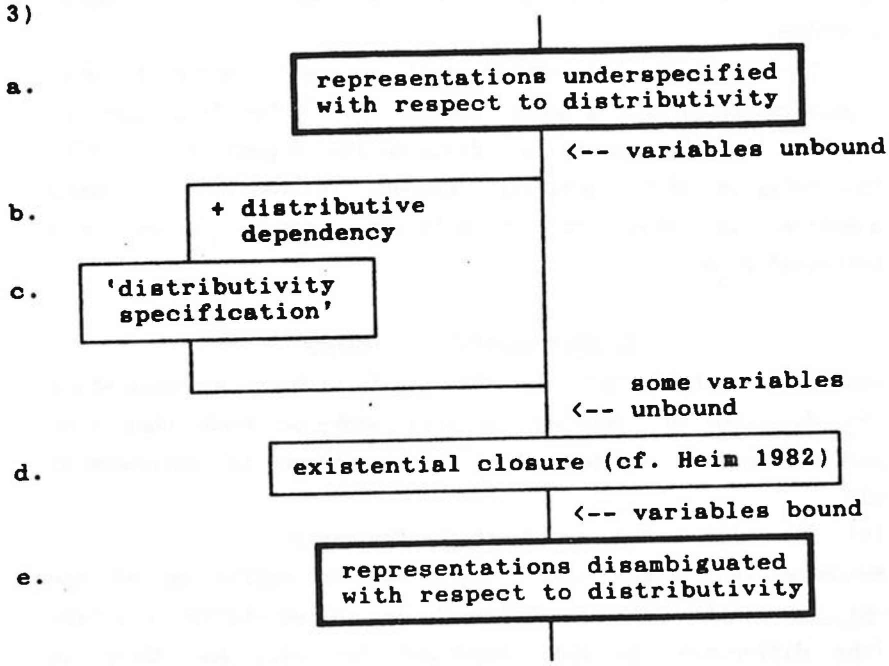
(1) Each child bought a balloon.
(2) The children bought a balloon each.

Both sentences mean that there is a certain number of x's such that for every x, if x is a child, x has a balloon. I assume that the distributive reading comes as a result of certain dependency between each child or the children and a balloon (each).

Here is an outline of the analysis I will be proposing in this paper: First, I take a relational view of distributivity. It is relational in the sense that distributivity is claimed to be a relation defined on two arguments that are accessible[2] to each other. Second, I will adopt a view according to which the logical forms that are fully specified with respect to distributivity are derived step by step, taking as input 'underspecified' representations and producing as output representations disambiguated with respect to distributivity.[3] In other words, I first factor out the distributive meaning from other aspects of the meaning of the sentence and then combine them together at a later stage of the derivation in a systematic way. The combining process, it is claimed, is an introduction of quantifier sets to representations with unbound variables.

The underspecified representations, the input, can be taken as a result of compositional semantics, and the output, the combined meaning of distributivity and other aspects of the meaning will turn out to be logical forms of the standard sort. The following diagram shows the framework I am assuming for distributivity: (next page)

(3)



There are three points I would like to emphasize with respect to the model of the grammar given in (3). First, I start with representations underspecified with respect to distributivity (3a), and eventually obtain disambiguated representations (3e). It essentially means that we have as input representations with free variables, and the output of the process will be representations with all the variables bound. So the whole derivation could be understood as variable binding, specifying, or disambiguating process.

Second, there are two sub-processes in the model. One is existential closure in (3d). What is done there is to introduce existential quantifier for all the variables left unbound up to that point (cf. Heim 1982). The other process is 'distributivity specification' in (3c). It essentially means that we introduce a quantifier set, and the details of this process will be shown later. It is less general than the existential closure in that it is sensitive to the presence or absence of the distributive dependency projected.

Thirdly, I factor out distributivity from other aspects of the structure or meaning of the sentence, but I provide a way in which it rejoins to the representation it came from, thereby yielding a more standard sort of logical formulae.

The rest of this paper will basically concern two subtopics raised in the grammar model (3). The first question is what is the nature of distributive dependency in (3b) that triggers the translation process in (3c). The second question is what the translation process is--a more technical side.

1. Distributive Dependency

What is distributivity? I will start with a sentence where the distributive reading is very weak--so weak that some native speakers do not think the sentence is ambiguous at all.

(4) The children made a red hat for the party.

Sentence (4) means that there is an entity called <u>the children</u> (or 'a set of children' as in set-theoretic terms--the difference is not important to us.) and there is another entity called <u>a red hat</u> such that the former has a certain relation <u>made</u> to the latter. But there is another relation possible between <u>the children</u> and <u>a red hat</u> in (4). It is a number dependency between them. It is this number dependency that I call distributivity or distributive dependency. The preferred reading of (4) is, of course, the one where there is a single red hat such that it was made by a group of children. But (4) also has the reading where each of the children made a red hat. The second reading becomes clearer, or even required according to the discourse, in the following example:

(5) (Everybody made a hat for the party.)
The children made a red hat.

Then what is the nature of the number dependency? The number dependency shows up in the numeric interpretation of <u>a red hat</u>. In the above we have taken the number dependency as 'a red hat per child.' But it is not the only one we can think of. There are many other possibilities:

(6) a. a red hat per child
b. two red hats per child
c. three red hats per child
d. two or three hats per child
e. a red hat per group of two or three children
....

But notice that the only number dependency we get from (4) and (5) is (6a). One way to test this is to provide a context so that the other readings may sound more likely:

(7) The kids in groups of two or three bought a hat each.

Even with an explicit phrase in groups of two or three that may make the reading of a hat per group of two or three kids more likely, it is the reading of a hat per kid that we get in (7).

The lexical content of the verb may affect the likelihood of distributive dependency between the two NP's, but verbs themselves do not regulate the relation. For example, the choice of verb between made and wore may affect whether it is likely that there is a number dependency between the children and a red hat, but it does not affect the nature of the dependency itself. In other words, it is not the case that if the verb were made, the number dependency would be (6b) and if the verb were wore, it would be (6e). Whichever verb we may choose, once we decide that there should be a number dependency, the nature of the dependency remains the same, that is, (6a). I will call the children 'Sorting Key' (=SrtKy) and a red hat 'Distributed Share' (=DstrShr) in (5).[4] The nature of distributive dependency between SrtKy and DstrShr, once the dependency is projected, is systematic and thus predictable. The distributive dependency is not altered by what type of NP the SrtKy is, either. Suppose we substitute an (overt) quantifier every child for the plural the children in (5).

(8) Every child made a red hat.

Again, the lexical property of SrtKy affects the projectability of distributive dependency between every child and a red hat, but the nature of the dependency, namely, a red hat per child is not affected. Incidentally, the distributive reading, which is strong in (8), is a lot less so in the following sentence, where the VP is replaced by different lexical items, but where the structure remains essentially the same.

(9) Every child saw an airplane in the sky.

It is not difficult to find similar sentences where the distributive reading is less likely.

(10) a. Every child gathered at a museum.
b. Everybody wants a president who knows his job.
c. Every senator voted for a bill that banned any research on Star Wars.

(10a) is interesting in that gathered is a 'group denoting verb', and had the distributive reading with every child been obligatory, the sentence would be unacceptable. The projectability of distributive dependency can be influenced by the contents of the lexical items concerned, but the nature of the dependency is not affected.

Furthermore, natural languages have systematic ways to represent the distributive dependency. One way of making the dependency obligatory is to mark SrtKy morphologically.

(11) Each child made a red hat at the contest.

It is virtually impossible not to project a distributive dependency in (11), and the reading we get is a red hat per child. Another way is to designate the DstrShr morphologically.

(12) The children made a red hat each.

In Choe (1987), I call a red hat each an anti-quantifier, and show that anti-quantifiers are found in other languages as well. The function of the anti-quantificational particles like each in (12) is to mark DstrShr for distributive dependency just as the function of -self in English is to mark an anaphor for anaphoric dependency.

Among the many factors that may influence the distributivity or the quantifier scope interactions, I take the role of the 'distributive morphemes' as the central one. Other theories usually take the sentence structure, that is, c-command relation as the basis for treating distributivity (cf. Link 1985, Roberts 1987, May 1977, Hornstein 1984, etc.). But the following contrast between anaphora and distributivity indicates that the influence of c-command relation to distributivity dependency is less apparent than in anaphora.

(13) a. *Himself$_i$ was recommended for the job by John$_i$.
b. One interpreter each was assigned to the visiting diplomats. (Burzio 1981/1986; Chomsky 1981)

Furthermore, as far as I can see, the c-command based theories of distributivity cannot handle the distributivity morphemes in a systematic way. For example, we need a stipulatory condition to block the 'group' reading of the visiting diplomats in (13b). The same is true for the phrases with determiner each.

Now, the following sentences involve the same distributive dependency, namely, a red hat per child as I have discussed in the above:

(14) a. Each child made a red hat.
b. Every child made a red hat.
c. The children made a red hat.
d. They (=the children) made a red hat.
e. The children made a red hat each.
f. They (=the children) made a red hat each.

In my analysis, I treat the many cases of distributivity in (14) as the same; it is the result of a single set of principles. Furthermore, my analysis predicts the distinction between (14a, e, and f) and (14b, c, and d) with respect to distributivity. Why is it that the sentences in the latter group are ambiguous, or potentially ambiguous, while the other sentences are not? The difference is attributed to the optionality of distributivity unless it is morphologically marked. In (14a, e, and f) where I have underlined the expressions that trigger distributivity, the distributive dependency is obligatory, so the sentences do not allow the group reading. On the other hand, in (14b, c, and d), the distributive dependency remains as an option, and thus the ambiguity.

There are two predictions made by the above claim. First, if there is no appropriate SrtKy in the given domain, a sentence with an anti-quantifier would not be acceptable. Distributive dependency is based on, and thus requires, both DstrShr and SrtKy. The following sentences with s-each are indeed unacceptable; the possible SrtKy's in each example, namely, John in (15), somebody in (16), and the visitor in (17), do not meet the conditions set for the SrtKy.

(15) * John hates a person each.
(16) * Somebody hates a person each.
(17) * Two interpreters each were assigned to the visitor.

Second, if there IS an appropriate SrtKy in the given domain, the sentence would not only be acceptable, but allow only the distributive reading since the distributive interpretation is obligatory. The following sentences are not ambiguous, as expected.

(18) Everybody saw a plane each.
(19) Two interpreters each are assigned to
     the five visitors.
(20) The children made a book each.
(21) Jane and Bill bought a book each.

We also noted that in English the following contrast is predicted, though with the possibility of some dialectal variations:

(22) a. ?? Each child left.
     b. Each child bought a balloon.

In (22), we have a morphologically marked SrtKy, which requires a distributive dependency based on it. The difference between (22a) and (22b) is whether there is an appropriate DstrShr or not.

2. 'Distributivity Specification'

What is the semantics of "distributive dependency"? Stated informally, the speaker is adding an extra 'meaning' when he projects a distributive dependency. In this subsection, I will provide a systematic way to implement this idea, and then in the following subsection, it will be shown how the (quasi) logical forms can be converted into the more standard logical forms.

2.1. The relation 'Dstr'

Let us take some concrete examples to show how the addition of extra meaning could be achieved.

(23) Two examiners marked six scripts.

I will start with the assumption that (23) has three readings, or three kinds of readings.

(24) i. A group of two examiners marked a group of six scripts.
(two examiners and six scripts)
ii. Each of the two examiners marked a group of six scripts.
(two examiners and a maximum of 12 scripts)
iii. Each of the six scripts was marked by a group of two examiners.
(six scripts and a maximum of 12 examiners)

Under our analysis, there are three possibilities with respect to distributive dependency. The first is where the speaker did not project any of the (optional) distributive dependency. Then there will be no "added meaning" as far as distributivity is concerned.

(25) M (E^2, S^6) where M denotes an action 'marked'
E^2 is a variable for the plural individual 'two examiners'
S^6 is a variable for plural individual 'six scripts'

(25) is underspecified since it contains unbound variables, and, thus, is not a well-formed logical form. It is not interpretable yet. Let us for the moment assume that the unbound variables will eventually be bound by appropriate existential quantifiers. Then, (25) can informally be stated as this: a plural individual $\underline{E}^2$ is in an $\underline{M}$ relation to another (plural) individual $\underline{S}^6$--the group reading in (24i).

In order to capture the idea of distributive dependency, I will tentatively introduce a formula of the following kind:

(26) Dstr (A, B)

(26) represents the reading of "the i-parts of the denotation of <u>A</u> distribute over the denotation of <u>B</u>." Later I will show how (26) should be interpreted, but in the meantime, I will make use of the formula in (26) as a way to capture our intuitive idea about distributivity meaning. Now we have a systematic way of representing other interpretations of (23). One reading of (23) is the wide scope reading of <u>two examiners</u>. For this, a distributive dependency is set up between <u>two examiners</u> and <u>six scripts</u>. During the translation process, when we find a distributive dependency, let us assume that we simply

'add' distributivity meaning to the (underspecified) logical form.

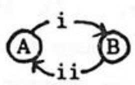
(27) M (E^3, S^6) & Dstr (E^3, S^6)

In (27), <u>Dstr (E^3, S^6)</u> represents the distributive dependency with <u>E^3</u> and <u>S^6</u> as SrtKy and DstrShr, respectively. It is simply a way to capture the idea that "when there is a distributive dependency projected, add the distributivity meaning to the existing representation." Since both arguments in (23) meet the condition for SrtKy and DstrShr, either can function as SrtKy and DstrShr. Thus, there is another distributive dependency we can project for (23):

(28) M (E^3, S^6) & Dstr (S^6, E^3)

So far we have created three quasi logical forms, and they match the three readings listed in (24).

There is, however, a fourth logical form that is initially allowed under our current analysis. To see how it is possible, let us consider how many forms are mathematically possible out of two arguments:

(29) 

There are two possible relations, <u>i</u> and <u>ii</u>, in (26), so there are three mathematically possible combinations of the two relations: taking either <u>i</u> or <u>ii</u> alone and taking both. Therefore, including the case where we do not take either, there are four logical forms we can derive from (29):

(30) a. R (A, B)
b. R (A, B) & Dstr (A, B)
c. R (A, B) & Dstr (B, A)
d. R (A, B) & Dstr (A, B) & Dstr (B, A)

Are the logical forms in (30) all well-formed? The answer partly lies in the nature of the relation "Dstr." "Dstr" is an asymmetric relation.[5] If "Dstr" is asymmetric, according to the definition, (30d) is not well-formed. Therefore, the fourth possible combination is blocked by virtue of the nature of the relation "Dstr."

2.2. Interpretation of 'Dstr'

In the previous subsection, I have concluded that there are three well-formed (actually, not quite yet) representations for (23) under our analysis. I will recapitulate them.

(31) a. $M(E^2, S^6)$
b. $M(E^2, S^6)$ & $Dstr(E^2, S^6)$
c. $M(E^2, S^6)$ & $Dstr(S^6, E^2)$

Although the relation "Dstr" seems to be a way to capture the idea of "adding a distributivity interpretation," I still have not shown how the added meaning of distributivity should be interpreted with respect to the real world. What are the truth values of "Dstr"? In this subsection, I provide an answer to this question. Essentially, I define the loose statement "adding a distributivity meaning" as "binding the unbound quantifiers by introducing quantifier sets."

How do we implement the intuitive idea of "adding a distributivity meaning to the underspecified forms."? I regard it as introducing a set of quantifiers that will roughly match the idea that "i-parts of <u>A</u> distribute over <u>B</u>," as is given in (32):

(32) $\forall_{a*A}\, a\, \exists\, B$ $\quad$ <u>a*A</u> := <u>a</u> is an atomic i-part of <u>A</u>

Now, given a representation with unbound variables in it,

(33) $M(E^2, S^6)$

to add a meaning <u>Dstr (E^2, S^6)</u> to (33) is to introduce a group of quantifiers for the unbound variables:

(34) $\forall_{e*E2}\, e\, \exists\, S^6\ (M(e, S^6))$

I have also replaced the variable <u>E^2</u> with its i-part variable <u>e</u>. When we do the same conversion for (31c), we will have the following three logical forms that match the three forms in (31).

(35) a. $M(E^2, S^6)$
b. $\forall_{e*E2}\, e\, \exists S^6\ (M(e, S^6))$
c. $\forall_{s*S6}\, s\, \exists E^2\ (M(E^2, s))$

How about the still unbound variables? They are <u>E^2</u> and <u>S^6</u> in (35a), <u>E^2</u> in (35b), and <u>S^6</u> in (35c). We have a rule that is independently motivated elsewhere, which will handle all the remaining unbound variables. Here, I will adopt Heim's (1982) idea of existential closure or the similar concept in her file-change semantics. According to Heim, there is a pragmatic reason why we should introduce existential quantifiers for the unbound variables.

When we introduce existential quantifiers for the still unbound variables in (35), the finally well-formed, fully specified logical forms will be:

(36) a. $\exists E^2 \exists S^6 \; (M\,(E^2, S^6))$

b. $\exists E^2 \; \forall_{e \leq E^2} e \; \exists S^6 \; (M\,(e, S^6))$

c. $\exists S^6 \; \forall_{s \leq S^6} s \; \exists E^2 \; (M\,(E^2, s))$

The translation process can be informally stated as follows:

(37) If a distributive dependency from A to B is projected (cf. Dstr (A, B)),

i) Introduce a universal quantifier for a, where a is an i-part of A, and replace the variable A with a in the given representation.

ii) Introduce an existential quantifier for B to the right-hand side of the universal quantifier.

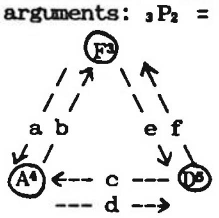
2.3. A more complex case

Can the mechanics of my analysis also work for more complicated cases? In this section, I will show that we can maintain the same mechanics even for a complicated situation, with some minor revisions. Consider the following sentence (Kempson & Cormack 1981):

(38) Three fanatics have submitted four articles on the race issue to five dailies.[6]

Since there are three arguments available for distributive dependency, either as a SrtKy or as a DstrShr, the following diagram will present all the possible six relations a - f that are projectable on the basis of the three arguments: $_3P_2 = 6$.

(39)



There are, in principle, 64 mathematically possible combinations from the six relations in (39):

$$\sum_{i=0}^{6} {}_6C_i = 64.$$

Are there really 64 readings for a single sentence in (38)? Although we are not sure, it seems hardly likely that a native speaker of English would get from the sentence as many as 64 readings. There indeed is a reason to believe that the number of logical forms could be drastically reduced to a small set. There are factors that may constrain their proliferation. We have already mentioned one such constraint—"Dstr" is asymmetric.

"Dstr" has another important property, which I will call "reversely unique." I will first motivate this property and then give a formal definition. In projecting distributive dependency on argument structure, we do not want a single argument to be defined more than once with respect to distributivity. Suppose there are three arguments A, B, and C. We would not project Dstr (A, B) and Dstr (C, B) simultaneously since, once the numeric interpretation of B is obtained and specified by the first relation, conflicting interpretation would result if we force another numeric interpretation to be defined on the same argument by the second relation. Stated in formal terms, the property "reversely unique" can be defined as follows:[7]

(40) Definition: (Given a set A and a relation R in A,)
If $R \subseteq A \times A$, R is reversely unique iff

$$\forall_{x,y} \; [\; xRy \rightarrow \neg\exists z \; [\; z \neq x \wedge zRy \;]]$$

Now, let us go back to the issue of the number of logical forms available for (38). The two combined properties[8] of "Dstr" reduce the number of logical forms from 64 to 16[9]— to less than a third of the original numbers. I will show how that is possible in the following discussion.

First, when there is no distributive dependency projected in (38), as was done before, we will get a logical form of the following kind (cf. ${}_6C_0 = 1$): (I have deleted irrelevant things from the representation.)

(41) S (F^3, A^4, D^5) : 3 fanatics, 4 articles, 5 dailies

Secondly, when there is one dependency projected, there are six possibilities (cf. ${}_6C_1 = 6$). In the following, I enumerate the six possibilities and their numeric interpretation. The reason I have added the numeric interpretation is to show that the logical forms are different from each other in terms of their truth values. In order to make the comparison clear, I am ignoring the underspecified input <u>submit' (F^3, A^4, D^5)</u> for the moment. For example, <u>{(F^3, A^4)}</u> can be understood as representing <u>submit' (F^3, A^4, D^5) & Dstr (F^3, A^4)</u> in the following. ($\geq$ means "a maximum of".)

(42) a. {(F^3, A^4)} : 3 fanatics, $\geq$12 articles, 5 dailies
b. {(A^4, F^3)} : $\geq$12 fanatics, 4 articles, 5 dailies
c. {(D^5, A^4)} : 3 fanatics, $\geq$20 articles, 5 dailies
d. {(A^4, D^5)} : 3 fanatics, 4 articles, $\geq$20 dailies
e. {(D^5, F^3)} : $\geq$15 fanatics, 4 articles, 5 dailies
f. {(F^3, D^5)} : 3 fanatics, 4 articles, $\geq$15 dailies

So far, nothing blocks the logical forms--we now have seven well-formed forms.

Next, consider a case where the speaker project two distributive dependencies on (38). We would have 15 possible combinations (cf. ${}_6C_2 = 15$).

(43)
a. * {(F^3, A^4), (A^4, F^3)}
b. * {(F^3, A^4), (D^5, A^4)}
c. {(F^3, A^4), (A^4, D^5)} :
3 fanatics, $\geq$12 articles, $\geq$60 dailies
d. {(F^3, A^4), (F^3, D^5)} :
3 fanatics, $\geq$12 articles, $\geq$15 dailies
e. {(F^3, A^4), (D^5, F^3)} :
$\geq$15 fanatics, $\geq$60 articles, 5 dailies
f. {(D^5, A^4), (A^4, F^3)} :
$\geq$60 fanatics, $\geq$20 articles, 5 dailies
g. {(A^4, F^3), (A^4, D^5)} :
$\geq$12 fanatics, 4 articles, $\geq$20 dailies
h. {(A^4, F^3), (F^3, D^5)} :
$\geq$12 fanatics, 4 articles, $\geq$60 dailies
i. * {(A^4, F^3), (D^5, F^3)}
j. * {(D^5, A^4), (A^4, D^5)}
k. {(F^3, D^5), (D^5, A^4)} :
3 fanatics, $\geq$60 articles, $\geq$15 dailies
l. {(D^5, A^4), (D^5, F^3)} :
$\geq$15 fanatics, $\geq$20 articles, 5 dailies
m. * {(A^4, D^5), (F^3, D^5)}
n. {(A^4, D^5), (D^5, F^3)} :
$\geq$60 fanatics, 4 articles, $\geq$20 dailies
o. * {(F^3, D^5), (D^5, F^3)}

Out of 15 possibilities, only nine are well-formed: in (43), a., j., and o. are ill-formed because "Dstr" is asymmetric; b., i., and m., are also ill-formed because "Dstr" is "reversely unique."

Finally, when the speaker projects more than two distributive dependencies on (38), all the remaining 42 logical forms will turn out to be ill-formed. Forty of them are ill-formed by virtue of the asymmetric nature of "Dstr." The other two, that are listed below, should also be blocked

(44) a. * $\{(F^3, A^4), (A^4, D^5), (D^5, F^3)\}$
b. * $\{(A^4, F^3), (F^3, D^5), (D^5, A^4)\}$

since we do not want to allow some relations to form a complete chain among them as in (44). If we allow such a chain, there is no way to stop the computation of numeric interpretation for the arguments involved. Suppose we have allowed a distributive dependency like (44a). If we starts with three fanatics, there will be 14 articles, and there will be 60 dailies, and there will be 120 fanatics, and 480 articles, and so on and so forth. This property of 'Dstr' subsumes asymmetry since asymmetry can be understood as a complete chain between two arguments. I will call this property of "Dstr" strongly asymmetric, and the following definition will serve our purpose:

(45) Definition: (Given a set A and a relation R in A,)
If $R \subseteq A \times A$, R is strongly asymmetric iff
for no x there is a chain R such that
$R^b = x$ and $R^e = x$ where
i) R-chain is a chain $x_1 R x_2$, $x_2 R x_3$, ..., $x_{n-1} R x_n$
and
ii) $R^b = x_1$ and $R^e = x_n$.

So far we have specified two properties of the relation "Dstr," which, in combination, reduce the number of well-formed logical forms for (38) to 16. Then, how many more other properties, one might ask, are there for a yet more complicated situation? As far as I can see, we need only two, not any more, even for a yet more complicated situation. There is another question a native speaker might ask: "O.K., it is good that you could reduce the number of well-formed logical forms (readings) from 64 to 16, but I still feel uncomfortable with your conclusion that the given sentence should have that many readings." This kind of doubt is understandable when we consider the fact that people in general get one or two readings, maybe a couple more when pushed further, out of the given sentence. But notice that no two out of the sixteen logical forms I have provided in the above have the same truth values. Notice also that there are yet other (secondary) factors that influence the distributive dependency, namely, grammatical functions, structural prominence, word order, and others. These factors may conspire to determine some most probable distributive dependencies. Furthermore, distributive dependency is optional unless it is morphologically specified. If there is no distributive dependency projected, then the result would be the group reading, the most easily available one unless specified otherwise, namely, the default reading. The fewer distributive dependencies are projected, the fewer logical forms there would be. Not all the sixteen logical forms have equal chance for life in our system.

How about their translation into the standard logical forms? Can the translation process we set up before on the basis of the simple cases handle the more complicated representations? My answer is "yes, with one minor revision." When we project only one distributive dependency (recall that there are six of them), it is just the same procedure as for the cases we have done before. That is, we simply introduce a set of quantifiers to the underspecified logical forms.

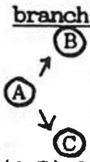
When there is more than one distributive dependency projected, the conversion becomes a bit complicated. Essentially, there seems to be two types that two relations can be related to each other, however many dependencies there might be. One is chain type and the other branching type:

(46) a. <u>chain type</u>

Ⓐ->Ⓑ->Ⓒ

{Dstr (A,B) & Dstr (B,C)}

b. <u>branching type</u>



{Dstr (A,B) & Dstr (A,C)}

We will see how each of the two types can be converted step by step into appropriate forms. Suppose we are converting distributive dependency in (46a) to corresponding quantifier sets. First, we convert Dstr (A, B).

(47) a. $\underset{a \Pi A}{\forall a}$: (37i)

b. $\underset{a \Pi A}{\forall a}\ B$: (37ii)

Next step is to convert Dstr (B, C). We concatenate this to the quantifier set in (47b).

(48) a. $\underset{a \Pi A}{\forall a}\, \exists B \quad \underset{b \Pi B}{\forall b}$: (37i)

b. $\underset{a \Pi A}{\forall a}\, \exists B \quad \underset{b \Pi B}{\forall b}\, \exists C$: (37ii)

(48b) is the right logical form for the distributive dependency in (46a).

What happens if we reverse the order of application, starting with Dstr (B, C) instead of Dstr (A, B)? If we follow the steps specified in (37), we will have the following quantifier set.

(49) $\underset{b \Pi B}{\forall b}\, \exists C \quad \underset{a \Pi A}{\forall a}\, \exists B$

But (49) is not well-formed anyway since the variable B is outside the scope of its quantifier ∃ B, and does not cause any problem. We just let the algorithm in (37) apply freely, and it produces the right kind of well-formed forms and does not give rise to any ambiguity.

For the conversion process for the branching type dependency in (46b), we need only a minor revision of (37). (37), as it is, will convert {Dstr (A, B) & Dstr (A, C)} to:

(50) $\underset{a \Pi A}{\forall a}\, \exists B \quad \underset{a \Pi A}{\forall a}\, \exists C$

But (50) is not the kind of representation we expect since it does not capture the fact that the two variables A are the same--there is a single SrtKy involved. The variable a is considered in (50) as just two free variables bound to different quantifiers. Thus, we revise (37i) as follows:

(37i)' Introduce a universal quantifier for a, unless there is one introduced already, where a is in i-part relation to A, and replace the argument A with a in the given representation.

With the revised (37i)', its effects would now be null if the same quantifier was introduced already. Therefore, the branching type dependency will result in one of the following logical forms.

(51) a. $\forall_{a \in A}\, a\ \exists B\ \exists C$

b. $\forall_{a \in A}\, a\ \exists C\ \exists B$

Both are well-formed logical forms, and, importantly, they are logically equivalent to each other. Thus, again, the algorithms in (37) do not give rise to any ambiguity.

2.4. "Reversely unique" and "strongly asymmetric"

As a result of our discussion in the previous section, we have reached two logical properties of distributivity relation. In this section, we will briefly consider their theoretical implications.

First, let us consider "reversely unique" property of "Dstr" in (40). (40) can be translated into a constraint on adjacency. It says that if an element x̲ is adjacent to another element y̲ with respect to a relation R̲, there cannot be a third element z̲ that is simultaneously adjacent to y̲ with respect to the relation. If there is, then x̲ is not adjacent to y̲ any more. In other words, a constraint that comes as a result of the property in (40) blocks the situation where more than one elements is simultaneously adjacent to an element.

The same property has an interesting bearing on phrase structure rules. Why is it that we can only have a single constituent on the left-hand side of a phrase structure rule? In other words, why is it that a rule of the form

(52) X + Y --> Z

is not a legitimate one, while another rule

(53) X --> Y + Z

is well-formed? Since a phrase structure rule is a specification on binary relation, it comes as no surprise if the relation has certain properties. On the other hand, it is rather surprising that the property "reversely unique" is perfect for blocking the illegitimate rule like (53).

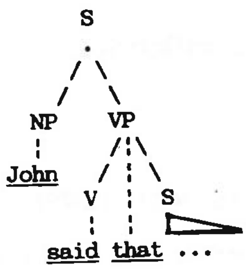
The other property given in (45), "strongly asymmetric," can be understood as a condition on hierarchical relation. (45) brings about a condition on dominance. The condition says that if an element *x* is dominant over another element *y*, *y* cannot simultaneously be dominant over *X*. Consider the following recursive pair of phrase structure rules.

(54) a. S --> NP VP

b. VP --> V *that* S

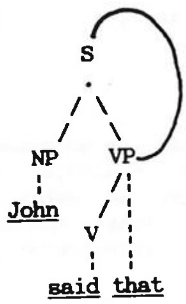
The pair of rules generate the following phrase marker:

(55)



But (54) can also generate the following ill-formed phrase-marker:

(56)



S dominates *VP*, and the latter in turn simultaneously dominates the former. There is nothing that will block this kind of mutual dominance relation in the given pair of phrase structure rules; the two rules are perfectly satisfied in the phrase marker. Subcategorization would not help, either, since nothing is violated here in that regard.

The dominance condition given in the above comes in handy when we want to block the ill-formed structure as in (56), while allowing the well-formed structure as in (55).

NOTES

1. This paper is a shorter version of a chapter of my dissertation Anti-quantifiers and a Theory of Distributivity (=Choe (1987)), and a more detailed discussion of the issues raised in this paper can be found in the dissertation.

This paper was presented at the 6th Amsterdam Colloquium (April 13-16, 1987). I would like to thank the helpful audience at the meeting, especially, Godehard Link, Barbara H. Partee, and Craige Roberts.

2. Roughly, co-arguments are "accessible" to each other.

3. I am departing from the standard compositional semantics.

4. In Choe (1987), I propose two conditions on distributive dependency.

a. SrtKy is semantically plural.
Examples: everybody, the children, they, ...

b. DstrShr is indefinite.
Examples: somebody, a book, three, books, ...

5. According to the definition given in Wall (1972), "if it is never the case for any (x, y) in R that (y, x) $\in$ R, the relation is called asymmetric. (p. 112)" The formal definition is as follows:

Definition: (Given a set A and a relation R in A,)
If $R \subseteq A \times A$, R is asymmetric iff

$$\forall_{x,y}\ ((x, y) \in R \rightarrow (y, x) \notin R)$$

6. Incidentally, Kempson & Cormack cites this as an example that shows the implausibility of "ambiguity analysis" for numeric quantifiers. They argue that "under an ambiguity account, this sentence-string will be at least nineteen ways ambiguous, the majority of the interpretations pairwise logically independent."

7. I am grateful to Fred Landman (personal communication) for his help with formal definition of the two properties of "Dstr"--reversely unique and strongly asymmetric.

8. The first property will later be replaced by another called 'strongly asymmetric.'

9. Kempson & Cormack (1981) claims that there are 19 possible readings for the same sentence. Although I do not know what are the other three readings they get, the difference perhaps has something to do with their sub-classification of the group reading into "complete group interpretation" and "incomplete group interpretation."

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ITERATION AND QUANTIFICATION

Frank van Eynde

Eurotra-Leuven
Katholieke Universiteit Leuven
Maria-Theresiastraat, 21
3000 Leuven
Belgium

Departement Linguistiek
Katholieke Universiteit Leuven
Blijde-Inkomststraat, 21
3000 Leuven
Belgium

Abstract

The analysis of iteration in this paper is part of a comprehensive semantic analysis of temporal expressions in natural language. It is developed in the framework of Eurotra, a project for machine translation of the European Community (1).

The paper has four parts. The first presents a formalism for the representation of time meanings. The second and the third show how this formalism can be used for the representation of sentences with a non-iterative and an iterative meaning respectively. And the fourth deals with the interaction between iteration and quantification.

Part one - A formalism

1.1. aim and scope

The aim of the formalism is to provide a language for the representation and model-theoretic interpretation of temporal expressions in natural language.

Those temporal expressions include the tenses, the auxiliaries with a temporal meaning and the time adverbials.

The set of *time adverbials* comprises

the WHEN-adverbials	yesterday, tomorrow, soon, at two o'clock, in 1975
the boundary adverbials	since 1982, from 2 to 5 till now, until Christmas
the duration adverbials	for an hour, for years in two minutes
the frequency adverbials	always, never, often every morning, each year twice, three times

The tenses and auxiliaries to be dealt with are the grammaticalised *verb forms with a temporal meaning*. They may be either bound morphemes such as the past tense marker (-ED) or separate words such as the future tense marker (will/shall). For English the set of relevant verb forms can be summed up as follows :

```
Verb form  ---->  [+/-Past]
                  (shall/will + inf)optional
                  (have + ED)optional
                  ({be going to + inf})optional
                  ({  be + ING       })
```

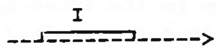
This rule yields 24 (=2x2x2x3) forms and each of those forms has one or more temporal meanings.

The formalism for the representation and interpretation of these temporal expressions consists of a model (1.2.), a syntax and a semantics (1.3.). All of these have been formally defined in Van Eynde, des Tombe and Maes (1985). In this paper I will only give a short and informal presentation of it.

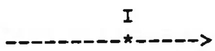
1.2. an interval topology

The model for the interpretation is a set of linearly ordered intervals.

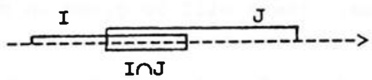
An interval is a continuous set of time points on the time axis :



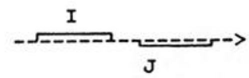
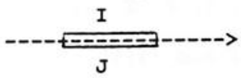
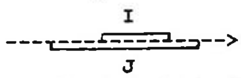
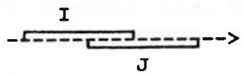
It might also consist of one point of time :



The intersection (∩) of two intervals is the interval which contains all time points which belong to both intervals



Pairs of intervals can be related in any of the following ways

* precedence		I before J J after I	<(I,J) >(J,I)
* identity		I simul J	=(I,J)
* containment		I part-of J J contain I	⊂(I,J) ⊃(J,I)
* overlap		I leftover J J rightover I	<<(I,J) >>(J,I)

It is worth noting that for any ordered pair of intervals, I and J, there is one and only one of these seven relations which can hold between them. For,

either I∩J = 0 ===> <(I,J)
or >(I,J)

or I∩J ≠ 0
and then either I∩J = I and I∩J = J ===> =(I,J)
or I∩J = I and I∩J ≠ J ===> ⊂(I,J)
or I∩J ≠ I and I∩J = J ===> ⊃(I,J)
or I∩J ≠ I and I∩J ≠ J ===> <<(I,J)
or >>(I,J)

1.3. syntax and semantics

For the analysis of temporal expressions I start from the assumption that every sentence can be analysed in two parts : the temporal information on the one hand, and a basic atemporal proposition on the other hand.

(1) the cat sat on the mat

will, for instance, be analysed in a basic proposition "the cat sit on the mat" and the information conveyed by the past tense.

The relation between both is established in two steps ; the basic proposition is first related to the interval for which it is said to be true (I), and then this interval is related to the time of speech (S) :

$\exists$ I [AT(I,the cat sit on the mat) & BEFORE(I,S)]

This formula states that "the cat sit on the mat" is true at an interval I which precedes the time of speech S.

For the systematic derivation and interpretation of formulae like these one needs a specification of both the syntax and the semantics of the formalism. These will be given in parallel in the following seven points.

The expressive power of the formalism is limited to that of first order predicate logic.

(i)
The set of basic expressions includes
- variables for basic propositions : p, q ...
- variables for intervals : I, J, S, R, E ...
- one-place predicates : cf. (iv)
- two-place predicates : cf. (ii) and (iii)

(ii)
There is a two-place predicate AT which takes an interval and a basic proposition to form a proposition : AT(I,p).

Informally, it says that p is true at the interval I.

(iii)
If I and J are symbols for intervals, and Rel is a two-place predicate, then Rel (I,J) is a proposition.

The relations I will work with are the ones defined in 1.2.

(iv)
If I is a symbol for an interval and Pred is a one-place predicate, then Pred (I) is a proposition.

Examples : at two o'clock (R)
for two hours (I)

Intuitively, the predicates denote properties of the intervals to which they are applied. These properties concern either the length of the interval or the location of the interval on the time axis.

Examples : V(for two hours(I))=1 iff the interval I has a length of two hours
V(Christmas(R))=1 iff the interval R is Christmas day

An important distinction in this respect is that between temporal units and temporal designators. Temporal units are nouns like "day", "month", and "year"; temporal designators are nouns like "January", "summer", and "Monday".

The semantic difference between these two is that the instances of the former are immediately adjacent to each other, whereas the instances of the latter are not : a day is immediately preceded and followed by another day, but a summer is not immediately preceded or followed by another summer.

Temporal units are typically used in measure phrases and are especially apt for expressing the length of an interval. Temporal designators, on the other hand, do not occur in measure phrases and are more apt for specifying the location of an interval.

(v)
If p and q are propositions, then p & q is a proposition.

V(p & q)=1 iff V(p)=1 and V(q)=1

If p and q are propositions, then p --> q is a proposition.

V(p --> q)=1 iff V(p)=0 or V(q)=1

(vi)
If I is a symbol for an interval and p is a proposition, then ∃ I [p] is a proposition.

V(∃ I [p])=1 iff there is at least one interval I which satisfies the truth conditions for I mentioned in p.

The universal quantifier (∀) can be defined in a similar way.

(vii)
A temporal representation is well-formed if and only if it can be constructed by means of the given rules.

The technique of the temporal analysis can now be summed up as follows :

1. take the basic proposition (p) and relate it to the interval for which it is said to be true. Technically this is done by the formula AT(I,p).

2. define the position of I on the time line by relating it to the time of speech (S). This is done by means of binary relations between intervals.

3. add any extra information concerning the location and the length of the relevant interval(s) by means of one-place predicates.

   This information can be represented in formulae of the form :

   $\exists$ I,J, ... R,S [AT(I,p) & Rel(I,J) & ... & Rel(R,S) & Pred(I) & Pred(J) & ... & Pred(R) & Pred(S)]

1.4. three temporal systems

Many publications on time meaning make a distinction between an internal and an external temporal system.

The external system is about the temporal relation between the time at which the basic proposition is said to be true and the time at which the utterance takes place. This system refers to the speaker or the writer, and is, therefore, called the deictic system.

The internal system is about such things as whether a state of affairs is described as going on, just started, completed, repeated, etc. This type of information is often called aspectual.

Since this distinction is both useful and familiar, it will be adopted here too. One qualification is in order, though. The information about the repetition of a state of affairs is crucially different from the other aspectual information and will, hence, be treated separately.

Part two - The analysis of sentences with a non-iterative meaning

As for the representation of sentences with a non-iterative meaning the following three principles will be adopted.

(i)
Each representation contains exactly three intervals :
- the time of speech or writing (S)
- the time of event (E)
- one time of reference (R)

(ii)
The deictic part of the time meanings is represented by a binary relation between R and S, and optionally by one predicate over R

(iii)
The aspectual part is represented by a binary relation between E and R, and optionally by one predicate over E

The general format can, hence, be reduced to

∃ R,E [Rel(R,S) & Pred(R) & Rel(E,R) & Pred(E) & AT(E,p)]

where Rel is any of the seven possible relations between intervals
Pred specifies the length or the location of an interval
p is a basic proposition

Apart from the constraints on possible time meaning representations there are some constraints on the relation between the representations and their language specific counterparts.

(iv)
The predicates over R are WHEN-adverbials

(v)
The predicates over E are boundary or duration adverbials

(vi)
The relational information is mainly determined by the verb forms

(vii)
S is never specified linguistically ; it is pragmatically given

It goes without saying that the proposed format embodies a number of assumptions about the proper treatment of temporal deixis and aspect, and some of those assumptions will no doubt be considered controversial, but this is not the place to justify or motivate them. The interested reader is referred to Van Eynde, des Tombe & Maes (1985).

A few examples may be useful as an illustration of the given principles.

(2) we leave at eigth o' clock

∃ R,E [>(R,S) & at eight o'clock(R) & =(E,R) & AT(E,we leave)]

```
                 E
------*------*------>
      S      R
```

In words : there is a time of reference (R) and a time of event (E), such that R follows S, that the location of R is eight o'clock, that E coincides with R and that "we leave" is true at E.

(3) they were singing in the rain

∃ R,E [<(R,S) & ⊃(E,R) & AT(E,they sing in the rain)]

```
        E
--[---*---]---------*------>
      R             S
```

In words : there is a time of reference (R) and a time of event (E), such that R precedes S, that E contains R, and that "they sing in the rain" is true at E.

Part three - The analysis of sentences with an iterative meaning

The format presented above is not adequate for the representation of sentences with an iterative meaning, such as

(4) last year they played chess every week
(5) he was always late

For, the basic propositions "they play chess" and "he be late" do not hold for one particular time of event E, but rather for a set of intervals which are distributed over the time axis in some way specified by "every week" in (4) and "always" in (5).

In the next sections I will introduce an extended format for the analysis of these types of iteration. The first is about the analysis of frequency adverbials like "every week", "yearly" and "each morning". In Quirk e.a. (1985) they are called definite frequency adverbials ; in Stump (1981) they are called fixed frequency adverbials. They have to be distinguished from the socalled indefinite (Quirk e.a. 1985) or variant (Stump 1981) frequency adverbials, like "always", "often", and "sometimes", which are treated in the second section. The third section discusses a special type of iteration, namely habituality, and the fourth deals with the relevance of the given analyses.

3.1. definite frequency adverbials

Definite or fixed frequency adverbials, such as "every week", convey the information that the state of affairs described in the basic proposition is repeated at regular intervals.

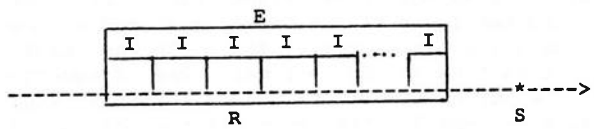
For their semantic analysis I first introduce the notion frame time. The frame time is the interval which contains all the instances of the state of affairs described in the basic proposition. In

(4) last year they played chess every week

the frame time is last year. In the general format the frame time occupies the same place as the time of event in non-iterative interpretations (= the E-interval).

Next, I define a set of distinct, non-overlapping subintervals (I) which are all part of the frame time. In (4), these intervals have a length of one week each. This gives the following (preliminary) representation :

$$\exists\ R,E\ [<(R,S)\ \&\ \text{last year}(R)\ \&\ =(E,R)\ \&$$
$$\forall\ I\ [\subset(I,E)\ \&\ \cap I=0\ \&\ \text{week}(I)\ \text{--->}\ \text{AT}(I,\text{they play chess})]]$$



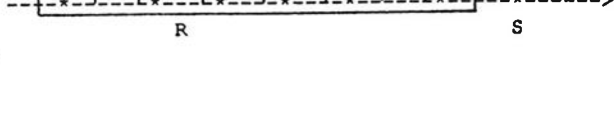
As a representation of (4) this formula is not adequate, though, since the instances of chess playing do not have to take a whole week for (4) to be true. A more adequate paraphrase is to say that every week contained at least one subinterval (e) during which they played chess :

...
$$\forall\ I[\subset(I,E)\ \&\ \cap I=0\ \&\ \text{week}(I)\ \text{--->}$$
$$\exists\ e[\subset(e,I)\ \&\ \text{AT}(e,\ \text{they play chess})]]$$

An argument in favor of this refinement is that languages have special means for specifying the e-times. In

(6) last year she arrived at 8 o'clock every day

the adverbial "at eight o'clock" denotes the location of the e-interval :



Notice that the properties of e are constant within the frame time : the adverbial "at eight o'clock" specifies the time of each of her arrivals of last year.

The general format for the representation of cyclic iteration is, hence, (2)

$$\exists\, R,E\ [Rel(R,S)\ \&\ Pred(R)\ \&\ Rel(E,R)\ \&\ Pred(E)\ \&$$
$$\forall\, I\ [\subset(I,E)\ \&\ \cap I=0\ \&\ P(I)\ \longrightarrow$$
$$\exists\, e\ [\subset(e,I)\ \&\ M(e)\ \longrightarrow\ AT(e,p)]]]$$

where P is replaced by the head of a definite frequency adverbial, specifying the location or the length of I
M is (optionally) replaced by a time adverbial, specifying the location or the length of e

One may wonder at this point whether the format is not too complex. Is it, for instance, really necessary to distinguish two kinds of subintervals (I and e) ? The question is worth asking, for there is at least one analysis of the frequency adverbials which makes use of only one kind of subinterval, namely the one proposed by Stump in "The interpretation of frequency adjectives" [F in his formula stands for a fixed frequency adverbial]

" Fϕ' is true in a world w at an interval i
iff $^{\vee}\phi$' is true in w at non-overlapping subintervals of i
distributed throughout i at periods of a specified length l"

[Stump 1981, 226]

Stump's i-interval corresponds to my frame time (E), but instead of distinguishing two types of subintervals (I and e), he has only one type, namely the subinterval for which the basic proposition is said to be true (= my e-time). The frequency adverbials themselves are not considered to denote a special kind of interval, but rather to specify the length of the period in between two occurrences of the same event :

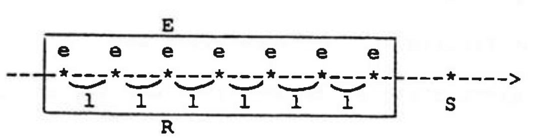
" In the case of a fixed frequency adverb, the value of l is strictly determined by the adverb itself ; for example, "yearly" requires that l be a year's length. "

[ibidem]

Following this proposal the analysis of

(6) last year she arrived at eight o'clock every day

would look like this :



where the frame time is last year
l = a day
e = at eight o'clock

The problem with this analysis is, however, that it does not work for frequency adverbials with a temporal designator as their head, such as "every Monday" and "each morning". Stump's rule predicts that in those cases the length between the e-intervals will be a Monday or a morning, but that is clearly wrong.

It could be replied, of course, that the head of the frequency adverbial in such cases does not denote the length of the intervening periods, but rather the location of the e-intervals, and that the value of l should be computed from pragmatic or lexical information, for instance, from the information that the period between two subsequent Mondays is a week and the period between two subsequent mornings is a day.

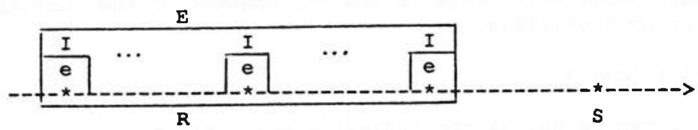
In this way the problems could be solved, indeed, but at the expense of giving up the generality of the relation between form and meaning. In Stump's analysis the definite frequency adverbials would specify either the length of the intervening periods (l) or the location of the subintervals (e), whereas in my analysis they unambiguously specify the properties of the I-intervals. And in Stump's analysis the length of the intervening periods (l) will have to be computed from implicit lexical information in cases like "every Monday", whereas in my analysis it is not necessary to include this information in the semantic representation.

The representation of

(7) last year they played chess every Monday

would, for instance, look as follows :

$$\exists\ R,E\ [<(R,S)\ \&\ \text{last year}(R)\ \&\ =(E,R)\ \&$$
$$\forall\ I\ [\subset(I,E)\ \&\ \cap I=0\ \&\ \text{Monday}(I)\ \text{--->}$$
$$\exists\ e\ [\subset(e,I)\ \&\ \text{AT}(e,\text{they play chess})]]]$$



Another interesting property of the proposed format is its chain-like structure :

e is defined with respect to I : $\subset(e,I)$
I is defined with respect to E : $\subset(I,E)$
E is defined with respect to R : Rel(E,R)
and R is defined with respect to S : Rel(R,S)

As it stands, the format does not provide any means for stating a direct relationship between the intervals inside the frame time (I and e) and the intervals outside the frame time (S and R). As a consequence, the formalism predicts that temporal adverbials which are in the scope of a frequency adverbial (= the e-specifiers) cannot refer back to the speech time or the reference time: * Rel(e,S) and * Rel(e,R).

A good piece of evidence for this hypothesis is provided by the WHEN-adverbials. In general one can distinguish two kinds of those adverbials : the relational ones, which express a relation between the reference time and the speech time, such as "yesterday" and "tomorrow", and the non-relational ones, which identify the location of an interval without any reference to the speech time, such as "between 8 and 9" and "at two o'clock".

The interesting thing now is that only the latter adverbials can occur in the scope of a frequency adverbial. Compare

(8) she arrived every day *between 8 and 9*$_{e}$

*(9) she arrived every day *yesterday*$_{e}$

The fact that the relational WHEN-adverbials cannot occur in the scope of a frequency adverbial provides some positive evidence for not including direct relations between e and S in the formalism. The chain-like structure of the representation format is, hence, linguistically motivated.

3.2. indefinite frequency adverbials

As a starting point for the analysis of the indefinite frequency adverbials I take the general format for the representation of sentences with a definite frequency adverbial :

$$\ldots \forall I\ [\subset(I,E)\ \&\ \cap I=0\ \&\ P(I) \dashrightarrow \exists e\ [\subset(e,I)\ \&\ M(e)\ \&\ AT(e,p)]]$$

For a semantic analysis of the indefinite frequency adverbials this format has to be generalised.

The most important change is the replacement of the universal quantifier by a variable :

$$\ldots\ Q\ I\ [\subset(I,E)\ \ldots$$

where Q can be any of the following quantifiers

$\forall$	always
$\exists$	sometimes
$\neg\exists$	never
Few	seldom, rarely, now and then
Many	often, frequently
Most	usually, mostly, generally

This sixfold division is taken over from Lewis (1975).

Some linguistic evidence for analysing the indefinite frequency adverbials as quantifiers over the I-intervals is provided by the anomaly of the following sentences (3) :

? (10) we *sometimes* played chess *every week*
$\exists$ $\forall$

? (11) they *often* met *every month*
Many $\forall$

? (12) we *always* played chess *every week*
$\forall$ $\forall$

These sentences are semantically anomalous because the same kind of information, namely the value of Q, is specified twice. This leads to inconsistency in (10) and (11) where the Q-variable is said to be both universal and non-universal at the same time, and it leads to pleonasm in (12) where the Q-variable is twice said to be universal. It follows, hence, that both the definite and the indefinite frequency adverbials can be treated as quantifiers over I-intervals.

Another similarity is that they both have to be interpreted with respect to some given frame time ($\subset(I,E)$) : the indefinite frequency adverbial in

(5) he was always late

doesnot denote *all* possible intervals, but all possible intervals *in the past*.

Apart from these similarities, however, there are also a few differences.

The first concerns the status of the I-objects. In the case of the definite frequency adverbials they can be interpreted as intervals, but this is not always possible in the case of the indefinite frequency adverbials. A good example is

(13) quadratic equations are always simple

in which the objects of the quantification are cases, rather than intervals : (13) does not mean that quadratic equations are simple at all intervals, but rather that they are simple in all cases (cf. Lewis 1975).

A second difference concerns the condition that the I-objects may not overlap ($\cap I=0$). This condition is relevant for the interpretation of the definite frequency adverbials, but not for the indefinite ones, as has been demonstrated by Lewis :

> " ... the entities we are quantifying over may be distinct although simultaneous. For instance,
>
> (14) riders on the 13th Avenue seldom find seats
>
> may be true even though for 22 hours out of every 24 - all but the two peak hours when 86% of the daily riders show up - there are plenty of seats for all. "

[Lewis 1975, 4]

The third difference concerns the properties of the I-objects. The definite frequency adverbials always specify either the length or the location of the I-intervals (cf. the P(I) formula), but it is precisely one of the typical properties of the indefinite frequency adverbials that they do not contain an explicit specification of any of these. This has been highlighted in Stump 1981. Compare

(15) during the commercial, the fly occasionally landed on my foot
(16) during their westward migration, the Celts occasionally encountered hostile indigens

" In (15), *occasionally* might be interpreted as having an average period of under 30 seconds, while in (16) it might be interpreted as having an average period of over thirty years. "

[Stump 1981, 221]

This shows that the length of I is not determined by the adverbial itself, but rather by an interplay of various pragmatic factors. It will, consequently, be left out of the semantic representation.

Taking into account the observed similarities and differences between the definite and indefinite frequency adverbials one arrives at the following general format for the representation of the latter :

∃ R,E [Rel(R,S) & Pred(R) & Rel(E,R) & Pred(E) &
Q I [⊂(I,E) --->/&
∃ e [⊂(e,I) & M(e) & AT(e,p)]]]

where Q is replaced by any of {∀, ∃, ¬∃, Most, Few, Many}
M is (optionally) replaced by some time adverbial, specifying the location or the length of e

When applied to

(17) Caesar seldom awoke before dawn

this scheme gives the following result :

∃ R,E [<(R,S) & =(E,R) &
Few I [⊂(I,E) --->
∃ e [⊂(e,I) & before dawn(e) & AT(e, Caesar awake)]]]

In words : there is some given frame time (E) in the past which contains relatively few cases (I) on which "Caesar awake" is true at an interval (e) which precedes dawn.

This representation can be contrasted with the one proposed by Aqvist, Hoepelman & Rohrer in the article "Adverbs of frequency":

Seldom-When (λ x[x is a day & Caesar awoke before dawn on x],
λ x[x is a day & Caesar awoke on x (at all)])

" It is *seldom* the case that the property λxHx of being a day on which Caesar awoke before dawn is realised *when* the property λxJx of being a day on which Caesar awoke (at all) is realized. "

[Aqvist, Hoepelman & Rohrer 1980, 5]

This representation differs in many respects from the one that I have proposed, but the most striking difference concerns the addition of a socalled reference condition : x is a day & Caesar awoke on x (at all). The function of the reference condition is to delimit the set of "admissible" cases with respect to which the set of "favorable" cases is compared. In this case

" the ratio of the number of "favorable" days on which Caesar awoke before dawn to that of the "admissible" days on which Caesar awoke (at all) is low, say, < 0.3. "

[ibidem]

It might be considered now whether the general format should not contain some slot for specifying the relevant reference condition. In the case of a sentence like

(5) he was always late

one might want to express, for instance, that he was always late *on those occasions on which his being late or early could have mattered.*

The problem with such reference conditions is, however, that their specification is highly context dependent. In

(18) he always leaves at twelve

the "admissible" occasions could just as well be all occasions on which he leaves (at all), as all occasions on which he leaves for work, as all occasions on which he leaves for watching the home game of his favourite football team. In short, this information is typically determined by pragmatic factors, and I, therefore, do not see any reason for adding it to the semantic representations.

3.3. habituality

The sentences discussed so far all contain an explicit indication of iteration. The presence of such an indication is, however, not necessary for deriving an iterative interpretation. Take, for instance,

(19) he leaves at twelve

This sentence cannot only mean that he will leave at twelve, but also that he has the habit of leaving at twelve.

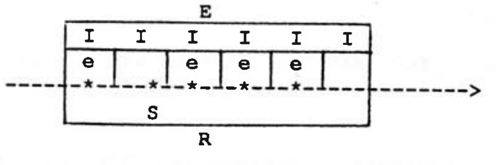
In the representation of the former interpretation the time adverbial "at twelve" specifies the time of reference :

$$\exists\ R,E\ [>(R,S)\ \&\ \text{at twelve}(R)\ \&\ =(E,R)\ \&\ AT(E,\ \text{he leave})]$$

```
                E
------*-------------*--------------->
      S             R
```

In the representation of the habitual interpretation, on the other hand, the time adverbial should be taken to specify the multiple e-time, for the sentence does not report on one of his leavings at twelve, but rather on several of such leaves. As a representation of this interpretation I propose :

$$\exists\ R,E\ [\supset(R,S)\ \&\ =(E,R)\ \&$$
$$\text{Most } I\ [\subset(I,E)\ \longrightarrow$$
$$\exists\ e\ [\subset(e,I)\ \&\ \text{at twelve}(e)\ \&\ AT(e,\ \text{he leave})]]]$$



In words : there is a frame time (E) which contains the time of speech (S) and within which a number of cases (I) can be distinguished, such that in most of those cases he leaves at twelve.

The choice for the quantifier "Most" is based on the assumption that the universal quantifier would be too strong and the other quantifiers too weak : (19) is still true if he sometimes leaves a bit later or earlier, but it would no longer be true if he would leave more often before or after twelve than at twelve.

Sentences with an habitual interpretation will, hence, be analysed in the same way as sentences with an indefinite frequency adverbial of the type "Most", such as "usually", "generally" and "mostly".

The absence of those "understood" adverbials from the surface form of the sentence will, of course, complicate the assignment of representations to sentences. For, every sentence which does not contain a frequency adverbial will in principle be ambiguous between a non-iterative and an habitual interpretation (cf. the ambiguity of "he leaves at twelve").

In practice there are some disambiguating factors, though, such as the form of the verb. A clear example is the English form "used to", as in

(20) he used to leave at twelve

which can only mean that he had the habit of leaving at twelve. Another form with this property is the Simple Present (in its simultaneous meaning). Compare

(21) he is drinking coffee
(22) he drinks coffee

(21) can denote a single instance of drinking as well as a recent habit of him to drink coffee (cf. in the sense of "he is drinking coffee nowadays"). (22), on the other hand, can only denote a habit ; it cannot be used to report on a single instance of drinking.

Another disambiguating factor is the Aktionsart (4) of the basic proposition. If the latter denotes a process or an event then the sentence can have an habitual interpretation, but if it denotes a state then the habitual interpretation is less likely :

(19) he leaves at twelve

can mean that he has the habit of leaving at twelve, but

(23) he is in jail

does not normally mean that he has the habit of being in jail (5).

3.4. relevance

The previous sections have mainly dealt with representational issues. Formats have been developped for the representation of sentences with an iterative interpretation and those formats have been compared with other existing proposals, especially the ones in Stump (1981) and in Aqvist, Hoepelman & Rohrer (1980).

It could be asked now what all these representations are good for. Do they have any relevance ? Do they serve any purpose ?

As a matter of fact there are a number of purposes that they can serve.

First, there is the obvious purpose of any analysis whatsoever, namely to provide an adequate analysis of the phenomena at hand, i.c. iteration and habituality. It is worth pointing out in this connection that the given analyses differ from most existing analyses in (at least) three respects. First, they are integrated in a semantic analysis of temporal expressions in general. Second, they do not require any notations which go beyond the expressive power of first order predicate logic, such as higher order types and intensions. And third, they can be derived in a straightforward way from the surface forms of sentences, since there is a one-to-one correspondence between the surface constituents and their representations : definite frequency adverbials always specify P(I), indefinite frequency adverbials always specify Q, and there is no need to include any pragmatic or inferential information in the representations.

Second, there is the purpose for which the analysis was set up in the first place, namely to serve as a framework for the semantic analysis of verb forms in different languages. This use has been discussed in "Iteration, habituality and verb form semantics" (van Eynde 1987).

Third, there is the purpose of serving as a tool for investigating the interaction between iteration on the one hand and phenomena like conjunction, negation, Aktionsart and quantification on the other hand. To give an idea of how the proposed representations can serve this purpose I will conclude the paper with a few remarks on the interaction between iteration and quantification.

Part four - Iteration and quantification

In "Distributives, quantifiers and a multiplicity of events" Stirling has pointed out that singular noun phrases can get a plural interpretation when they are in the scope of a definite frequency adverbial. One of her examples is

(24) each day Mary wrote *a letter* to her sister ;
they were chatty letters

In spite of the disagreement in number between pronoun and antecedent this sentence is perfectly coherent, as opposed to

?(25) yesterday Mary wrote *a letter* to her sister ;
they were chatty letters

The crucial difference is that the singular noun phrase in (24) is in the scope of a frequency adverbial, and can, therefore, be interpreted as referring to as many letters as there are days in the (unspecified) frame time, whereas in (25) it can only refer to one letter, namely the letter that she wrote yesterday. This is made clear in the representations :

$$\begin{array}{l} \exists\ R,E\ [<(R,S)\ \&\ =(E,R)\ \& \\ \forall\ I\ [\subset(I,E)\ \&\ \cap I=0\ \&\ \text{day}(I)\ \text{--->} \\ \exists\ e\ [\subset(e,I)\ \&\ \text{AT}(e,\text{Mary write } \textit{a letter} \text{ to her sister})]]] \end{array}$$

$$\begin{array}{l} \exists\ R,E\ [<(R,S)\ \&\ \text{yesterday}(R)\ \&\ \subset(E,R)\ \& \\ \quad \text{AT}(E,\text{Mary write } \textit{a letter} \text{ to her sister})] \end{array}$$

An interesting consequence of this analysis is that it does not require the distinction of two meanings for the indefinite article, namely a normal singular one as in (25) and an exceptional plural one as in (24). Instead one can stick to the assumption that the indefinite article has only one meaning, to be represented by the existential quantifier, and explain the plural interpretation in (24) as resulting from the fact that the existential quantifier is in the scope of a universal quantifier.

Given the analysis of habituality in 3.3. it may even be possible to dispense with the socalled generic meaning of the indefinite article. To demonstrate this I take the following set of sentences. They are quoted from Hess (1985).

(26) a text editor *makes* modifications to a text file
(27) a text editor *is making* modifications to a text file
(28) a text editor *made* modifications to a text file
(29) a text editor *has made* modifications to a text file

In (26) it is said "that a text editor makes modifications to a text file *in general*, almost by definition. We might read this sentence in a reference manual" (Hess 1985, 10). In (27-29), on the other hand, it is said "that *there is*, or was, a case of a text editor making modifications to a text file. These remarks might be made by a system operator, watching his screen" (ib.).

Hess concludes from these observations that the quantifier of the subject is universal in (26) and existential in (27-29). So, he postulates (at least) two meanings for the indefinite article: a universal generic one and an existential specific one.

In the framework of the proposed analysis of habituality, however, it is not necessary to make such stipulations. It suffices to note that (26) has an habitual interpretation and (27-29) a non-iterative interpretation :

$\exists$ R,E [$\supset$(R,S) & =(E,R) &
MOST I [$\subset$(I,E) --->
$\exists$ e [$\subset$(e,I) &
AT(e, *a text editor* make modifications to a text file)]]]

$\exists$ R,E [Rel(R,S) & Rel(E,R) &
AT(E, *a text editor* make modifications to a text file)]]]

Since the existential quantifier is in the scope of a MOST-quantifier in the former representation, it will be interpreted generically, whereas in the latter it is in the scope of an existential quantifier, so that it will be interpreted specifically. Notice that in both cases the indefinite article can be represented as an existential quantifier. The differences in interpretation are due to scope relations, not to an inherent ambiguity of the article itself.

It remains to be seen whether all non-existential and non-singular uses of the indefinite article can be described in this way, but I am confident that the given representations are useful tools for the investigation of the interaction between iteration and quantification, and that the latter will shed new light on the relation between generics and habituals.

NOTES

1. The first attempts to develop a model-theoretic analysis of temporal expressions in the Eurotra project go back to 1983. The main source for inspiration in the beginning was the article "A model for temporal reference and its application in a question-answering program" (Bruce 1972). Several linguists have been involved in the further development and modification of this model and in its application to the brute facts of the different EC languages. These efforts have resulted in a number of internal Eurotra documents and in a few publications, such as "The specification of time meaning for machine translation" (van Eynde, des Tombe & Maes 1985) and "Iteration, habituality and verb form semantics" (van Eynde 1987). The development of the ideas presented in those papers has benefitted considerably from discussions with many (present and former) Eurotra colleagues and I would like to take this opportunity to thank them for their comments, insights and reactions, especially, Louis des Tombe, Fons Maes, Lisette Appelo, Pier-Marco Bertinetto, Paul Bennett, Jacques Durand, Elina Rigler, Jean-Claude Lejosne, Spiros Mouschonas, Richard Slotman, Bart Vandecapelle and Stef de Turck. I would also like to thank Tony Raw for making my English a bit more English.

2. For all examples in the text the reference time (R) coincides with the frame time (E), but this need not be the case. In

   "Next year he will have been teaching French for 20 years for two hours a week"

   the reference time is *next year* and the frame time *for 20 years*, and those intervals are definitely not the same.

3. Hans Kamp pointed out in the discussion that these sentences are not necessarily anomalous. For, a sentence such as

   (10) we sometimes played chess every week

   can be taken to mean that there were some periods in the past in which we played chess every week. In that interpretation the frame time contains three kinds of subintervals : the ones introduced by the existential quantifier ("sometimes"), the ones introduced by the universal quantifier ("every week"), and the ones for which the basic proposition is true. Plausible though this analysis is, most speakers find sentences like (10) rather unusual (cf. H. de Swart, personal communication).

4. The Aktionsart concerns the type of event expressed in a proposition. I distinguish three types of them : states, processes and events.

5. The rule that sentences denoting states are non-habitual is not without exceptions, though, for a sentence such as "the priest is in the hospital at 6 and in the school at 7" can have an habitual interpretation, as was pointed out by Co Vet in the discussion.

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Synonymy and Translation*

Franciska de Jong Lisette Appelo

Philips Research Laboratories
Eindhoven - The Netherlands

This paper is meant to give some insight into the interaction between on the one hand theoretical concepts in the field of formal semantics, and on the other hand linguistic research directed towards an application, more specifically, the research within the Rosetta Machine Translation Project. The central notion is **synonymy**. It will be used to discuss sameness of meaning for expressions belonging to **different languages**.

1 Introduction

Within the Rosetta-project we are facing the question whether and how translation can be performed automatically. There is no well-defined theory with respect to this process. Human translation does not provide enough interesting clues. Actually there is hardly more to observe than that two expressions are presented or accepted as translations of each other. Therefore, in our effort to let a machine perform the task of translating natural language, we will not aim at an empirical reconstruction of the human activity of translation, but at the construction of a formal system that defines the translation relation in accordance with human intuitions on acceptable translations.

A first move towards our goal is to answer the following question: what does it mean to claim that expression a is a translation of expression b? The translation relation should be based on considerations of meaning: two expressions are translations of each other if they have the same meaning. In the Rosetta- framework, the notion of meaning has a model-theoretic definition, which implies -more or less- that two expressions are considered translations of each other if they are true in the same set of models. It also implies that the pursued preservation of meaning is supposed to be independent of extra-linguistic knowledge: according to the definition of the translation relation above, Rosetta can be seen as a system that aims at a formal account for a special kind of synonymy, namely sameness of meaning for expressions belonging to different natural languages. As such the Rosetta-output amounts to the generation of equivalence-statements, which by nature are non-contingent. Their evaluation does not require any reference to extra-linguistic facts.

Knowledge of extra-linguistic facts is obviously a prerequisite for adequate translation, especially in view of the approach to ambiguity. Ambiguous sentences are supposed to have more than one meaning as they apply to more than one kind of situation. Consequently, they have more than one translation. Therefore, in case of ambiguous input, the part of the Rosetta system that makes use of linguistic knowledge only will define a set of possible translations.[1]

From the preceding remarks it follows that our current research activities consist mainly of the construction of linguistic modules, i.e. the definition of grammars and of the relation between grammars. In this paper the emphasis will be on the manner in which the the grammars for the languages involved are to be designed, in order to treat those languages as belonging to one and the same semantic system. In section 2 we will first sketch the requirements for synonymy of complex expressions in further detail, on the basis of the discussion in Carnap (1947) of a fairly trivial example of synonymy in the realm of formal languages. In section 3 a brief introduction to the Rosetta-framework will be given. This is followed by a more detailed discussion in section 4 on the role of the Isomorphy Principle in the preservation of meaning during the translation process. The complexities of the Rosetta grammars will be elucidated in section 5 by a discussion of some non-trivial translations that Rosetta is supposed to deal with. One of them will be addressed again in section 6, where a brief sketch is given of some descriptive requirements for the presumed semantic theory. Finally, section 7 will focuss on the relevance of the Rosetta framework from a more general linguistic point of view.

2 The Notion of Synonymy

Consider the following three examples.

(1) $7 > 3$
(2) Gr[VII, III]
(3) Gr[Sum(II, V), III]

The above statements can be seen as expressions with identical truth conditions. Each of them is true if and only if seven is greater than three. But in spite of the fact that they have corresponding parts that are equivalent, they are not three synonyms as a pairwise comparison will indicate.

The statements (2) and (3) are both true under the assumption that seven is greater than three. Hence, a transition of (2) into (3), or vice versa, will be meaning preserving in extensional contexts. The fact that the number of basic expressions differs for (2) and (3) causes a crucial difference: in intensional contexts they cannot be substituted freely.
The statements (1) and (2) do not only have identical meanings and equivalent corresponding parts, but they are also both built by means of the same number of basic expressions and operations. The differences in surface syntactic ordering and structuring devices, do not affect their meaning. In intensional contexts they can be substituted for each other freely. Paraphrasing Carnap: (3) has an intensional structure that is not isomorphic to that of (1) and (2).

> If two sentences are built in the same way out of designators [...] such that any two corresponding designators are L-equivalent, then we say that the two sentences are **intensionally isomorphic**. (o.c.:p.56)

This definition refers to Carnap's notion of L(ogical)-equivalence, which can be informally paraphrased as follows: Σ_i is **L-equivalent** to Σ_j if the truth of $\Sigma_i \equiv \Sigma_j$ can be established on the basis of semantical rules alone, without any reference to (extra-linguistic) facts. (o.c.:p.10)

Statement (3) contains an argument expression that is not isomorphic to the corresponding part in (1) and (2), therefore the pair (1) and (3) and the pair (2) and (3) fail to fulfil the isomorphy requirement implied by the above quotation. As only isomorphic expressions can be regarded as true synonyms, (3) is not a synonym of either (1) or (2).
From Carnaps identification of synonymy and intensional isomorphism it follows that there are two requirements for synonymy:

- equivalence
- isomorphism

In the arithmetical example above, the semantic systems referred to need not be reconstructed empirically. They are defined independently. The equivalence of the expressions involved is obvious. In the context of such examples it is almost trivial to decide on the presence or absence of synonymy. Carnap:

> We find that [these expressions] are isomorphic by **establishing** the L-equivalence of corresponding signs. (o.c.:p.58)

As a guideline for the development of computerized translation devices, this remark is by no means sufficient. First of all there is no uniformity concerning the grammatical structure of natural languages: there is no such well-defined principle that decides a priori what strings are to count as (basic or complex) expressions. Moreover, on the level of surface syntax there are numerous sources of mismatches, even in similar languages such as Dutch and English. Consequently it is not self-evident, and hence not easy to establish what is to count as an example of corresponding signs. So for our aims Carnap's heuristics of synonymy needs some revision. A formal account of synonymy between natural languages requires the **stipulation of synonymy**: expressions are isomorphic if we treat them as such. This may sound less informative than it is. In section 5 it will be argued that there is indeed a lot of stipulated synonymy needed in order to deal with larger fragments of natural language as is aimed for within Rosetta. In the sections preceding section 5 an introduction will be given to the Rosetta framework (section 3), and the way preservation of meaning is pursued in this framework (section 4).

3 The Rosetta Framework

The linguistic framework of Rosetta can be characterized by a number of 'working principles'. The Isomorphy Principle is only one of them. It will be discussed in detail in the next section. The current section is meant as a rough description of the Rosetta-framework. Rosetta will not be discussed here extensively, but just as much as is needed as a background for the understanding of the role of the Isomorphy Principle. In addition to a discussion of some of the Rosetta-principles, we will introduce here the levels of representation that will be referred to in the remainder of this paper.

3.1 Some Rosetta Principles

Note that the role of the principles to be discussed here, is to provide a guideline for systematic research on the possibilities for automatic translation and to be a support in the actual construction of the systems.

- **Principle of Explicit Grammars:** The translation relation is defined by means of explicit grammars for both source and target language. So the wellformedness of input and output sentences results from independent sets of rules. The actual rules of the grammar are strongly influenced by the next principle.

- **Compositionality Principle:** The meaning of an expression is a function of the meaning of its parts and of the way in which they are combined. This principle is adopted from Montague Grammar, at least in spirit. We will regard compositionality as an obvious ingredient for a translational system based on a formal notion of meaning and assume that the given definition is explanatory enough. For further comment, cf. Landsbergen (1987).

- **One Grammar Principle:** A multilingual bidirectional machine translation system requires for every language an analysis component (for its function as source-language) and a generation component (for its function as target language). In Rosetta these two components are based on one and the same grammar of which the rules are reversible: they can be used both for generating and for analyzing sentences.

- **Isomorphy Principle:** Two sentences are considered translations of each other if their meanings are derived in the same way from the same basic meanings. In the following sections, the function of the Isomorphy Principle in a framework for automatic translation based upon the notion of meaning will be discussed in more detail.

3.2 Representations in Rosetta

The translation process is divided into an analysis phase and a generation phase. Both phases are defined by three components of the compositional grammars of the Rosetta-system (which are called M-grammars): a morphological component, a syntactic component and a semantic component. In order to elucidate how the principles sketched above interact, and also to facilitate the reading of the next sections, this section will be addressed to a brief introduction to some of the levels of representation employed in Rosetta. Attention will be restricted to the representations of the syntactic and the semantic component of the M-grammars. In the sequel of this paper we will refer to the following three levels, of which the first two are defined by the syntactic component, and the third level by the semantic component. Figure 2 at the end of this section may serve as a schematic outline of the organisation of Rosetta.

- Surface syntactic trees
- Syntactic derivation trees
- Semantic derivation trees

The **surface syntactic trees** (S-trees) are defined by the rules of the syntactic component, which are called M-rules. These M-rules yield sentential as well as constituent structures. The S-trees represent the syntactic structure of complex

expressions. The nodes of these trees are labelled with syntactic categories and attribute-value pairs. The branches are labelled with relations.
The process of deriving a surface tree starting from basic expressions by applying syntactic combination rules recursively, is represented in a **syntactic derivation tree** (synt. D-tree) with basic expressions as terminal elements, and the names of the applied rules at the non-terminal nodes. To each node of the derivation tree corresponds an intermediate S-tree. In Rosetta, the distinction between meaningful operations and purely syntactic operations is reflected in the distinction between **rules** (in the syntactic derivation trees represented as R'_n) and **transformations** (in the syntactic derivation trees represented as T_n). The left part of figure 1 specifies the syntactic derivation tree, as well as the intermediate S-trees for the sentence *Oscar is sleeping.*[2]

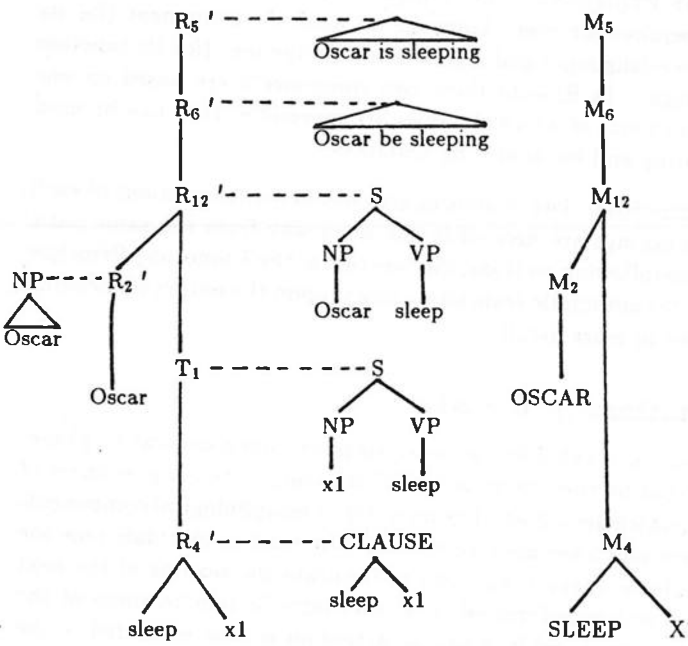

Figure 1: syntactic and semantic derivation for *Oscar is sleeping*

Surface strings of a certain language, which of course always exhibit language specific features, are mapped onto surface strings of another language via the representation of their common meaning. According to the Compositionality Principle the process that results in well-formed surface strings is in correspondence with the derivation of the meaning of the generated string. Therefore, the meaning of a complex expression can be represented in a **semantic derivation tree** (sem. D-tree): a tree with the same geometry as the syntactic derivation tree but labelled with the names of the meanings of the basic expressions as terminal elements, and the names of the meanings of the syntactic rules at the non-terminal nodes. In the right part of figure 1 an example of a semantic derivation tree is given. As purely syntactic operations by definition have no impact on the semantics of the expressions involved, transformations are irrelevant for establishing synonymy. They are so to speak **translationally irrelevant**. For a detailed discussion of the formal distinction between rules and transformation see Appelo, Fellinger & Landsbergen (1987). For the role of semantic derivation trees as interlingua, see Appelo & Landsbergen (1986).

In order to facilitate that a common semantic derivation tree is assigned to two synonymous strings belonging to different languages and with different surface syntactic properties, they must be derived in a parallel way, but regardless of the part of the derivation that is marked as meaningless, namely the part defined by the transformations. M-rules may perform various syntactic operations at once, and also the descriptive content of the M-rules is language-specific to a certain amount. Therefore, a careful division of the syntactic content over the various steps in the derivations is required in order to allow the pursued mapping of synonymous strings.
Note that the syntactic derivations to be displayed below will be given in a reduced form. In general only the meaningful part of the derivational history will be represented, so syntactic transformations are left out. (As a consequence the syntactic D-trees will be of the same geometry as the corresponding semantic D-trees.) Also some minor meaningful rules will be ignored. For example, the rule that defines the NP-node dominating proper names, and sometimes the rules replacing argument variables for full NPs or vice versa, will be omitted in the sequel of this paper.

To summarize: the syntactic rules and the basic expressions define what the chunks of meaning are, and application of these rules specifies surface trees that express a.o. language specific syntactic generalisations. The delicacy of the relation between syntactic and semantic derivation is elucidated extensively in the next section. The current section will be concluded with a schematic representation of the Rosetta translation process (figure 2).

4 Isomorphy

According to the Isomorphy Principle, sentences that are to be regarded as translations of each other, must be *derived in the same way*, i.e. by fully parallel processes. Consequently, the reduced syntactic derivation trees will have the same geometry. In order to guarantee that the mapping relation is indeed defined for equivalent expressions, the various steps in the derivation must be designed carefully, in such a way that each basic expression can be mapped onto its (stipulated) equivalent, and that there is a proper correspondence for each of the rules. (Remember that a source language derivation tree is mapped onto its target language equivalent via their common meaning derivation tree, with which they are isomorphic.) This process of careful design is called the **attuning** of (rules of)

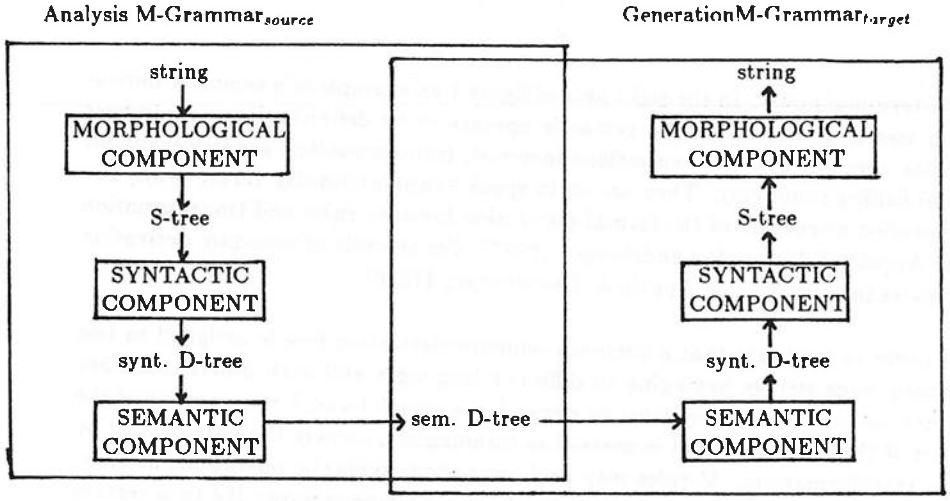

Figure 2: the Rosetta translation process

grammars.

Applied to the examples (1) and (2) of Carnap above, it must be guaranteed that if *Gr* is taken as a basic expression, > is a basic expression as well. Alternatively, a syncategorematic introduction of the one designator would require a syncategorematic introduction of the other as well. In general, synonymous expressions should have derivation trees with corresponding basic expressions as leaves, and representations of corresponding rules as nodes. The following syntactic derivation trees for (1) and (2) would obey the requirements imposed by the Rosetta Isomorphy Principle.

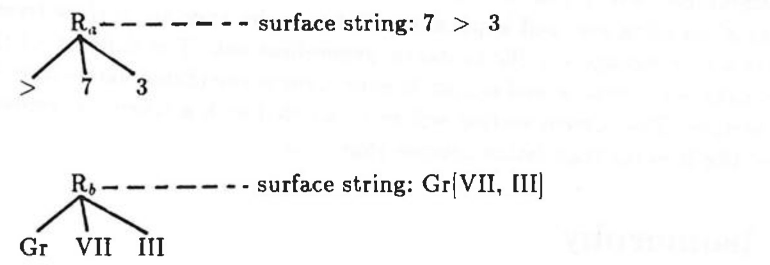

Figure 3: syntactic derivation trees for (1) and (2)

In Rosetta, information about the actual content of syntactic operations is not represented in the derivation trees, therefore derivation trees do not reflect differences as those between (1) and (2) directly. This is in accordance with Carnap's analysis:

> [...] the use of a functor preceding the two argument signs instead of one standing between them may be regarded as an inessential syntactical device.

(o.c.:p.56)

> For the intensional structure, in contrast to the merely syntactical structure, only the order of application is essential, not the order and manner of spelling. (o.c.:p.59)

Until now, we have not yet mentioned anything concerning the nature of the meaning representations in Rosetta. It was noticed before that the translation of synonymous expressions is effectuated via the mapping of their syntactic derivation trees, with a mapping onto their common semantic derivation tree as an intermediate step. In Rosetta, the basic meanings and meaning operations need not be made explicit. However, they are supposed to be compatible with the semantics as defined in Montague Grammar. In section 6 we will return to this issue in more detail.
The next section will be concerned with mappings that are far less trivial than the mapping of (1) and (2). The non-trivial nature of the process of attuning grammars will be demonstrated on the basis of several cases of mismatches between languages. Some of them even require the stipulation of synonymy of basic expressions while at first sight identity of meaning for these basic expressions does not exist.

5 Mismatches

Presuming the correctness of Carnap's claim that word or constituent ordering should be regarded as inessential from a semantic point of view, the mapping of synonymous expressions of different languages need not be complicated by mismatches due to differences in surface syntactic ordering. These can be accounted for by the language specific parts of the grammars, e.g. the transformations or the descriptive content of a meaningful rule. However, mismatches can be demonstrated at various other levels as well. To start with a relatively simple one, consider the following two equivalent sentences:

(4) Oscar slaapt (Dutch)
(5) Oscar is sleeping (English)

These two sentences have differently organized predicates: (5) contains an auxiliary to express the progressive tense, whereas in (4) only a present tense morpheme occurs. In order to let the grammars provide isomorphic derivations for these sentences it should be decided whether or not the English auxiliary is a basic expression. A basic expression is supposed to have a corresponding basic meaning, and in this case, the concept of progressive tense is intuitively connected with sentential features rather than with the verb *be* as a basic expression. Therefore it seems natural to treat *is* in (5) as a syncategorematically introduced expression that lacks an independently defined basic meaning. If the present tense morpheme in Dutch is also considered to be introduced by a rule, the two sentences can be derived isomorphically. Figure 4 contains the simplified syntactic derivation trees for (4) and (5). They illustrate the strategy pursued here: isomorphic syntactic derivations are gained by assuming two basic expressions in the derivations for both the Dutch and the English sentence. The rules R_5 and R'_5 respectively, combine the two basic expressions to form a clausal structure, while R_6 and R'_6 account for tense. The crucial difference between the surface strings (4) and (5) is the result of a difference in the descriptive content of R_6 and R'_6.

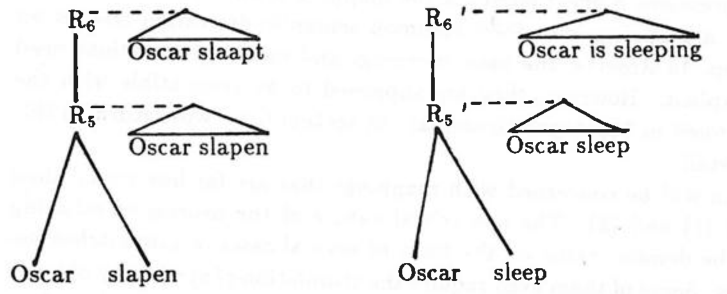

Figure 4: syntactic derivation trees for (4) and (5)

Other sources of mismatches are less trivial, because they require analyses and/or mappings that are counterintuitive in some sense. In this section we will discuss four examples. First two examples of mismatches of grammatical relations, one within the internal structure of NPs, and the other on the sentential level. The third example concerns the mapping of an adverb and a verb, and the fourth concerns the mapping of a one-word string onto a two-word string.

1. Genitive *-s* versus postnominal modification. Consider the following two equivalents (with the literal meaning: the book of Conchita).

(6) Conchita's boek (Dutch)
(7) el libro de Conchita (Spanish)

In (6) the possessive modification is expressed by a prenominal genitive NP. In (7) the prenominal structure contains a definite determiner, while the possessive modification is expressed by a postnominal PP. Stated otherwise, (6) and (7) illustrate that in Dutch and Spanish the possessor role is expressed by means of different syntactic relations, viz. a determiner relation in Dutch, versus a modifier or complement relation in Spanish. In Figure 5, isomorphic derivations for (6) and (7) are given.[3] These derivations presume several decisions.

- The introduction of modification and the introduction of definiteness is realized in two steps. A treatment along this line is motivated by the fact

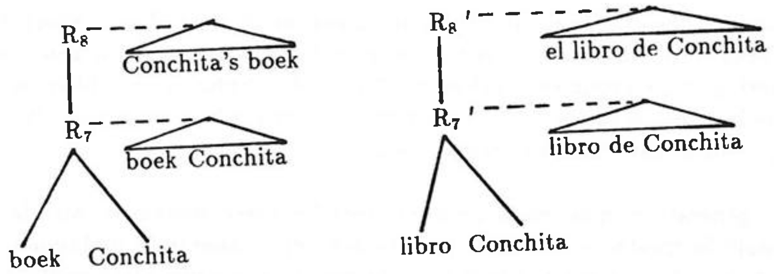

Figure 5: syntactic derivation trees for (6) and (7)

that in Spanish the string *libro de Conchita* must be available for the indefinite NP *un libro de Conchita* (a book of Conchita) as well. On the basis of the syntactic peculiarities of (6) alone there would be no need to assume a derivation in two steps. Note however that even from a monolingual point of view an analysis in two steps for (6) might be preferred in view of the fact that definiteness and possessive modification are separate semantic phenomena.

- The definite article *el* is introduced syncategorematically, rather than being treated as a basic expression. Obviously, this is not motivated by the analysis of Spanish NPs in general. However, if *el* were to be analysed as a basic expression, the derivation of (6) would require the deletion of the Dutch definite article. Under either solution, the analysis of either (6) or (7) is counter-intuitive and would probably not be chosen if Dutch and Spanish were to be analysed by a grammar of a monolingual system. In this example, it is an arbitrary question which of the two alternatives is to be preferred.

- A similar argument holds for the third decision implied by Figure 5: the preposition *de* in (7) is introduced syncategorematically, since its translation equivalent *van* does not show up in (6), but an analysis that presumes a *van*-deletion rule for Dutch might be preferred as well.

The synonymy of (6) and (7) indicates that grammatical relations (or categories) such as determiner and modifier, are in itself translationally irrelevant. Moreover, (6) and (7) illustrate the claim that the mapping of derivation trees is not always self-evident, but rather the result of a careful process of attuning, which might involve counter-intuitive decisions with respect to what is to count as a basic expression. The example involved in the next section is even more complicated, as it involves the mapping of basic expressions that intuitively are no synonyms at all.

2. Switching of arguments: *bevallen* versus *like*. Consider the sentences (8) and (9) that intuitively should be considered as acceptable translations of each other: both express the fact that the film Amadeus appeals to Jane.

(8) Amadeus bevalt Jane (Dutch)
(9) Jane likes Amadeus (English)

In (8) *Amadeus* is the grammatical subject and *Jane* the indirect object, whereas in (9) *Amadeus* is the direct object and *Jane* the subject. Consequently, also the surface ordering of the arguments differs in (8) and (9). Probably this difference is due to the fact that *bevallen* is a so-called ergative verb, while *like* is not. Still, (8) and (9) seem to have the same truth conditions.

In order to generate isomorphic derivation trees for these sentences, *bevallen* and *like* should be treated as translations of each other. Stated in formal semantic terms: it should be stipulated that they denote the same two-place relation, here represented as the semantic object LIKE. The argument of this 2-place relation LIKE is a pair, here consisting of the denotata of *Jane* and *Amadeus*. That is, the meaning of (8) and (9) should be a logical expression along the lines of (10). (Note that the choice of the ordering of the arguments is in fact arbitrary, although there must be some choice.)

(10) LIKE(JANE, AMADEUS)

In order to derive (10) as the result of a compositional process, we assume the semantic derivation that is represented in Figure 6.

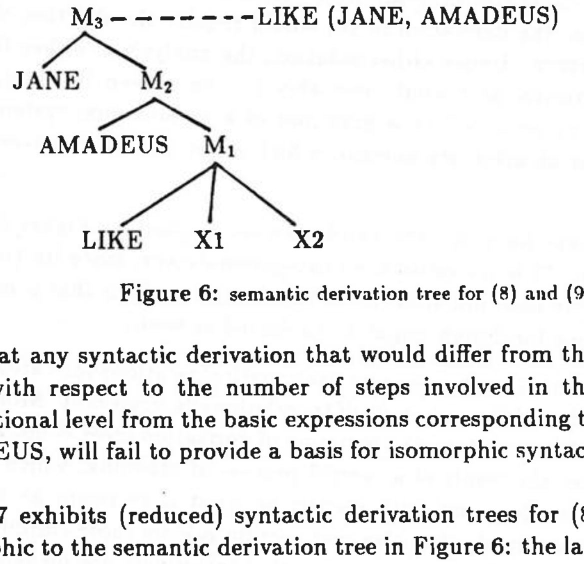

Figure 6: semantic derivation tree for (8) and (9)

Note that any syntactic derivation that would differ from the derivation in Figure 6 with respect to the number of steps involved in the formation of the propositional level from the basic expressions corresponding to LIKE, JANE and AMADEUS, will fail to provide a basis for isomorphic syntactic derivation trees.

Figure 7 exhibits (reduced) syntactic derivation trees for (8) and (9) that are isomorphic to the semantic derivation tree in Figure 6: the language specific syntactic rules that correspond to the common semantic rule M_1, i.e. R_1 and R'_1, specify the proper syntactic configurations for the occurrence of *like* and *bevallen*, respectively.

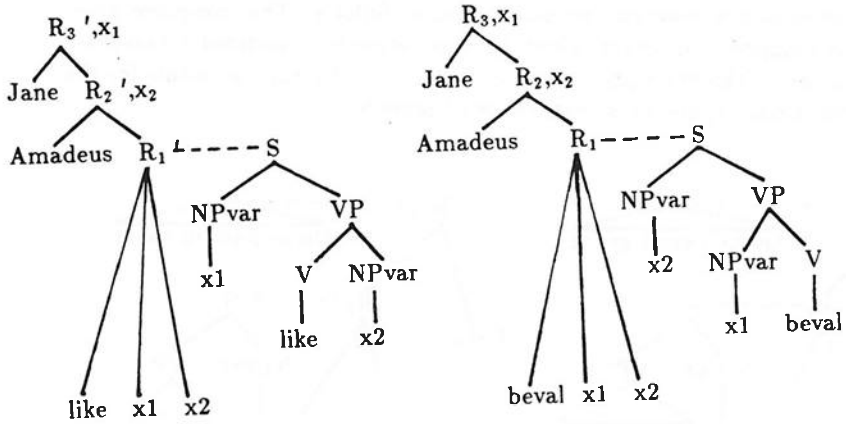

Figure 7: part of the syntactic derivation trees for (8) and (9) and derived S-trees

Two aspects of this analysis are prominent:

- in order to treat (8) and (9) as synonyms, the bi-lingual transfer dictionary of Rosetta must allow a translation of *bevallen* into *like* and vice versa. That is, it should allow the mapping of basic expressions that intuitively are no synonyms at all, but only by stipulation.

- According to the above treatment of (8) and (9), the syntactic bifurcation subject-NP versus VP is semantically empty, and given the semantic basis of Rosetta, translationally irrelevant. Within the analysis of Dutch alone it could be motivated that first the VP x_1 *beval* (x_1 to be substituted by *Jane*)is derived and then the sentence x_2 x_1 *beval* (x_2 to be substituted by *Amadeus*). In English the same could be said for the VP-constituent *like* x_2 and the sentence x_1 *like* x_2. But the required isomorphy excludes derivations that at any stage combine *like* and x_2, or *bevallen* and x_1, respectively. Again this illustrates that for a certain part the Rosetta-grammars are not founded in the syntactic and/or semantic analysis of a particular language. Instead the adopted analyses amount to the construction (or reconstruction) of synonymy.

3. The mapping of adverbials on verbs. A classic translation problem concerns the translation of the English sentence (11) into its Dutch equivalent (12).

(11) Oscar likes swimming
(12) Oscar zwemt graag

The problem consists in the fact that *like* should be considered a translational synonym for *graag*, while the categories for these two basic expressions are different: *like* is a verb and *graag* is an adverb. Due to this category mismatch, the sentences have to be assigned different surface structures as well: the surface structure of (11) contains a sentential complement, while (12) is a simple sentence without an embedded sentence. But as will be clear by now, the Isomorphy approach offers an adequate tool for the mapping of syntactic derivation as well as the mapping of the meaning of such different structures. The isomorphy of the relevant pieces of grammar can be established as follows. The two-place predicate *like* is mapped onto *graag*, which by stipulation is considered a two-place predicate as well. The descriptive content of the syntactic rules accounts for the difference in surface syntactic structure. See Figure 8.

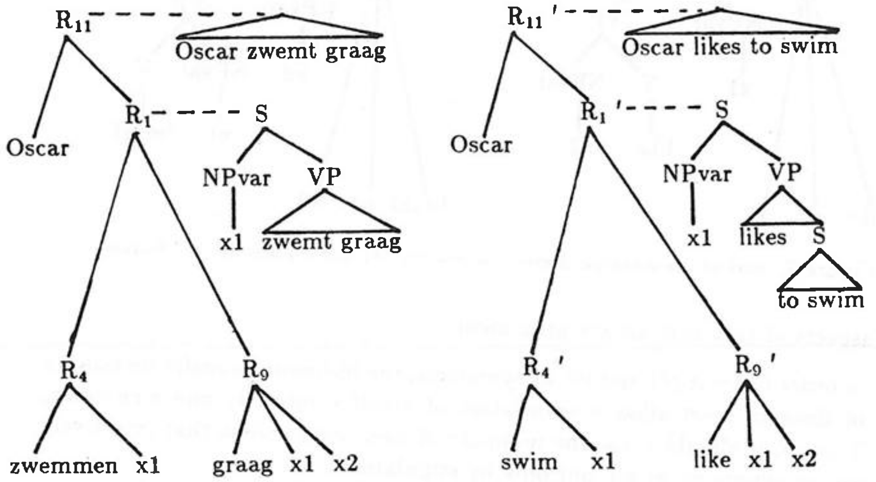

Figure 8: syntactic derivation trees for (11) and (12)

The urge to account for the synonymy of (11) and (12) enforces an analysis for certain adverbs as a two-place predicate. Note, however, that the relational nature of for example *graag* can be argued for on monolingual grounds as well. The occurrence of *graag* requires the presence of an animate subject: **het regent graag* (cf. '*it likes to rain'). The strong relation between *graag* and the sentential subject is also indicated by the impossibility to passivize a sentence with *graag* salva veritate.

Just as the preceding examples of mismatches, the synonymy of (11) and (12) illustrates the restricted relevance of surface syntactic notions from the translational point of view. The Rosetta framework offers an adequate strategy towards this phenomenon, because the preservation of meaning is pursued via the derivation trees, rather than via a surface analysis. In order to elucidate the advantages of a stategy for machine translation that accounts for identity of meaning by a reconstruction or construction (in case of mismatches) of the corresponding isomorphism, this section will be concluded by discussing some examples of mismatches on the level of basic expressions.

4. The mapping of *zeer* onto *very much*. The following quotation from Carnap (1947) makes reference to a notion that plays an important role in the strategy towards isomorphism: smallest subdesignator.

> We require for isomorphism of two expressions that the analysis of both down to the smallest subdesignators lead to analogous results. (Carnap 1947:57)

The preceding sections already indicated that not every word of a sentence need to have a counterpart in the derivation. That is, not every word is to count as a smallest subdesignator (= an expression denoting a basic model-theoretic meaning), and hence affect the isomorphy in case of synonymy. This section will sketch how this relativization provides us with a strategy towards the mapping of the Dutch *zeer* onto *very much*.

The occurrence of the English degree-modifier *very* is restricted to its use as a modifier to adjectives and adverbs. It never occurs as a sentential constituent. Its Dutch counterpart *zeer* it not restricted in its distribution. As shown in (13) it can modify verbs as well. As a translation of (13) we need (14b) rather than (14a).

(13) Amadeus bevalt Jane zeer
(14) a. *Jane likes Amadeus very
b. Jane likes Amadeus very much

According to the presumptions described thusfar, the Rosetta grammars should provide isomorphic derivations for (13) and (14b). The problem we are facing here concerns the question what is to count here, in Carnap's terms, as the smallest subdesignator corresponding to *zeer*: (1) *very* and *much*, (2) *very*, or (3) *very much*. The first alternative would require a derivation for the Dutch *zeer* with two basic expressions instead of one as well: next to *zeer* as corresponding to *very*, a basic expression corresponding to *much* should be distinguished. In order to derive the correct surface string a (meaningless) rule would be needed to delete this counterpart of *much*. The second alternative with *zeer* and *very* as corresponding basic expressions requires the syncategorematic introduction of *much*. A third alternative would be to treat *very much* as a complex basic expression, synonymous with a simple basic expression in Dutch.

Each of these alternatives appeals to devices that are available in the Rosetta framework on independent grounds. The syncategorematic introduction of words, for example, was already demonstrated in the preceding sections. Deletion rules are needed for, among other things, the deletion of the subject arguments of infinitival complements. The incorporation of complex expressions is independently motivated by the treatment of idioms.
In a compositional framework, idioms need a special treatment, because their meaning cannot be composed out of the meaning of their syntactic parts. This is due to the fact that the parts do not have a meaning. For example, in the idiomatic reading of *kick the bucket*, the noun *bucket* does not refer to a bucket

at all. The meaningful part of the VP in a sentence such as ***John kicks the bucket*** is ***kick the bucket***. Accordingly, this string is to be considered a basic expression, or in Carnap's words, a smallest subdesignator. The notion of complex basic expression is thus independently motivated for, irrespective of translational purposes. For a detailed discussion of the treatment of idioms in Rosetta, see Schenk (1986).

Applying this notion to *very much* would of course be a slightly different matter. From the perspective of the analysis of English alone, there is no need to consider *very much* a complex basic expression. Only the synonymy of *zeer* and *very much* induces such an approach. These special instances of complex basic expressions are therefore marked as **translational idioms**, i.e. expressions of which the idiomatic nature is motivated by translational purposes, rather than by monolingual analysis. Other examples of translational idioms are: *to rise early* which is considered a complex basic expression in view of its Spanish one-word counterpart *madrugar*, the Dutch *blijven staan* in view of *to stop*, and the Dutch and English *niet weten* and *not know*, respectively, in view of the Spanish *ignorar*. In addition to the derivation that is to be expected on the basis of monolingual analysis, these complex strings get an alternative treatment. The alternative analysis is obtained by extending the Rosetta dictionary entries with the complex basic expressions mentioned above.

6 VP-less Semantics

In the preceding section it was argued that for an adequate account of the synonymy of (8) and (9), it is necessary to do away with the VP-level in derivation.[4] This approach is characterized by the following features:

- The classical distinction between subject and predicate is present only in surface trees, if it plays any role at all. It is not the basis for semantic interpretation.

- No one-to-one correspondence between semantic roles and syntactic relations can be established in a generalized way. The first argument of a verb is not a priori the subject, nor are objects excluded from such an interpretation.

- As a consequence of the treatment described above it follows that there is no semantic level corresponding to the syntactic VP. This influences the treatment of what is usually dealt with as VP-modification. Moreover it complicates the account of some scope-phenomena.

In this section, we will address the third issue of VP-less semantics in some more detail.

The classical PTQ semantics, which is supposed to supply a basis for the contents of the semantic rules of Rosetta, would have to be extended in order to supply a suitable semantic rule corresponding to the sentence-formation rules R_1 and R_1'

as displayed in Figure 7, and to deal with the interpretation of non-sentential modifiers, as for example the so-called 'intensifiers'.
Traditionally, semantic frameworks such as Montague's PTQ treat non-sentential modifiers as VP-modifiers. Taken in isolation it is certainly possible to treat *zeer* in 'Amadeus bevalt Jane zeer' (13) and *very much* in 'Jane likes Amadeus very much' (14b) as VP-modifiers. However, as their respective VPs are not composed of synonymous basic expressions, we have to account for the intuitive synonymy of these sentences by enforcing the grammars to define isomorphic derivations for them as sketched above, and, moreover, to specify some suitable level other than VP, to function as the argument of these modifiers.
According to the derivations of (8) and (9) as represented in Figure 7 two other levels are available: the sentential level and the level with the verbal head of the construction as a terminal basic expression. As the former is not the most appropriate level for the expression of non-sentential modification, a solution can be sought in the incorporation of modification rules that apply to the verbal head. As the presumed intuitive synonymy of (8) and (9) already enforced the stipulated synonymy of *like* and *bevallen*, modification of the bare verb allows us to preserve the pursued isomorphy. See Figure 9 for a derivation tree along these lines.

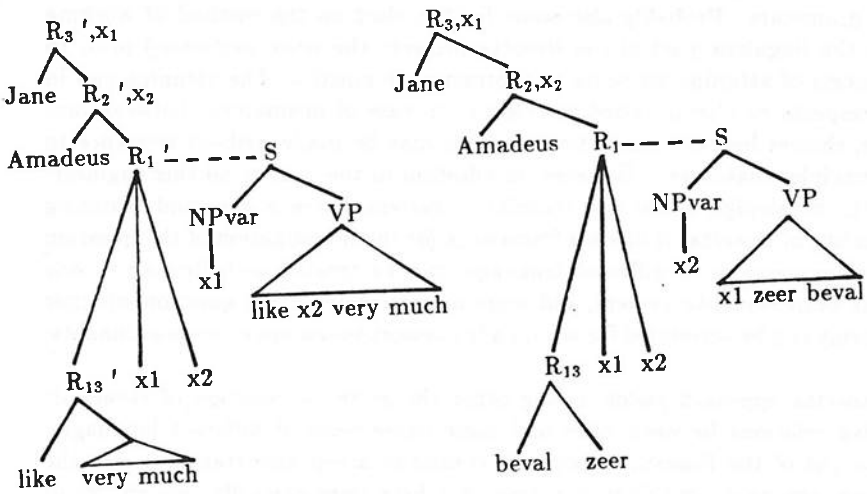

Figure 9: part of the syntactic derivation trees for (13) and (14a) and derived S-trees

In general, modifying expressions are assigned a semantic type of the scheme $< ty, ty >$: when a modifier is applied to an expression of type ty, the result is again an expression of type ty. Consequently, if verbs are of different semantic types, varying in their number of arguments, their modifiers should belong to different types as well. As one-place predicates and VPs are considered $< e, t >$-type expressions in classical semantic frameworks, the semantic type assigned to intensifiers is: $<< e, t >, < e, t >>$.

In order to account for the modification of verbs denoting a two-place predicate, for example *like* and *bevallen*, intensifiers should have an additional type-assignment based upon the type of two-place predicates. Transitive verbs are of type $<< e, < e, t >>$. Accordingly, the additional semantic type required for intensifiers is: $<< e, < e, t >>, < e, < e, t >>$.

Of course, introduction of this new type raises the question how to account for the systematic relation between the two readings for intensifiers. In general there are two approaches conceivable: either we assume that modifiers such as *very much* and *zeer* are ambiguous between the two type-assignments discussed here, or we make use of the so-called type-shifting devices as described for example in Geach (1972), and recently discussed in several other publications. In the former option we do not account for the systematic relation between the two readings. In the latter option we will have to make use of the principle of combinatory logic known as the Geach-rule, i.e. the rule which states that expressions of category x/y may be analysed as expressions of category (x/z)/(y/z).[5]

7 Discussion

In the preceding sections we have shown how judgements concerning the intuitive synonymy of expressions of different languages may direct and influence the design of the Rosetta grammars. What we deliberately tried to emphasize was the amount of engineering involved in the process of what we called the attuning of grammars. Probably also some light is shed on the method of working within the linguistic part of the Rosetta project: the work performed prior to the process of attuning amounts to contrastive linguistics. The attuning can in some respects be characterized as eclectic: in case of mismatches between languages, choices between conflicting analyses may be made without reference to any principle whatsoever. However, in addition to the goal of all this engineering, viz. developing a machine translation system, there is a second tempting perspective of Rosetta: it offers a framework for the investigation of the question whether expressions of different languages can be treated as belonging to one and the same semantic system, and more in particular for the question whether synomymy can be accounted for within a framework based upon compositionality.

The Rosetta approach yields among other things the stipulation of reversible mapping relations between rules and basic expressions of different languages. The output of the Rosetta system will consist of acceptable translations if the attuning -among other things of course-, has been done carefully enough. As illustrated by the examples of non-trivial attuning in section 5, it may be necessary to adopt analyses that are not motivated by the more limited goals of explanatory monolingual description. This final section is meant to provide some insight into the amount of linguistics in Rosetta and consequently, into the relevance of the presented analyses for the study of natural language semantics and universals.

First of all it should be stressed that the Rosetta framework distinguishes various levels of analysis. As indicated in section 3.2 there are two kinds of representations relevant for sentential analysis: the surface trees and the derivation trees. For the compositional mapping of expressions onto their semantic interpretation, and subsequently onto their target language counterpart, the derivation tree is the crucial level. In the actual elaboration of M-rules, the structure of the intermediate results as represented in the surface trees is important in several respects. Its role concerns both the translational system sec, and the method of labour during the design of the system. For example, the surface trees represent not only the result of the meaningful steps in the derivation, but also the translationally irrelevant features of a language that the derivation trees abstract away from. Consequently, the S-trees may exhibit surface syntactic configurations that are independently motivated for in a certain language. As such they are of interest for the study of natural language syntax. The language-dependent nature of the S-tree level has a practical advantage too. For the method of design it is crucial that there is a separate level for the representation of monolingual generalizations: in order to preserve control over the generated structures, the linguists who are the authors of the M-rules need the possibility to refer to the language-specific syntactic generalizations. For example, Dutch is more easily described if it is considered an SOV-language rather than an SVO-language. Therefore, in the Dutch intermediate S-trees the underlying order is SOV. Without the possibility to make use of monolingual syntactic generalizations, the linguistic labour would be complicated enormously.

Another interesting effect of the formalisation of synonymy between languages is mentioned briefly in section 5: the attuning of grammars may result in analyses that from a monolingual point of view are not obvious at first sight, but that in fact capture a monolingual generalisation as well. For example, the two-step analysis of modification by means of possessive genitive, and the analysis of the adverb *graag* as a two-place predicate.

Presuming that the analyses employed in Rosetta cannot be denied linguistic relevance, it seems justified to address the issue of natural language universals here in some more detail. The crucial assumptions are (a) that natural language semantics should account for intuitive synonymy, and (b) that different natural languages should be described by the same semantic model. As a consequence the intuitive synonymy of expressions belonging to different languages should be accounted for by assigning them identical meaning representations. Given the framework described above, this requires parallel derivational histories for synonymous expressions.
As argued above, careful attuning of grammars may require arbitrary choices between an analysis based on language A instead of language B. As Rosetta is designed for a very small set of languages, nothing concerning the universality of a certain analysis can be concluded on the basis of a single derivation tree. If we conceive of a future Rosetta system which deals with a less restricted set of

languages, the choices to be made may become less arbitrary due to the fact that there will be more facts to reckon with.
For example, if *like* and *bevallen* should be analysed as synonymous predicates, then one suggestion concerning universality is already implied by the preceding sections: the notion of VP is a surface syntactic notion, irrelevant from a semantic point of view, and consequently not belonging to the set of shared universal linguistic categories. Support for this conclusion is provided by an analysis of Modern Irish: as argued in McCloskey (1979), Modern Irish could be considered a VSO-language, a language with an underlying stucture that lacks a syntactic VP.

A more general conclusion to be drawn on the basis of the particular way in which Rosetta treats synonymy between languages is that the establishment of the proper balance between syntactic and semantic analysis may require the distinction of more levels of representation. In addition to the representation of surface syntactic generalizations we need a level representing the derivational history. The correspondence between syntax and semantics should not be sought in the establishment of a correspondence between surface syntactic structures and semantic representations. Surface syntax need not be complicated by considerations of semantic nature. In this respect the critics of Montague (1974) were right. If we distinguish between syntactic structure and its derivation, each motivated by different facts, the relation between surface syntax and semantic representation might turn out to be even weaker than is often argued. Presuming that Montague did not intend to account for the syntactic well-formedness of the expressions involved in his analysis, the account of synonymy described here might even be considered as supporting Montague with respect to his totally ignoring surface syntax.

Notes

* We would like to thank Carel Fellinger, Jan Odijk and especially Jan Landsbergen for their comments on earlier versions of this paper.

1. Actually this restriction only holds for the system presently under design, i.e. Rosetta3. In the follow-up of this system, Rosetta4, knowledge of some specialized domain will be incorporated in order to select the right translation. In addition it will deal with remaining ambiguities by means of interaction with its users.

2. Note that all derivation trees in this paper, including the one in Figure 1 are in fact simplified versions of the kind of derivation trees actually employed in Rosetta. Also the S-trees are simplified: the labels on the branches are omitted, and sometimes parts of the structure are abbreviated by triangles.

3. Actually, in Dutch both configurations are available. In addition to *Conchita's book* there is the equivalent form *het boek van Conchita*. They are true synonyms. Hence isomorphic derivations for (6) and (7) might as

well provide the basis for a formal account of the synonymy of the Dutch equivalents.

4. In fact this claim is tentative as long as the presumed synonymy of *like* and *bevallen* is not checked in all relevant contexts. Especially scope phenomena may turn out to be complicating the analysis.

5. This amounts to the claim that an expression that applies to a y to result in an x, can also be analysed as an expression that applies to an expression of category y/z to result in an expression of category x/z.

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ASYMMETRIC QUANTIFICATION

Nirit Kadmon

University of Massachusetts at Amherst

This paper is about manifestations of quantifier scope. I will discuss two phenomena which I take to reflect scope relations: the uniqueness implications associated with definite NPs under quantification, and an 'asymmetric' reading of quantified sentences, which is a problem for the Lewis/Kamp/Heim treatment of quantification.

1. Introduction: Manifestations of Scope Relations

This paper will focus on different ways in which relative scope of quantifiers is reflected in natural language. I will first mention some well known manifestations of scope relations, and then discuss two other phenomena which I take to reflect scope relations as well.

One thing which reflects scope is anaphora. Ever since Frege, it's been the normal practice in logic to translate pronouns as bound variables, as in (1), for example. The antecedent and the pronoun correspond to the same variable, under the scope of the same quantifier.

(1) <u>Every man</u> loves <u>his</u> mother.
$\forall x[\text{man}(x) \rightarrow x \text{ loves } x\text{'s mother}]$

In Kamp 1981 and Heim 1982, there is emphasis on discourse anaphora. Kamp and Heim show how the possibilities of discourse anaphora are constrained by scope relations. To illustrate this briefly, look at (2)-(5). (I am using Kamp 1981's framework, because his DRS diagrams are easy to read.)

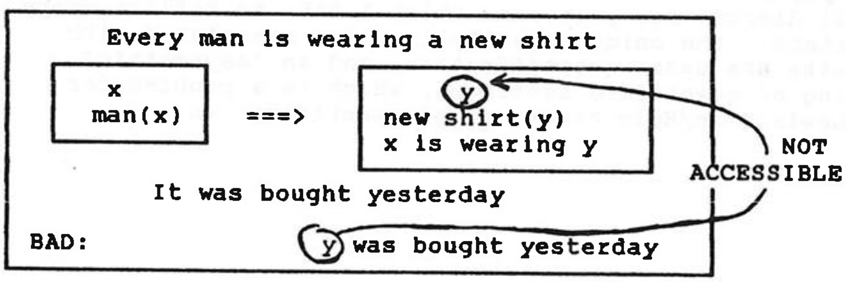
(2) John is wearing a new shirt. It was bought yesterday.

(3)

x
John is wearing a new shirt
new shirt(x)
John is wearing x
It was bought yesterday
x was bought yesterday

(4) Every man is wearing a new shirt. #It was bought yesterday.

(5)



The anaphora in (2) is OK, because in the discourse representation, given in (3), the new shirt variable x is an accessible antecedent for the pronoun. In (4), the pronoun can't refer back to the shirt. In the DRS in (5), the shirt variable y is not accessible to the pronoun, so it can't serve as its antecedent.

Accessibility is defined syntactically on DRSs. But given the semantics for DRSs, accessibility encodes a generalization about scope: The pronoun must be under the scope of the quantifier that binds the antecedent. In (3), the pronoun and the antecedent are both under the existential quantification over the whole DRS, which is induced by the definition of truth. (The DRS is true if there is an x that satisfies the conditions in it). In (5), the variable y is under the scope of the quantification induced by the verification clause for the conditional (for every man x there is a shirt y...), but the pronoun is not under the scope of that quantification. (For related discussion, see Chierchia & Rooth 1984.) The same generalization about anaphora and scope is stated clearly in Heim 1982 and captured in Heim's system.

That was about anaphora, where two elements are trying to refer to the same thing. But I will concentrate on cases involving two NPs, or two variables, which stand for two different things.

Consider for example sentence (6).

(6) Everybody in this room speaks two languages.

We say that there is a scope ambiguity here, either everybody in this room has wide scope over two languages, or the other way around. But what does that mean? The bare fact is that the sentence is ambiguous in this way: It may mean that each person in the room can be matched with two languages that that person speaks. Or, it may mean that there are two languages which are spoken by everybody in the room. In other words, the sentence may describe different correspondences between the set of people in the room and the set of languages. Or: it describes two different possibilities of distribution of languages per person or distribution of people per language.

Another fact about this same ambiguity concerns speakers' intuitions about predication. On the reading where there are two languages per person, in some sense the topic of the sentence or the 'logical subject' of the sentence is the people in the room. I think that speakers have some intuition that on this reading (6) is ascribing a property to the people in the room. But on the reading where there are two language that all the people speak, the intuition is that in some sense a pair of languages is the topic or the 'logical subject', and (6) ascribes to that pair the property of being spoken by everybody. In other words, speakers feel that there is a difference in predication - predicating something of people or predicating something else of languages.

(I will not attempt to be more precise or go into the literature on topic/comment or predication. I find that speakers (non semanticists) agree on these judgements.)

The above two facts are analyzed as a matter of scope relations. They are both attributed to the scope ambiguity which is expressed in (7).

(7) a. <u>everybody in this room</u> wide scope:
$\forall x\ [\ person(x) \rightarrow \exists 2y[language(y) \wedge x\ speaks\ y]\ ]$

b. <u>two languages</u> wide scope:
$\exists 2y\ [\ language(y) \wedge \forall x[person(x) \rightarrow x\ speaks\ y]\ ]$

The different scope relations are designed to capture different correspondences between people and languages. They also capture the intuition about predication: No matter how you represent scope, you can always find a subformula or some stage in your translation procedure which is a property ascribed to people or to languages, or which corresponds to such a property. In (7a), speaking two languages is predicated of every person (the subformula $\exists 2y$ etc. says that there are two languages y that x speaks). In (7b), being spoken by everybody is predicated of the languages ($\forall x$ etc. says that y is spoken by every person).

Typically, the manifestation of scope relations which receives the most attention is the aspect of truth conditions which has to do with correspondences or distribution. You say that <u>Everybody in the room</u> has wide scope over <u>two languages</u>, and you mean by that that the sentence describes a certain distribution of languages over people.

I want to stress in this paper that this is **not** the only manifestation of scope relations. The scope configuration creates asymmetries among different elements in the representation. For example, in (7a) there is an asymmetry between the two variables: the y is bound 'deeper down' than the x. This kind of asymmetry shows up in several different ways, and effects having to do with distribution are only one way. I will now discuss two other phenomena which reflect the same asymmetry. The list in (8) is for future reference - it's a summary of all the scope manifestations which have been and will be mentioned in this paper.

(8) <u>Manifestations of Scope Relations</u>

A. Anaphora
B. Asymmetries:
1. An aspect of truth conditions concerning <u>correspondences/distribution</u>;
2. Intuitions about <u>predication</u>;
3. <u>Uniqueness</u> of definite NPs under quantification;
4. An aspect of truth conditions which creates the <u>'proportion problem'</u> in <u>asymmetric readings</u> of quantified sentences with **most**, usually, etc.

2. Uniqueness and Quantification

I believe that definite NPs must have a referent which is understood to be unique in some way. I argue for this in detail in Kadmon 1986, 1987, and will concentrate here on how uniqueness relates to scope. Take examples (9) and (10).

(9) Leif has a chair. It is in the kitchen.

(10) Leif has a chair and a table. The chair is in the kitchen.

The sentence Leif has a chair may well be true and felicitous in a situation where Leif has more than one chair. For example, if I tell you that I need to borrow a chair, you can say Leif has a chair, even if Leif has ten chairs.

But when the anaphora is added, there is always a uniqueness implication. The definite NP it or the chair acts like the 'E type' pronouns of Evans 1977, 1980. Out of the blue, there is an implication that Leif has only one chair. In the right context, the definite can refer to a chair which is unique in some other way. For example, suppose you know that Leif would lend only one chair even though he has ten. You can now say (9), referring to the only chair that Leif is willing to lend.

The point is that the chair must be unique in **some** way. Suppose Leif has ten identical chairs, and he is willing to lend any subset of them. We have no way of distinguishing any chair from the other chairs. Also, six of the chairs are in the kitchen. In this situation, (9) is infelicitous. One wants to object: What do you mean 'it'? Which chair?

In short, a definite must be unique in some known way or other. To account for that, we need to require that whenever a definite is used, there must be some information in the discourse representation which guarantees that it is unique. And by unique I mean that there is only one thing in the world or in the model that the definite could refer to (be mapped onto). So we need something like (11).

(11) A definite NP associated with a variable x in DRS K is used felicitously only if for every model M, for all embedding functions f,g verifying K relative to M, f(x)=g(x).

That is, we need to require that given a definite x, all the embedding functions which verify the discourse must agree on the value of x. This requirement is intended for discourse anaphora only, as opposed to syntactic or c-command anaphora. (I am following Sells 1985 in stating the principle responsible for uniqueness implications in terms of embedding functions.) An example is in (12).

(12)

```
+---------------------------------------------+
|                      x                      |
|          Leif has exactly one chair         |
|                  chair(x)                   |
|                 Leif has x                  |
|                                             |
|   +--------------+        +----------+      |
|   |      y       |        |          |      |
|   |   chair(y)   |  ==>   |   y=x    |      |
|   |  Leif has y  |        |          |      |
|   +--------------+        +----------+      |
|                                             |
|           It is in the kitchen              |
|            x is in the kitchen              |
+---------------------------------------------+
```

The little conditional in (12) captures the truth conditions of <u>exactly</u>. It says that all the things y which are a chair of Leif's are identical to x. I.e., x is the only chair Leif has. The pronoun <u>it</u> refers back to the same variable x. This means that it satisfies the uniqueness requirement: the only truthful value for it would be the one chair that Leif has.

Now take example (9) again. I said that out of context it implies that Leif has only one chair. Why? The hearer constructs a representation for (9), something like (13).

(13)

```
+------------------------------+
|              x               |
|       Leif has a chair       |
|           chair(x)           |
|          Leif has x          |
|     It is in the kitchen     |
|      x is in the kitchen     |
+------------------------------+
```

But this DRS does not satisfy the uniqueness requirement. Nothing in this representation guarantees that x stands for a unique chair. Therefore, to satisfy uniqueness, the hearer must do some accommodation, in the sense of Lewis 1979. In this particular example, the hearer is likely to accommodate the very same conditional we saw in (12), which creates the DRS in (14).

(14)

```
+---------------------------------------------+
|                      x                      |
|               Leif has a chair              |
|                  chair(x)                   |
|                 Leif has x                  |
|                                             |
|   +--------------+        +----------+      |
|   |      y       |        |          |      |
|   |   chair(y)   |  ==>   |   y=x    |      |
|   |  Leif has y  |        |          |      |
|   +--------------+        +----------+      |
|                                             |
|           It is in the kitchen              |
|            x is in the kitchen              |
+---------------------------------------------+
```

This creates the right uniqueness implication, since x is now the only chair Leif has.

The uniqueness requirement on definites holds under quantification as well. Take example (15) (from Sells 1985).

(15) Every chess set comes with a spare pawn. It is taped to the top of the box.

(15) implies that there is a unique spare pawn per chess set. Out of the blue, it implies that there is exactly one spare pawn per chess set. In context, the spare pawn associated with each chess set may be unique in some other way. For example, if we have been talking about special bonuses, it could be the only one that comes as a special bonus. The important thing is that it has to be unique in **some** way, and unique **relative to a choice of chess set**.

The DRS of (15) is in (16).

(16)

```
Every chess set comes with a spare pawn.
It is taped to the top of the box.

[ x            ]  ==>  [ y                            ]
[ chess set(x) ]       [ x comes with a spare pawn    ]
                       [     spare pawn(y)            ]
                       [     x comes with y           ]
                       [ It is taped to the t.o.t.b.  ]
                       [ y is taped to the t.o.t.b.   ]
```

This DRS captures the truth conditions of (15), although it does not yet capture the uniqueness implication. It says that for every chess set x, there is some spare pawn y that comes with it and which is taped to the top of the box. (The second sentence got into the consequent box by the process of discourse subordination of Roberts 1985, 1987.)

To see intuitively why there is a uniqueness implication in such examples, consider the relation between the spare pawn and the chess set. Again, for each choice of a chess set in the world (or in the model) there has to be a spare pawn that goes with it. So in some sense when you evaluate the example, you 'first' pick a chess set, and then you see if it can be matched with a spare pawn. So in some sense the spare pawn is dependent on the chess set. That is why it has to be unique relative to the chess set. You first pick a chess set, and then the uniqueness requirement is that there must be only one spare pawn that goes with that chess set.

The dependence I have just described between the pawn and the chess set is of course a reflection of the quantification and the scope configuration. There is an asymmetry between the chess set variable and the pawn variable, due to their different positions relative to the quantifiers that bind them. The pawn variable y is bound 'deeper down'.

On the basis of this and other examples, I suggest that the variable of a definite NP must be unique relative to the set of variables that are bound higher up. To capture that, I have formulated the uniqueness requirement as in (18). Some relevant definitions are given in (17).

(17) Notation: U_K = the universe of K.

$A_K := \{x : \exists K'$ accessible to K s.t. $x \in U_{K'}\}$

An embedding function f for a DRS K in a model M=<D,F> (D domain of individuals) is a partial function from the set of variables to D which maps all and only the variables in A_K onto members of D.

(18) $B_K := \{x : \exists K'$ accessible to K s.t. $K' \neq K$ and $x \in U_{K'}\}$

<u>The Uniqueness Condition</u>

Let α be a definite NP associated with a variable y, let $K_{1o\alpha}$ be the local DRS of α, and let K be the highest DRS s.t. K is accessible to $K_{1o\alpha}$ and $y \in U_K$.

α is used felicitously only if for every model M, for all embedding functions f,g verifying K relative to M, if $\forall x \in B_K$ $f(x)=g(x)$ then $f(y)=g(y)$.

<u>Notes:</u>
- This can be relativized to assignment functions for free variables, but I am only concerned here with (matrix) DRSs of a complete piece of discourse, which don't contain free variables.
- Again, the uniqueness requirement is intended for discourse anaphora only.

What I have done in (18) can be described as follows. We consider a definite with a variable y, and the DRS K in which y was introduced. I have defined a set B_K of variables which the definite depends on, in the same way that the pawn depended on the chess set. B_K contains variables that are bound higher up than y. Then the uniqueness requirement is relativized to B_K: y must be unique relative to a choice of values for all the variables in B_K. (All embedding functions which verify K and agree on the values of the variables in B_K must also agree on the value of y.)

Now look at (16) again. In the consequent box, there is a definite NP <u>it</u> associated with the variable y. y depends only on the variable x. That is, the only member of B_K is x. The uniqueness condition says that once you fix a truthful value for x, there must be only one way of finding a truthful value for y. (16), as it is, does not satisfy this requirement. Therefore, uniqueness must be guaranteed by accommodation, as in (19) below.

(19)

```
Every chess set comes with a spare pawn.
It is taped to the top of the box.

[ x            ]       [ y                                  ]
[ chess set(x) ]  ==>  [ x comes with a spare pawn          ]
                       [ spare pawn(y)                      ]
                       [ x comes with y                     ]
                       [ [ z              ]                 ]
                       [ [ spare pawn(z)  ]  =>  [ z=y ]    ]
                       [ [ x comes with z ]                 ]
                       [ It is taped to the t.o.t.b.        ]
                       [ y is taped to the t.o.t.b.         ]
```

The little accommodated conditional says that y is the only spare pawn that x comes with. So we get the right implication: one spare pawn per chess set.

Consider now example (20).

(20) If a semanticist hears of a good job, she applies for it.

There is no uniqueness implication associated with (20). The claim made in (20) is not restricted to a unique semanticist or to semanticists who hear about a unique good job each. If a semanticist hears of several good jobs (none of them unique in any known way), then according to (20), she applies for them all.

(20) would normally be assigned the DRS in (21).

(21)

```
If a semanticist hears of a good job, she
applies for it.

[ x         y           ]       [ she applies for it ]
[ a semanticist hears   ]       [                    ]
[ of a good job         ]  ==>  [ x applies for y    ]
[     semanticist(x)    ]       [                    ]
[     good job(y)       ]       [                    ]
[     x hears of y      ]       [                    ]
```

The universal quantification over the pair of boxes is unselective. It binds both x and y in the antecedent box. So (21) means that for every pair of a semanticist x and a good job y that she hears of, x applies for y.

Two things have to be explained: (i) why isn't the job unique relative to a choice of semanticist? (ii) Why aren't both semanticist and job unique in an absolute sense, relative to nothing? In regards to (ii), note that according to (18), the relevant B_K, for both x and y, is the empty set. This predicts, incorrectly, that both must be absolutely unique, which disallows any 'real' quantification, over more than one instance.

You could say that (20) is understood to be about instances of a semanticist hearing about a good job, and that there is a unique semanticist and a unique job per instance. I think that that's right, but not enough. Why is the job unique per instance? Because it is part of the instance? Then why is it? And how can the uniqueness condition be sensitive to that? Also, why does the job contrast with the spare pawn in (15), which is unique relative to a choice of chess set? Is the pawn unique because it is not part of the relevant instance? Why isn't it? (Presumably, (15) too involves quantification over instances, since we wouldn't want ad hoc distinctions between different quantified sentences.)

I believe that the right account has to combine quantification over instances/cases/situations with a generalization about the role of the scope configuration. I propose that the necessary generalization about scope is the one encoded in the analysis of uniqueness given in (18).

I will not make the quantification over instances precise here, but I think we would want to interpret (20) more or less as follows. 'Every situation where there are a semanticist x and a good job y s.t. x hears of y is or can be extended to a situation where x applies for y'. (I have in mind universal quantification along the lines of Kripke 1965.) I suppose situations could be syntactically represented in the DRS, or else only introduced via the verification clause for the pair of boxes.

To explain (ii), i.e., why x and y are not unique relative to the empty set, we could posit a variable over situations, say s. According to the interpretation mentioned in the last paragraph, s would be bound higher up than x and y, so it would be a member of B_K. So x and y would have to be unique relative to s. This kind of account (due to Fred Landman, p.c.) utilizes the fact that the definition of B_K is sensitive to the scope configuration.

And how about (i), why doesn't y have to unique relative to x? That is again due to the scope configuration, and it is predicted by the analysis in (18). Unlike in the chess example, there is no asymmetry between the two variables. In the scope configuration we have in (21), neither variable is bound deeper down than the other one. So their values are picked 'at the same time', so to speak. There is no question of choosing the semanticist 'first' and then checking if there is a job that she hears of. So there is no question of choosing a semanticist and checking if the job she hears of is unique, either. Technically, y doesn't have to be unique relative to x, because x is not in the set B_K of variables that y depends on. (Note that this is independent of whether or not the quantification is over situations.)

To summarize, uniqueness depends on the scope configuration. An element has to be unique relative to all and only the elements that are bound higher up.

This generalization explains why one variable is unique relative to another one in (15) but not in (20). Also, if the quantification in such examples is taken to be over situations, it looks like we should be able to use the same generalization to explain why the variables in (15) and (20) don't have to be unique absolutely, relative to the empty set: x and y would have to be unique relative to a situation variable which is bound higher up.

3. Asymmetric Readings

Kamp 1981 and Heim 1982 adopt and extend the treatment of quantification which stems from Lewis 1975, with unselective restricted quantification. It has been pointed out by Partee 1984 and Bäuerle & Egli 1985 that examples like (22) are a problem for this treatment.

(22) Most women who own a dog are happy.

Consider (22) in the following situation: There are ten women. One woman owns 50 dogs and she is happy, and the other nine women own exactly one dog each and they are miserable. Is (22) true in this situation? No, it is false. This judgement is not predicted by the unselective binding treatment. The DRS would be as in (23).

(23)

Most women who own a dog are happy		
x y woman(x) dog(y) x owns y	MOSTLY ===>	x is happy

The unselective quantification induced by mostly binds x and y. So we have quantification over pairs of a woman x and a dog y such that the woman owns the dog. The whole DRS is true if for most such pairs, the woman is happy. This predicts that in the situation under consideration, the sentence should be true. There are 59 different woman-dog pairs, and in most of them the woman is happy.

I call this the 'proportion problem', because what's crucial for the truth or falsity of (22) is the proportion of dog-owning women who are happy to all the dog-owning women. That's what the unselective binding analysis fails to capture.

To get the right truth conditions, we need a way of counting dog-owning women, instead of counting woman-dog pairs. I think the intuition is this: The woman part determines that the quantification is over women, and the dog part specifies a property that these women should have (they should be dog-owners). I will call the things playing these two roles the 'boss' and the 'dependent'. The boss is the element that we quantify over. Here the woman is the 'boss' and the dog is the 'dependent'.

I have now mentioned in this paper two kinds of readings for quantified sentences. Borrowing some terminology from Rooth 1986, we can call them 'symmetric' readings and 'asymmetric' readings. The job example discussed above seems symmetric. We are talking about instances of a semanticist hearing about a good job, and there is no asymmetry between the semanticist and the job. For this reading, quantifying over pairs (or over situations which in some sense contain pairs) seems like an adequate analysis. As illustrated below (see examples (24)-(26)), there are symmetric examples with quantifiers like <u>mostly</u>, and they do not give rise to the proportion problem. In examples like (22), on the other hand, there is an asymmetry betwen two elements, the boss and the dependent, and the quantification is over bosses alone. We are not talking about pairs, but about women with a certain property. These examples create the proportion problem for the unselective binding analysis.

Regularities in distribution confirm the systematic nature of the symmetric/asymmetric distinction.

First, Partee 1984 points out that examples like (22) contrast with their conditional counterparts. I think that relative clause examples are unambiguously asymmetric while conditionals are ambiguous. For example, while (22) seems unambiguously asymmetric, (24) below is ambiguous, and although its asymmetric reading may be prominent, it has a symmetric reading as well. On the symmetric reading, (24) is true in the following situation (which I have already used above). There are ten women, one of them has 50 dogs and is happy (I think that to get the reading we have to understand that she is happy about owning each of the dogs), and the other nine own exactly one dog each and are not happy. This judgement is correctly predicted by the unselective binding treatment, with quantification over woman-dog pairs.

(24) Mostly, if a woman owns a dog, she is happy.

Secondly, the availability and relative prominence of the two readings are affected by choice of verb and prosodic changes. For example, while (24) is easily understood as asymmetric, it is much harder, if not impossible, to get the asymmetric reading in the case of (25) and (26) below. (25) and (26) just seem symmetric, and don't give rise to the proportion problem. (Check the truth conditions, and compare (26) with (27) and (32).)

(25) Mostly, if a woman meets a dog, she is happy.

(26) Mostly, if a woman OWNS a dog, she talks to it.

This is not surprising. The asymmetric reading of (25) would be about women with the property of meeting a dog, but this is a much less likely description of women than as dog-owners. On the other hand, one **is** likely to think about instances of a woman meeting a dog and get the symmetric reading. As for the emphatic stress in (26), it suggests that the speaker is concerned with the relation between women and dogs, and not primarily with women, which means quantification over woman-dog pairs again.

The question is, how do we analyze the asymmetric examples?

It has been suggested that the analysis would have to do with quantification over events or situations. (See Berman 1987 (who tries to pursue this idea), Bäuerle & Egli 1985 (who suggest and then drop it); cf. also Partee 1984.) My response is similar to what I said above about using situations (in connection with uniqueness). Saying something about situations is not in itself a solution, unless you say something about how the situations are individuated and how that relates to the data you are trying to account for.

There are different things you could say to get the right truth conditions of the asymmetric reading (see e.g. Bäuerle & Egli 1985, Root 1986, Rooth 1986). What I am going to say is that (22) means something like 'Most women x s.t. there is a dog that x owns are happy'. (You can think about it as saying something about how the relevant situations are individuated, if you like.) But before I present this proposal properly, let me discuss two more properties that the asymmetric reading has.

First, in asymmetric examples, there are uniqueness implications. For example, in (27).

(27) Most women who have four dogs talk to them.

There is an implication here that there is a unique set of four dogs per woman. Out of context, (27) seems to be only about women who each have exactly four dogs. According to my informants, it doesn't say anything about women who have more than four dogs. Example: Suppose Martha has six dogs. This is all you know about her. If (27) is true, do you think she is likely to talk to her dogs? My feeling is, I have no idea. For all I know, six dogs may be too many to talk to. I think that the sentence only tells me what to expect of women with exactly four dogs.

In the right context, (27) can be about women who each have more than four dogs, but only if each woman has a set of four dogs which is understood to be unique in some other way. For example, if we are talking about animals that are kept indoors, (27) might be about women who have exactly four dogs that they keep indoors. The point is that (27) is about women who each have a set of exactly four dogs which is unique in some way.

In short, if there is a definite NP referring to the 'dependent', then the dependent must be unique relative to a choice of boss.

Last property now. In examples like (22), it's not obvious that out of the woman and the dog one has wide scope over the other. But there are also examples like (28), which have some readings where one NP clearly has wide scope over another. In such readings, the wide scope NP is the boss, the element that you quantify over.

(28) Usually, if two students review three papers, {they enjoy it / they get rejected by the editor}.

Take the case where <u>two students</u> clearly has wide scope. That's a reading where each student reviews three papers. (Read (28) with 'they enjoy it'.) On this reading, <u>two students</u> is the boss. The sentence is about pairs of students, characterized as students who review three papers each. The quantification induced by <u>usually</u> is over pairs of students, and what matters is the proportion of pairs of students who review three papers each and enjoy it to pairs of students who review three papers each.

Now take the case where <u>three papers</u> clearly has wide scope. That's a reading where each paper is reviewed by two students. (Read (28) with 'they get rejected by the editor'.) On this reading, <u>three papers</u> is the boss. The sentence is now about triples of papers, characterized as papers that are each reviewed by two students. The quantification is over triples of papers, and what matters is the proportion of triples of papers each reviewed by two students which are rejected by the editor to triples of papers which are each reviewed by two students.

To repeat, where wide scope can be independently identified, the wide scope NP is the boss. These examples led me to the idea that the asymmetric reading is always a matter of the boss NP having wide scope, even in examples where this is not immediately obvious. To motivate this, consider the list of properties of the reading, in (29).

(29) <u>Properties of the asymmetric reading</u>:

1. The truth conditional effect which creates the proportion problem;
2. The intuition that the 'dependent' is used for predicating some property of the 'boss';
3. The uniqueness implications associated with a definite NP referring back to the dependent;
4. The correlation between bosshood and wide scope

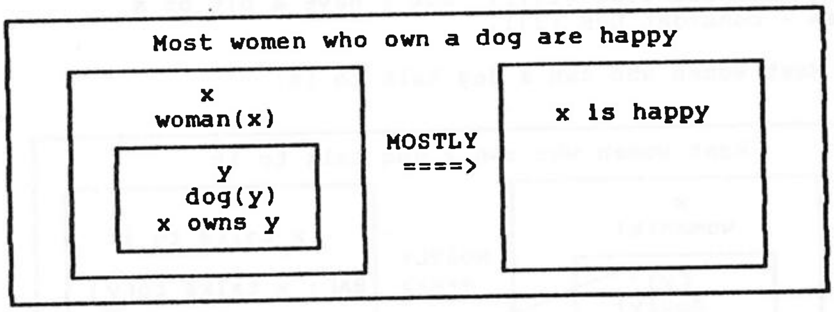
I have just talked about the fourth property, which immediately leads to my analysis. #2 and #3 are both phenomena that are known independently to be a matter of scope relations.

First, #2: I mentioned in section 1 above the intuition that the element with wide scope is in some sense the topic or the 'logical subject' of the sentence, and something is predicated of it. In the asymmetric reading, the intuition is that the dependent is used to specify some property that the boss has. This intuition suggests that the dependent has narrow scope relative to the boss.

And #3: As discussed above, uniqueness depends on the scope configuration. In asymmetric examples where a definite NP refers back to the dependent, the dependent must be unique relative to a choice of boss. This suggests again a scope configuration where the dependent is bound by a narrower quantifier relative to the boss.

As for property #1, I would like to claim that it too results from the same scope configuration. Back to example (22), I propose that here too the boss has wide scope, and the DRS is as in (30).

(30)



The little box inside the antecedent DRS is bound by existential quantification. It means that there is a dog y which the woman x owns. (The source of this existential is not the NP <u>a dog</u>, but the construction it occurs in.) So the x is bound higher up than the y. Now the quantification induced by <u>mostly</u> binds only one variable, x. So the whole DRS means this: 'For most women x s.t. there is a dog y that x owns, x is happy'.

This analysis gets the correct truth conditions for the asymmetric reading: the quantification is over women, not over woman-dog pairs, just as it should be. (If the quantification is over situations, we would have here situations containing only a woman, rather than a pair of a woman and a dog.) The representation in (30) also reflects the intuition that the dependent is used to ascribe a property to the woman, because the little box is just the property of owning a dog.

To describe what I am doing from a different angle, consider the antecedent boxes in (23) and (30). Each of these antecedent DRSs, taken on its own, represents something like A woman owns a dog. The difference between them is summarized in (31).

(31) In (30): $\exists x$ [woman(x) $\wedge$ $\exists y$ [dog(y) $\wedge$ x owns y]]

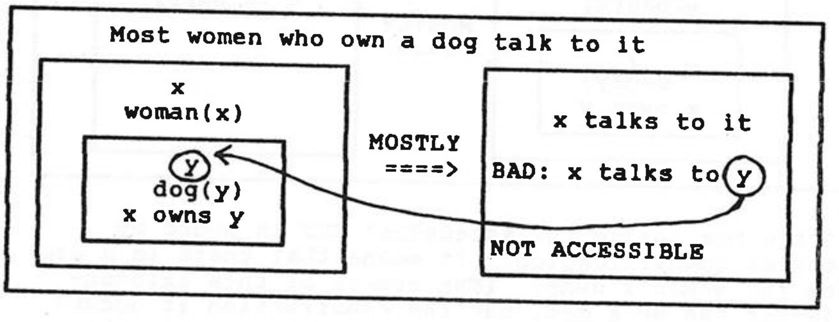
In (23): $\exists x$ $\exists y$ [woman(x) $\wedge$ dog(y) $\wedge$ x owns y]

In (30), there is a significant difference in scope between the two existentials, so that the y is bound deeper down. In (23), that is not the case. In Kamp's and Heim's systems, representations of such cases are generally 'flattened', to be more like the one in (23). The two kinds of representation often yield the same truth conditions, like the two formulas in (31). But for some examples, there is evidence that one kind of representation is more appropriate than the other. What I am saying is that in the case of the asymmetric reading, there is evidence for a representation which is less flat, with an existential which crucially has narrow scope.

Finally, I would like to show that my analysis predicts the uniqueness implications. I should predict, for example, that (32) is only about women who have a unique dog. (If you are not sure about this judgement, substitute (27) for (32). Even speakers who don't get uniqueness implications in examples with singulars do get them in examples like (27).) But I have a bit of a problem - consider DRS (33).

(32) Most women who own a dog talk to it.

(33)



The problem is that this DRS is not well formed. The pronoun <u>it</u> can't refer back to the dog, because the antecedent, the y in the little box, is not accessible to it. The existential quantification that binds the y does not extend to the position of the pronoun.

I propose that the anaphora is licensed by a trivial bit of accommodation. To allow the use of the pronoun, the conditions in the little box are copied into the consequent DRS, as in (34).

(34) Most women who own a dog talk to it

x woman(x) [y dog(y) x owns y]	MOSTLY ====>	**y** **dog(y)** **x owns y** x talks to it x talks to y

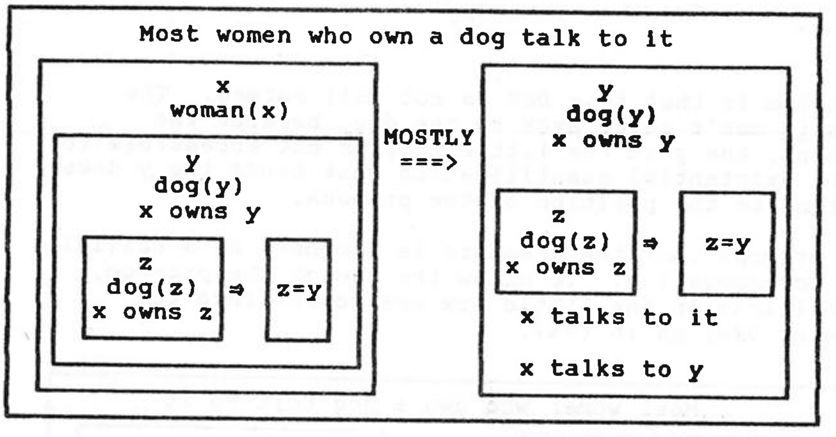
boldface conditions accommodated

Now the pronoun has an accessible antecedent in its own box, and the DRS is well formed.

The proposed accommodation is very trivial, since it doesn't affect truth conditions. (34) means that usually, if a woman x is such that there is a dog that she owns, then **there is a dog that she owns**, and she talks to that dog. The repetition has no effect on truth conditions. It seems plausible that such trivial accommodation would be very readily executed. This would explain why the anaphora feels perfectly natural and smooth, in spite of the fact that it is based on accommodation.

Back to uniqueness, the dog must be unique relative to a choice of woman, because the dog variable y is bound deeper down than the woman variable x. The set B_K of variables that y depends on has one member, x, so y must be unique relative to x. The DRS as it is doesn't satisfy this requirement. So again something has to be accommodated, resulting in a DRS like (35).

(35)



The added conditional says that y is the only dog that x has. This creates the implication that there is only one dog per woman.

To summarize, I have proposed an analysis of the asymmetric reading, where the boss has wide scope over the dependent. This analysis accounts for all the properties of the asymmetric reading listed in (29) above.

4. Conclusion

The scope relations among quantifiers create asymmetries among the different variables that they bind. The truth conditional effect which has to do with distribution, or correspondences between sets, is one well known reflection of this kind of asymmetry. I have proposed that the uniqueness requirement on definite NPs and the asymmetric reading of quantified sentences should both be analyzed as reflecting this same asymmetry.

I have used different reflections of this asymmetry as diagnostics for scope relations, in examples where the scope cannot be identified on the basis of distribution or correspondences. Several manifestations of scope relations cluster together in the case of the asymmetric reading. This made it possible to identify the scope configuration which creates the reading, and to give a unified account of the different properties that it has.

5. Asymmetric Readings Uncovered

As I have just mentioned, different manifestations of scope relations may be used as useful diagnostics for the scope configuration. To end, let me give one more illustration of that, with a case which is important for the understanding of donkey sentences in general.

I believe that there are asymmetric readings in examples where the truth condtional effect related to the proportion problem doesn't exist. For example, in (36).

(36) Every woman who has a dog is happy.

Here the proportion problem can't arise. It can't make any difference to truth conditions if we quantify over women who are dog-owners, or over woman-dog pairs. If the dog-owners are happy, then in all the woman-dog pairs the woman is happy, and vice versa. Nevertheless, it is possible to identify an asymmetric reading here.

First, I think the intuition about predication is there. There is a clear conceptual difference between (36) and (37).

(37) If a woman meets a dog, she is happy.

The intuition is that (36) is about women who are dog-owners, while (37) is about instances of a woman meeting a dog, i.e., about woman-dog pairs.

Secondly, there is a uniqueness implication associated with the asymmetric (38), but not with the symmetric (39).

(38) Every woman who has a dog talks to it.

(39) If a woman meets a dog, she talks to it.

Example (38) is only about women who have a unique dog (try with <u>four dogs</u> instead, if you are not sure about uniqueness with the singular), while (39) does say something about women who meet more than one dog.

Thus intuitions about predication and the presence of uniqueness implications can serve as diagnostics for scope relations and for the asymmetric reading, in examples where they cannot be identified on the basis of truth conditions.

These phenomena allow us to draw the conclusion that donkey sentences are systematically interpreted in two ways, even in cases of universal quantification, where the truth conditions of the two readings collapse. Note that recognizing the two readings, and the fact that one and only one of them displays uniqueness effects, illuminates the conflicting and insecure intuitions reported in the literature about uniqueness in donkey sentences.

Evans 1977, for example, believes that there are uniqueness implications in donkey sentences. Heim 1982 and others believe that there aren't. The existence of the two readings resolves the disagreement: there are uniqueness implications in asymmetric readings, but not in symmetric readings.

There is also an uncertainty about what donkey sentences say about men with more than one donkey. Heim 1982 reports an insecure judgement on whether Most men who own a donkey beat it says that most men who own a donkey beat all the donkeys they own, or at least one of the donkeys they own. Upon reading this, I found that I couldn't accept either possibility; my intuition was that the sentence didn't talk about men with more than one donkey. Also, I felt exactly the same about examples with universal quantification, like (38). If it is recognized that donkey sentence have asymmetric readings (even in cases of universal quantification), the insecure judgements are explained: Asymmetric donkey sentences really don't tell you anything about men with more than one donkey (or more precisely, about men who don't have a donkey which is unique in some known way), because to satisfy the uniqueness requirement, they must be understood as being about men who have a unique donkey each.

NOTES

The phenomena discussed in this paper are studied in much greater detail in Kadmon 1987.

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Semantic Case Theory

Edward L. Keenan
UCLA

Semantic Case Theory initiates an axiomatic treatment of the ways natural languages constrain the interpretation of simple main clause sentences. It provides (1) an explanation of the existence of quantifier scope ambiguities, (2) a variety of universal generalizations concerning the distribution and interpretation of anaphors, (3) an explanation for a surprising asymmetry in the distribution of Passives and Reflexives, and (4), for the limited class of structures considered, an empirically non-circular way of construing universal generalizations using notions like 'subject' and 'direct object'.

I introduce here the notion of semantic case as a way of extending the interpretation of NPs in simple contexts to more complex ones. The idea is developed from the treatment of scope in van Benthem (1986) and contrasts in interesting ways with the treatment of the same phenomena in Montague (1973) and Keenan & Faltz (1985).

1. Notation and Limitations of the Present Study

I limit myself here to nuclear sentences (Ss)--ones formed from simple one and two place first order predicates (P_1s and P_2s). Given a universe E of objects, P_1s (and common nouns, like student) denote subsets of E, called properties. P_2s denote subsets of E^2, called binary relations. So for n = 1 or 2, a nuclear n-ary S consists of n independent NP occurrences, a simple P_n, and no optional material. (An NP occurrence is independent if it is not a proper subconstituent of another NP occurrence).

The class of NPs considered is extensive, properly including those denoting generalized quantifiers. An NP is called initial if it combines with a simple P_1 to form a nuclear (unary) S. The initial NPs in a language are partitioned into basic NPs and deictic NPs.

Basic NPs are ones which may be adequately interpreted by functions from the set P of properties of the model into {0,1}, the set of truth values. Such functions are also called basic. I use basic S to mean a nuclear S whose independent NP occurrences are occurrences of basic NPs. Some examples of basic NPs are:

(1) every student, some teacher, every boy but not every girl, no boy's cat, all but two boys, every boy but Tom, more male than female students, Bob's friends, most of the students, fewer boys than girls, John

For example, every boy denotes that function EVERY BOY from properties into {0,1} which sends q to 1 (true) iff the property BOY is a subset of q. More generally, EVERY denotes that function from properties into basic functions given in (2). (For other definitions in this format see Barwise & Cooper (1981) and Keenan & Stavi (1986)).

(2) a. EVERY(p)(q) = 1 iff $p \subseteq q$

b. SOME(p)(q) = 1 iff $|p \cap q| \geq 1$

Proper nouns (e.g. John) denote individuals, where for each $b \in E$, I_b or the individual generated by b, is that basic function sending a property q to 1 iff $b \in q$.

Deictic NPs are initial NPs which are not basic. To interpret nuclear unary Ss containing them we must know not only the property denoted by the P_1 but also additional information provided by the context (of utterance). Up to isomorphism then we may represent deictic NPs as denoting functions from contexts into basic functions. (I.e. in context _you_ might denote the same as _Fred_). Such functions are called _deictic_, and _initial_ functions are ones which are either basic or deictic. Some examples of deictic NPs:

(3) I, you, every friend of yours, the same student, he, most of the papers he wrote, a different boy, this cat

2. _Semantic Cases_

A basic unary S differs in a crucial way from a basic transitive (= binary) one: its interpretation is uniquely determined by the denotation of its basic NP and its P_1--it is just the value of the former at the latter.

But interpretations for basic transitive Ss (henceforth _batSs_) are _under_determined in two ways merely given the basic functions denoted by the two basic NPs and the binary relation denoted by the P_2. We must state in addition which NP is "logical subject" and which "logical object", and given this, we must state their relative semantic scopes. I provide here a way of specifying these two properties without committment as to how any particular language syntactically presents its batSs. So e.g. "scope" is independent of syntactic relations like C-command.

Consider the two readings of (4):

(4) Every student kissed some teacher

On the "object narrow scope" reading (4) is true iff the basic function EVERY STUDENT holds of the property expressed by _kissed some teacher_. To build this property from the binary relation KISS and the basic function SOME TEACHER we shall extend the domain of the latter so that it sends binary relations to properties (in addition to sending properties to truth values). Specifically this extended function must send KISS to the set of objects b which are such that the basic function SOME TEACHER holds of the set of things b bears the KISS relation to. More generally:

(5) a. For F basic, F_{acc} or the _accusative case extension_ of F is that extension of F which sends each binary relation R to $\{b:F(R_b) = 1\}$. ($R_b =_{df} \{a: (b,a) \in R\}$

b. ACC is that function sending each basic F to F_{acc}

In this notation then, the object narrow scope reading of (4) is given by (EVERY STUDENT)[(SOME TEACHER)$_{acc}$(KISS)].

To get the object wide scope reading of (4) we want to say that some teacher has the property that every student kissed him. To build this property from EVERY STUDENT and KISS we extend the domain of the former so that it takes KISS to the set of objects b which are such that the basic function EVERY STUDENT holds of the set of objects which bear the KISS relation to b. Generalizing:

(6) a. For F basic, F_{nom} or the <u>nominative case extension</u> of F is that extension of F which sends each binary relation R to $\{b: F(R^b) = 1\}$. $(R^b =_{df} \{a: (a,b) \in R\})$

b. NOM is that function sending each basic F to F_{nom}.

The object wide scope reading of (4) then is given by (SOME TEACHER)[(EVERY STUDENT)$_{nom}$(KISS)].

NOM and ACC are called <u>semantic cases</u>.

Informally, note that the nom. ext. of David sends KISS to the set of objects which David kissed. Formally,

(7) $(I_d)_{nom}(KISS) = \{b: I_d(KISS^b) = 1\} = \{b: (d,b) \in KISS\}$

Similarly the accusative extension of David sends KISS to the set of objects which kissed David.

We see then that given two basic NPs and a simple P_2, denoting say F,G, and R respectively, there are four[1] ways we may build a sentence interpretation, illustrated in (8).

(8) $F(G_{acc}(R))$ "G is logical object & has narrow scope"

$G(F_{nom}(R))$ "G is logical object & has wide scope"

$G(F_{acc}(R))$ "G is logical subject & has wide scope"

$F(G_{nom}(R))$ "G is logical subject & has narrow scope"

Thus given two basic NPs and a simple P_2, <u>argument structure</u> (which is logical subject/object) is expressed in terms of which case extensions are used to interpret the NPs, and "scope" is determined by which of these extensions takes the binary relation as argument--that one having narrow scope. Note that these purely semantic notions are expressed in purely semantic terms.

Finally note that the semantic cases extend in the obvious way to deictic NPs. E.g. NOM(THIS CAT) sends a context c to NOM[(THIS CAT)(c)]. Thus we may in general refer to case extensions of initial functions.

3. <u>Semantic Case Theory</u>

From (8) we have seen that given an arbitrary batS in an arbitrary L there are at least four ways it might be semantically interpreted. Usually however batSs in a language are not four ways ambiguous (or vague). (9a) from English has only two truth conditionally distinct readings and (9b) has only one.

(9) a. Every student kissed some teacher
    b. John kissed David

Neither of these Ss is <u>argument ambiguous</u>. E.g. (9b) is not ambiguous (or vague) according as (b,d) ∈ KISS or (d,b) ∈ KISS. Clearly then English constrains the acceptable interpretations of its batSs over and above what is logically possible. One statement of these constraints is given by:

(10) <u>English Case Constraint</u> (ECC)

> In a batS of the form [NP_1 [V NP_2]], interpret NP_2 accusatively and NP_1 nominatively

The ECC is a claim about English and thus naturally refers to structural properties of English Ss, such as linear order and constituency with the verb. But the ECC also instantiates several quite general properties concerning the ways in which languages constrain the interpretations of simple Ss. Three such constraints are given below. I take them as the axioms of Semantic Case Theory in the sense that all natural languages are held to satisfy them.

(11) <u>Case Existence</u> (CE)

> The independent NPs in a batS are interpreted by case extensions of the basic functions they denote

The motivation for this axiom is given by the <u>Argument Structure Theorem</u> in section 5. In essence the theorem says that NOM and ACC are the only ways a basic function may be extended to binary relations so that basic NPs in transitive contexts preserve, in a uniformly retreivable way, the meaning they have in intransitive contexts. If CE failed generally we would not be able to determine the truth conditions of batSs (up to scope and subject/object ambiguities) given the denotations of the basic NPs and the P_2. So CE rules out e.g. that <u>every student</u> might mean <u>not a single student</u> when in collocation with a transitive verb. Ultimately then the motivation for CE is that we interpret familiar items in complex contexts in the same way as in simple ones, the only differences being induced by the complex context itself i.e. does the NP function as logical subject or object, does it have wide or narrow scope. These are questions which cannot arise in intransitive contexts.

(12) <u>Case Distinctness</u> (CS)

> The independent NPs in a batS are interpreted by distinct case extensions

The reader may compute that if both NPs in a batS like <u>John kissed David</u> were interpreted nominatively (or both accusatively) the S would be argument ambiguous (depending on which NP had narrow scope (= took KISS as argument).

Note that CE and CD jointly claim than an interpretation of a batS determines a bijection from the independent NPs into the set {NOM,ACC} of semantic cases. They do not preclude however that a given batS have two such interpretations. So the axioms so far eliminate some but not all possibilities of argument ambiguities.

It is easily seen that the ECC satisfies CD and CE (with respect to the batSs it quantifies over).

A third general property possessed by the ECC is that case interpretations of the NPs in a batS are determined as a function of the structure of the S. Thus we want an axiom which guarantees that Ss with the same structure (regardless of what it is) have their corresponding NPs assigned the same case.

(13) Case Structure (CS)

> Let T and T' be nuclear transitive Ss such that T is derived from (NP_1, NP_2, V) in the same way that T' is derived from (NP_1', NP_2', V'). Then,
>
> if an interpretation f interprets NP_1 and NP_1' by case extensions of initial functions then these case extensions are identical (i.e. both nom or both acc)

E.g. given that (14a) is derived from (John, David, Kiss) in the same way that (14b) is derived from (David, John, Kiss), CS tells us that there is no interpretation f of English which interprets these Ss with the case extensions indicated.

(14) a. John kissed David — John: nom, David: acc b. David kissed John — David: acc, John: nom

(Clearly the ECC guarantees this by blocking (14b)). Note that if there were such an interpretation f then these two Ss would have a reading on which they were logically equivalent, which is empirically false.

In the statement of CS, we quantify over nuclear Ss, not just basic ones, whence the NP variables range over NPs in general, not just basic (or even deictic ones, see section 4.3) ones. The *if* clause in CS is needed since some non-basic NPs are interpreted by functions which are not case extensions of any initial function. CS may be further refined by requiring that the corresponding NPs match in syntactic and semantic subclass.

To appreciate how our axioms constrain the possible Case Constraints (CCs) languages may present, consider that CS rules out ECC* below as a possible English Case Constraint.

(15) ECC* In batSs of the form [NP_1 [V NP_2]] interpret NP_2 accusatively unless it begins with a vowel, in which case interpret it nominatively

Given that Mary kissed Ellen is derived from (Mary,Ellen,Kiss) in the same way that Ellen kissed Mary is derived from (Ellen,Mary,Kiss) we infer from CS that the second NPs in these Ss must have the same semantic case, contradicting ECC*.

The empirical nature and generality of the three axioms in constraining how natural languages may interpret batSs may be further elucidated by contrasting the ECC with the Japanese CC below. Note that in general, having adopted the axioms, we may avail ourselves of them in stating CCs. For example, the ECC can be given by: "In a batS containing a VP of the form [V NP] interpret that NP accusatively". That the other NP, however presented, is interpreted nominatively follows from this statement plus CE and CD.

(16) Japanese Case Constraint (JCC)[2]

> In a batS, interpret an independent NP suffixed -o accusatively if there is one; otherwise interpret some -ga suffixed NP accusatively

The JCC entails, correctly, both that (17a) is not argument ambiguous and that (17b) is.

(17) a. Taroo-ga Hanako-o nagutte
Taroo Hanako hit
"Taroo hit Hanako" *"Hanako hit Taroo"

b. Taroo-ga Hanako-ga suki
Taroo Hanako likes
"Taroo likes Hanako" or "Hanako likes Taroo"

(I am indebted to George Bedell for these examples and much relevant discussion, cf footnote 2).

The JCC differs in several respects from the ECC. First it does not refer to linear order or VP constituency[3] but rather to the system of NP morphological markings. Second, in distinction to the ECC, the JCC permits argument ambiguities in the class of batSs it quantifies over. The reader may compute that the ECC does not allow two interpretations for a batS of the form [NP_1 [V NP_2]] one of which interprets NP_1 nominatively and NP_2 accusatively and the other of which does just the opposite.

Third, the existence of Case Constraints for two languages presents an empirical consequence not derivable from the CC for any given L. It says that a structurally identified NP in one L is interpreted by the same case extension as that of some differently identified NP in the other L. And this has empirical consequences in terms of translation equivalences. Thus in a situation in which the Japanese expressions in (17a) have the same denotations as their English glosses and in which the equivalently denoting NPs are interpreted in the same case extensions, it follows that the Japanese S and the English Taroo hit Hanako have the same truth value. That is, the one is judged a translation of the other.

In the actual practice of linguists, in my judgment, it is to a significant extent these translation equivalences on which we rely in determing which NP is "subject" and which "object" in a language we are studying. It is then an advantage of the approach taken here that it entails translation equivalences.

Note in this regard that on the basis of English alone it is quite arbitrary that we assigned NP_1 nominative case and NP_1 accusative. The opposite assignment would have satisfied the axioms just as well. Comparable remarks obtain for Japanese. But once the CC for one of these Ls is given that for the other ceases to be arbitrary in this respect. Had we chosen to interpret -o marked NPs nominatively... in Japanese then the translation of (17a) would be judged to be Hanako hit Taroo. But it isn't.

Finally we observe that the use of morphological markings on NPs to code semantic case interpretation is very widespread among the world's languages. In one way or another it is used in Ls as diverse as Latin, Warlpiri (Australia), and Tagalog (Philippines). As is well known, batSs in Warlpiri present all six relative orders of the two NPs and P_2 with about equal freedom. (18) is a Warlpiri S and (19) gives the WCC.

(18) Ngarrka-ngku karli-∅ jarntu-run
man boomerang trim -past
"The man trimmed the boomerang"

(19) Warlpiri Case Constraint (WCC)

In batSs, interpret a -ngku marked NP nominatively if there is one, otherwise interpret a -∅ marked one nominatively

The WCC is stated with sufficient generality to (correctly) interpret batSs formed from P_2s translating "wait for", "accompany", in which one NP is marked -∅ and the other -ku (called "dative" in Warlpiri grammars). Thus both Warlpiri and Japanese show that there is no one to one relation between morphological markings and semantic case assignment. In general in such Ls markings on both NPs must be checked to determine semantic case.

We have so far illustrated VP constituency and NP morphology as indicators of semantic case. Linear order of elements will be crucially referred to in "VSO" languages like Maori (Polynesian), Nandi (Nilo-Saharan), Welsh (Celtic), and Jacaltec (Mayan). There batSs have the form [V NP_1 NP_2] with NP_1 interpreted nominatively and NP_2 accusatively. By contrast [V NP_1 NP_2] Ls like Tzeltal (Mayan), Malagasy and Fijian (Malayo-Polynesian) ,nterpret NP_1 accusatively and NP_2 nominatively.

Less widely realized perhaps, though discussed in Keenan (1979), is that verbal morphology is also an indicator of semantic case. Schachter (1984) provides an important example for our later discussion from Toba Batak (Malayo-Polynesian; Sumatra).

(20) a. Mang-ida si Ria si Torus
see art Ria art Torus
"Torus sees Ria" *"Ria sees Torus"

b. Di-ida si Torus si Ria
see art Torus art Ria
"Torus saw Ria" *"Ria saw Torus"

P_2s in Toba are presented with one of two prefixes (see Schachter for many details), an M- prefix and a D- one. Main clause Ss with M- verbs are interpreted "imperfectively", e.g. the action is presented as continuous or habitual. Main clause Ss with D- verbs are by contrast interpreted "perfectively"--the action is presented as a single undivided whole. So for example speakers tend to reject main clause M- forms where the verb is inherently perfective, such as pukkul 'hit' (though such forms occur in subordinate structures).

I note further that both verb forms above are transitive in requiring two independent NPs. Moreover Schachter argues in convincing detail that regardless of the verbal prefix, the immediately postverbal NP forms a syntactic constituent with the verb. Thus the Toba CC can be given:

(21) Toba Batak Case Constraint (TBCC)

In batS including a constituent of the form [x-V NP] interpret NP accusatively if x = M- and nominatively if x = D-

Thus, in contrast to English, Toba presents one type of batS (D- ones) in which the NP which forms a constituent with the transitive verb is interpreted nominatively rather than accusatively. Crucial here in establishing case assignment is that if the immediate postverbal NP in D- Ss were accusative then (20b) would be translated as "Ria saw Torus", which is in fact incorrect.

We see then that CCs may refer to VP constituency, linear order, and both verbal and nominal morphology. In addition they may also refer to verb agreement paradigms and NP subclass (e.g. definiteness, animacy, etc.).

4. Consequences of the Theory

4.1 Subjects and Objects

Consider commonplace linguistic generalizations like:

(22) a. Turkish is an SOV language; Hixkaryana is OVS

b. In batSs in English, the subject is the AGENT and the object is the PATIENT or THEME

Aside from a certain looseness in formulation, these generalizations suffer a methodological drawback. Namely, what prevents us from identifying NP occurrences ad hocly as "subject" and "object" so as to make the generalizations true? Clearly to be empirically significant we need some language general definition of these notions.

Within SCT as so far developed a solution to this methodological problem is at hand. Simply replace 'subject' and 'object' in (22) by 'nominatively interpreted' and 'accusatively interpreted' respectively. This move does not resolve all the problems associated with (22) but it does remove the empirical circularity one. It enables us to say e.g. that Toba Batak is neither a VOS language nor a VSO one. Some batSs (M- ones) have a VOS order and others (D- ones) have a VSO order.

The generalization in (22b) is given to emphasize that semantic cases as used here are independent of "theta roles" (AGENT, PATIENT, etc.). It is logically possible that batSs formed from certain verbs associate the nominatively interpreted NP with AGENT and their accusatively interpreted one with PATIENT whereas batSs formed from other P_2s would exhibit the opposite association. While I do not know of such cases in English we do find verb pairs such as like and please which (approximately) interchange their theta roles. Viz. the nominatively interpreted NP in John likes this book is associated with the theta role of experiencer whereas in This book pleases John it is the accusatively interpreted NP which is assigned this role. (I am indebted to Aryeh Faltz for discussion of these points).

4.2 Quantifier Scope Ambiguities (QSAs)

I claim here that SCT provides an explanatory account of the existence of QSAs. Observe first that our axioms have been largely concerned with argument structure and not with (semantic) scope. This is because natural languages commonly tolerate scope ambiguities (in distinction to argument ambiguities). Ls could perfectly well mark scope syntactically. Imagine English enriched with a suffix blik which attached to an independent NP in a nuclear transitive S just in case that NP was interpreted as taking the binary relation as argument, that is, just in case it had narrow scope. But generally speaking Ls do not present such scope markers in simple Ss. Why not? I claim this is due to the joint effect of (Q.1) and (Q.2) below:

(Q.1) In nuclear transitive Ss in which at least one of the independent NPs is individual denoting there is no communicative advantage in marking scope since the two scope analyses have the same truth conditions

(Q.2) Scope ambiguities arise as an artifact of presenting Quantified NPs (QNPs, = ones that do not always denote individuals) in the same syntactic format as individual denoting NPs

In support of (Q.1) note that, like batSs in general, elementary batSs such as *John kissed David* have two scope analyses. On the "David wide scope" analysis it says (paraphrasing the formal statement) that David has the property that John kissed him. On the "David narrow scope" analysis it says that John has the property that he kissed David. These statements are obviously truth conditionally identical. Moreover the lack of truth conditional ambiguity remains (Thm-1) when either NP is replaced by any basic NP or any deictically interpreted NP. E.g. the "noone wide scope" reading of *John kissed noone* says that noone has the property that John kissed him. The narrow scope reading says that John has the property that he kissed noone.

(23) *Thm-1* For all basic F and all individuals I,

a. $I_{nom}(F_{acc}(R)) = F_{acc}(I_{nom}(R))$ and

b. $F_{nom}(I_{acc}(R)) = I_{acc}(F_{nom}(R))$

Thus for what we may take to be the most widespread and earliest learned batSs--those with at most one QNP--there is no reason to mark scope. Scope ambiguities arise only when both NPs in a batS are quantified (and not always then). Thus QSAs are expected in a language in which QNPs may be presented in the same format as individual denoting ones.

I note in further support of the above claim that psycholinguistic research, such as Lee (1986) and Donaldson & Lloyd (1974), strongly supports that Ss with at most one QNP are understood much earlier than those with two. The detailed work by Lee showed both for Mandarin and English that simple singly quantified Ss like "All the pandas are asleep" were understood with adult competence by age 4 (but not age 3). But even by age 8 the child's performance lagged behind that of the adults for Ss with two QNPs.

Compare the view of QSAs presented here with others in the literature. In Montague's work multiply quantified Ss are instances *structural homonymity*: Syntactically they are derived in more than one way, the distinct derivations being compositionally associated with distinct truth conditions. Montague's analysis then is explanatory in the sense used here, but the explanation is different. The Ss are ambiguous because they are really two (or more) different syntactic structures with the same phonological interpretation. They are thus on a par with classical cases of structural homonymity like *Flying planes can be dangerous* and *The chickens are ready to eat*.

Despite the forceful presentation in Partee (1975), however, syntacticians have not in general found it fruitful to assign distinct syntactic analyses to Ss like (9a) Every student kissed some teacher. In partial support for the syntacticians' intuitions here I note that QSAs seem to lack the accidental character of the ambiguities in the classical cases of structural homonymity and they seem to elicit rather different sorts of reactions from native speakers. In the classical examples speakers seem antecedently clear about the two meanings but are surprised to have pointed out to them that the given phonological (or orthographic) string can be analyzed in such a way as to signify either of those meanings. In Ss presenting QSAs however we rather seem to have to teach even sophisticated speakers what the two meanings are.

To the extent then that the structural homonymity approach to QSAs is not independently supported we may say that Montague's explanation is not the correct one.

On more usual treatments within Linguistics, such as May (1977) and Higginbotham & May (1981), multiply quantified Ss like (9a) are not syntactically generated in two or more different ways, but they are assigned two "logical forms" structurally reminiscent of the distinct syntactic representations on Montague's treatment. On this view then scope ambiguities are surprising. The Ss are not syntactically ambiguous but they are semantically ambiguous as though they were. On our view of course these ambiguities are not surprising. They result from the fact that quantified NPs are treated in the same syntactic format as individual denoting ones and the language doesn't mark scope there.

4.3 Passives and Reflexives

The Ss in (24) illustrate respectively a reflexive and a passive construction in (Standard) English.

(24) a. Every student shot himself
b. Every student was shot

The reflexive pronoun himself in (24a) may be interpreted by the function SELF from binary relations to properties given in (25).

(25) $SELF(R) = \{b: (b,b) \in R\}$

The correct interpretation for (24a) then is given by applying the nominative extension of EVERY STUDENT to SELF(SHOOT).

In (24b) the passive predicate was shot is (a complex) intransitive. It may be derived from the transitive shoot by a (broadly) morphological function from P_2s to P_1s interpreted by the function PASS from binary relations to properties given below.

(26) $PASS(R) = \{b: \text{for some } a, (a,b) \in R\} = RanR$

The correct interpretation of (24b) then is given by applying the EVERY $STUDENT_{nom}$ to PASS(SHOOT).

We observe that both across and within Ls Passive and Reflexive have very much in common. Morphologically they are both commonly expressed in the verbal morphology. Indeed in many Ls, such as Quechua, Hixkaryana and Russian the same morphology is sometimes interpreted as passive, sometimes as reflexive. Semantically as well they are similar. SELF(R)   PASS(R) and thus John shot himself entails John was shot. And syntactically, like NPs in general, both Passive and Reflexive combine with P_2s to form P_1s. But there are a few striking differences in the way Passives and Reflexives are expressed in languages:

(27) Passive in distinction to Reflexive is never expressed by a structurally accusative NP

(An independent NP occurrence is said to be structurally accusative (nominative) if its replacement by a basic NP may be interpreted accusatively (nominatively).)

Thus (27) says that there is no language which is like St.Eng. except that it presents an NP blik with the property that Ss like (28a) are logically equivalent to those in (28b).

(28) a. NP kissed blik   b. NP was kissed

For supporting data on the forms Passives may take see the survey in Keenan (1985). Now the issue is this: Is (27) simply an artifact of our data or is the gap in the expression of Passive principled? The answer is the latter. In fact, unexpectedly, (27) follows from our axioms given how Passive is interpreted. Thus,

(29) Thm-2
- a. There is no basic function F such that $F_{acc}(R)$ = PASS(R), all R
- b. There is a basic function G such that $G_{nom}(R)$ = PASS(R), all R. Namely, G(p) = 1 iff $p \neq \emptyset$, all properties p.

The G given in (27b) is naively just the denotation of some individual or perhaps more exactly someone or something. Now by (29b) Passive is interpreted as a case extension of a basic function, hence the Case Structure axiom applies, whence the structurally accusative blik in (28a) must be interpreted by an accusative case extension of an initial function. But this contradicts (29a). Thus no language with Passive interpreted as indicated can present Passive as a structurally accusative NP.

Theorem 3 below shows that the same argument does not apply to Reflexive.

(30) *Thm*-3: It is not the case that there is a basic function F and a case extension k such that $F_k(R) = SELF(R)$, all binary relations R.

Thus the CS axiom does not apply and Reflexive is free to be expressed as an NP. Of course one might still wonder why something not interpreted as an extension of an initial NP *should* be expressible by an NP. This question among others is answered in the next section. Note that in St.Eng. (and in many other Ls, such as Hindi, Korean, and Malagasy) the reflexive pronoun *himself* is an NP. It occurs in an NP position, it takes the morphological markings of NPs (*himself*, **heself*), and coordinates with basic NPs, as in *John criticized both himself and Paul*.

4.4 Anaphora

The farthest reaching consequences of SCT and its extensions (below) concern the domain of anaphora. We have already observed that St.Eng. *himself* in (24a) is interpreted by a function from binary relations to properties which does not extend any basic function. The same is true of the structurally accusative NPs in (31):

(31) a. John criticized himself and noone else, only himself and Paul, noone but himself, everyone but himself, neither himself nor the other students who came late

b. Each student tackled a problem that ____
was chosen by someone other than himself
noone but himself could solve
only himself and the teacher could solve

To account for why these expressions are syntactically NPs we should like to find some non-trivial property they have in common with basic NPs when accusatively interpreted. The property in question is given by the accusative anaphor condition (32b) below. Informally, it will say that an accusative anaphor X satisfies e.g. the condition: "If John hugged the same objects he kissed then John hugged X iff John kissed X". Formally, we define:

(32) For H a function from binary relations to properties,

a. H is a *nominative anaphor* iff for all R,S and all $b \in E$ if $R^b = S^b$ then $b \in H(R)$ iff $b \in H(S)$

b. H is an *accusative anaphor* iff for all R,S, b as above if $R_b = S_b$ then $b \in H(R)$ iff $b \in H(S)$

c. H is a *proper anaphor* iff H satisfies (39a) or (39b) and H is not a case extension of an initial function (restricted to R, the set of binary relations)

d. A NP X is an anaphor iff some independent occurrence of X in a nuclear S is interpreted as a proper anaphor. An anaphor is called essential if all independent occurrences are interpreted as proper anaphors; otherwise it is non-essential

The definitions in (32) have several properties of interest. First it is easily seen that accusative extensions of basic functions satisfy the accusative anaphor condition in (32b). It is just a special case of (33b) below which characterizes which functions from **R** into P (the set of properties of the model) are expressible by basic NPs.

(33) Case Extensions Theorem (CET)

Let H be a function from **R** into P. Then,

a. there is a basic function F such that for all R, $H(R) = F_{nom}(R)$ iff for all binary relations R,S and all entities a,b if $R^a = S^b$ then a $\in$ H(R) iff b $\in$ H(S)

b. there is a basic F such that for all R, $H(R) = F_{acc}(R)$ iff for all R,S and all entities a,b if $R_a = S_b$ then a $\in$ H(R) iff b $\in$ H(S)

As it is easily seen that there are functions from **R** into P which fail to satisfy (32b) we have found a non-trivial condition which anaphors in St.Eng. have in common with basic NPs and in this sense accounted for why it is reasonable that anaphors are presented as NPs. See also Szabolsci (this volume) for a related perspective here. Note in this regard that what we are calling the nominative extension can be expressed in categorial terms by composing the P_2 with the "subject".

A more important feature of the definition of anaphor given in (32) (for the limited range of nuclear Ss considered) is that the definitions in (32a,b,c) are purely semantic. It thus makes non-circular sense to ask of an NP in some L whether it is an anaphor or not. For example, it is easily seen from (31) that St.Eng. presents denumerably many essential anaphors.

Note that most linguistic approaches to anaphor assume that the anaphors (essential or not) can simply be listed. But the above observation tells us that it is not even obvious that the essential anaphors in a L can be syntactically defined. As is well known, even in very tractable formal languages semantically defined subsets of the expressions may not admit of a syntactic characterization. E.g. the set of formulas in ordinary (second order) arithmetic is a recursive set, but the set of logically true formulas is not even recursively enumerable, much less recursive.

Given (32) then we may expect to make empirically non-circular generalizations concerning anaphors. For example:

(34) Anaphor Universal (AU)

All natural languages present NP anaphors

AU puts a certain lower bound on the expressive power of natural languages. As I indicate below however AU cannot be strengthened by replacing anaphor with essential anaphor.

Two further generalizations, which follow from SCT, are:

(35) Basic NPs are not anaphors

This follows immediately from Case Existence. A basic NP occurring independently in a nuclear transitive S must be interpreted by a case extension of the basic function it denotes and thus cannot be interpreted as a proper anaphor. Thus we rule out Ls which would be like English except that John was interpreted as himself when structurally accusative. More deeply,

(36) Anaphor Deixis Link (ADL)

For V a simple P_1 and A an anaphor, either [A V] is ungrammatical or A is interpreted deictically

If A is an anaphor then from (35) it is not basic, whence either it is not initial (so [A V] is ungrammatical) or else it is deictic. Given that reflexives like himself in St.Eng. lack a deictic interpretation then we infer from ADL that:

(37) *[Himself V]

Note that GB (Government Binding) theory also predicts (37), and without the assumption that himself lacks a deictic interpretation. GB needs only Principle A of the Binding Theory (BT) and that himself is in their English anaphor list. (37) then follows since himself is not coindexed with a C-commanding NP, there being none. SCT differs here from the BT in that it predicts that there could exist Ls which would be like St.Eng. except that the anaphor himself occurred with intransitive verbs and was interpreted deictically. SCT makes the correct prediction here as there are several such languages.

First, consider the Irish dialect of English. There an office worker might say to another who arrives late "Careful. Himself is in a foul mood today" meaning "The boss is in a foul mood". Thus in addition to its anaphoric interpretation Irish himself may be deictically interpreted to mean "the ranking individual in context".

Lest the Irish example appear "weird" consider the comparable cases in Japanese. There the standard reflexive anaphor *jibun* may also be interpreted deictically to mean "the individual from whose point of view the utterance is given". That individual will normally be the Speaker if the utterance is declarative, and the Addressee if the utterance is interrogative or imperative. (38) below from Sakaguchi (1985) is illustrative.

(38) a. Hanako-ga jibun-o utagatte-iru
Hanako doubts
"Hanako doubts herself" or "Hanako doubts Speaker"

b. Jibun-ga Hanako-o utagatte-iru
Hanako doubts
"Speaker doubts Hanako" *"Hanako doubts herself"

I may note here that recent work in generative grammar has been much interested in anaphora and little interested in deixis, and in consequence the deictic interpretations of *himself* in Irish and *jibun* in Japanese are regarded with modest hostility. I shall take a moment then to emphasize the very widespread facts from several areas of grammar which show that a given expression may have both deictic and anaphoric uses.

Consider first what on the basis of St.Eng. we might be inclined to regard as "essential deictics", i.e. expressions which only have deictic rather than anaphoric interpretations. Prime candidates here would be first and second person pronouns like *I* and *you*. But in subordinate clauses many languages may use these terms anaphorically, as in (39) below from Kannada (Dravidian; Bhat (1978)).

(39) Nanage bahuma:na bandideyendu ra:ju tilisidda:ne
me to prize come has thus Raju informed has
"Raju informed (me) that I have won a prize" or
"Raju informed (me) that he (Raju) has won a prize"

Anderson & Keenan (1985) provide a brief survey of deictic expressions used anaphorically, citing examples comparable to (39) from Persian and Aghem (Bantu).

Similarly recall the "sequence of tense" phenomena from traditional grammar. In main clauses tense marking is interpreted deictically in terms of the time of utterance. But in subordinate clauses tense interpretation may be relativized to that in the main clause--that is, it is anaphoric. C. Lee (1985) discusses this phenomenon extensively for Korean. For example, the simple present tense in (40a) is interpreted deictically relative to speaking time, as in its English translation. But the same present tense in the subordinate clause in (40b) is interpreted as co-temporal, i.e. anaphorically, with the main clause time.

(40) a. Mary-ka ca -ɨn -ta
Mary sleep-Pres-Dec
"Mary is sleeping"

b. John-ɨn [s Mary-ka ca -ɨn -ta] malha-jəs -ta
John Mary sleep-Pres-Dec say- Past-Dec
"John said that Mary was sleeping"

Anderson & Keenan cite comparable examples from Hebrew.

Returning now to the interpretation of main clause anaphors in Ss like (38), the data present a clear pattern (which holds for Irish as well). When the anaphor is structurally accusative it may be interpreted either anaphorically or deictically. But when it is structurally nominative or the only independent NP in collocation with a P, it may only be interpreted deictically. Observe that English presents denumerably many anaphors in this pattern. Thus the structurally nominative NP in (41a) has only a deictic interpertation while its occurrence in (41b) has both deictic and anaphoric interpretations.

(41) a. Most of the papers he wrote were excellent
b. Each professor likes most of the papers he wrote

St.Eng. appears to differ then from Irish and Japanese in that it presents lexical items like himself which are essential anaphors. But this lexical property of St.Eng. is very far from universal. Keenan (1976) cites N. Frisian (Fering dialect), Middle English(!) and Gilbertese as Ls lacking essential (reflexive) anaphors. Further examples are Iai (Melanesian), Tahitian and Fijian (shown below):

(42) a. a mokuti koya o ira kece
past hit 3sg pl all
"Everyone hit himself" or "Everyone hit him"

b. a mokuti jone o koya
past hit John 3sg
"He hit John" *"John hit himself"

In one respect here however the Binding Theory might appear to make a better prediction than SCT. Note that while SCT predicts (43a) it does not predict (43b) even given that St.Eng. himself is a non-deictic anaphor.

(43) a. *Himself walks
b. *Himself kissed every student

But this lack of prediction is as it should be. (43a) should follow from general principles given the non-deictic nature of St.Eng. himself. There is nothing in (43a) for it to be anaphoric to. But this is not the case in (43b). As (32a) makes clear, it is logically sensible to have nominative anaphors. Indeed the interpretative mechanisms independently needed for St.Eng. permit (43b) to be interpreted with the same meaning as Every student kissed himself. Simply interpret (43b) by first applying SELF to KISS, which we may do as himself is structurally nominative and such NPs may apply to binary relations on "subject narrow scope" readings; and then apply the accusative extension of EVERY STUDENT to the result. We obtain true just in case the students are a subset of those objects bearing the KISS relation to themselves.

Thus (43b) is logically sensible on an anaphoric interpretation of himself and more should be needed to block it than in the case of (43a). Moreover the fact that St. Eng. does not allow (43b) is non-circularly seen to be significant, as logically it could.

To capture the fact in (43b) we might consider enriching the axioms of SCT. A plausible candidate here is:

(44) Nominative Reference Condition (NRC)

> In nuclear transitive Ss structurally nominative NPs are always interpreted as nominative case extensions of initial functions

Basically the NRC says that the referential possibilities of the only NP in nuclear unary Ss are extended to the structurally nominative ones in nuclear binary Ss. The NRC then has the effect of blocking nominative anaphors. I know of no unequivocal counterexamples to the NRC. Moreover the NRC countenances certain cases of anaphora which are not reasonably handled within the Binding Theory. Recall in this regard the D- Ss in Toba Batak in which the structurally accusative NP is higher in the syntactic tree than the structurally nominative one. SCT enriched by NRC predicts the correct distribution of anaphors in this case:

(45) a. [[Di- ida si Torus] dirina]
perf-see art Torus self
"Torus saw himself"

b. *[[Di- ida dirina] si Torus]
perf-see self art Torus

Despite the apparent empirical adequacy of NRC however I am reluctant to adopt it as an axiom of SCT, at least in our current state of knowledge. The main reason for hesitation here is that there seems to me no strong positive reason why it should be true. To be sure, generalizing the referential autonomy of intransitive NPs to a fixed NP in a transitive S has the advantage of providing a uniform "anchor" for anaphors. But generalizing to the structurally accusative NP would have the same advantage. Recall in this regard the ergative-absolutive case marking systems in Ls like Warlpiri (Georgian, Tongan, etc.). In these Ls the structurally accusative NP in a batS is marked in the same way as the only NP in an intransitive S, and the structurally nominative NP has a special marker (the "ergative"). So these Ls have generalized the NP markings from intransitives not to the nominative NP in transitives, as is done in Ls like Latin and Russian, but rather to the structurally accusative NP. Why could there not exist referentially ergative languages just as there are morphologically ergative languages? Perhaps more research will reveal that there are. And if not, more thought is needed to reveal why not.

I conclude here with a proper statement and motivation for the Case Existence axiom. The discussion has some independent interest as it provides a direct characterization of individuals rather than the one given earlier which defines them in terms of entities.

5. The Argument Structure Theorem (AST)

The idea behind the Case Existence axiom and, in effect, the notions of "subject" and "object" it induces, is that there are only two ways in which the interpretations of basic NPs in intransitive contexts can be uniformly extended to account for their interpretations in transitive contexts in such a way that their meanings are preserved.

To build up to a formalization of this idea let h be a function which sends each basic function F to an extension h(F) of F which takes binary relations to properties. We investigate what conditions h should meet. Note that even in a tiny universe with just two elements there are four properties and 16 binary relations and thus 4^{16} = 131,072 functions from binary relations into properties. So there are that many ways any given basic function F can be extended and thus the number of functions h which simultaneously extend all the basic functions lies in the millions. But some of these ways would tell us, for example, that the basic function EVERY BOY would send KISS to the set of objects which didn't kiss a single boy. These functions then do not, intuitively, preserve the meaning of EVERY BOY.

Clearly a first condition that an acceptable extending function h must meet is that it preserve the logical relations among the basic functions. E.g. since NOT EVERY BOY is the boolean complement of EVERY BOY we want that h(NOT EVERY BOY) be the boolean complement of h(EVERY BOY). Thus we want h to be a (complete) homomorphism (c-hom). [Note here that [R --> P], the set of functions from binary relations into properties, is a (complete, atomic) boolean algebra with the operations defined in the obvious pointwise way].

But merely preserving the logical relations in this way is not sufficient. From Keenan & Faltz (1985) we know that any way of mapping the individuals into [R --> P] extends to a c-hom. We must then place requirements on how h behaves at the individuals.

The most obvious requirement is that h must treat all individuals in the same way. E.g. it could not both send John to a function which sent KISS to the set of objects which kissed John and also send David to a function taking KISS to the set of objects which David kissed or to the set of objects which kissed themselves. Thus h cannot really tell what individual it is looking at, and this amounts to saying that h is *automorphism invariant* (AI). A general definition of this notion is given in Keenan & Moss (1984). For present purposes it amounts to the following: Let n be an automorphism of the universe E (i.e. a one to one function from E onto E). Then n extends to an automorphism on all the denotation sets in an obvious way. In particular it sends a property p to $\{n(b): b \in p\}$, an individual I_b to $I_{n(b)}$, and a binary relation R to $\{(n(b),n(d)): (b,d) \in R\}$. Then to say that h is AIis to say that $h(n(I))(n(R)) = n[h(I)(R)]$, all individuals I, all binary relations R, all automorphisms n of E.

In effect this algebraic sounding condition guarantees that e.g. John doesn't suddenly take on the denotation of Fred in a transitive context.

But being an AI c-hom is still not a sufficient condition on h. It would allow for example that h(John) sends KISS to the set of objects that didn't kiss John. So we want to require that h preserve substantive properties of the individuals, not merely respect their distinctness (which is what is imposed by the AI condition).

What are these "substantive" properties? The most obvious is given by the logical equivalence below:

(46) a. John walks but doesn't talk
     b. John walks and it is not the case that John talks

That is, individuals, in distinction to other basic functions, respect the logical structure of their predicates. Thus we want the value of h at an individual I to be a (complete) homomorphism. This will guarantee for example that (*to*) *neither hug nor kiss John* will be interpreted as the same property as (*to*) *not hug John and not kiss John*.

Interestingly however this last condition is still not quite sufficient. Observe that the property of being a c-hom from P into {0,1} *characterizes* the set of basic functions which are individuals. That is, a basic function is provably an individual iff it is a c-hom. But this characterization fails for functions from R into P. Specifically there are many c-homs from R into P which are not, intuitively, proper extensions of individuals. For example the function SELF defined in the text is a c-hom: e.g. *to hug and kiss oneself* expresses the same property as *to hug oneself and kiss oneself*. (In fact SELF is an AI c-hom and uniquely characterized by that property). But clearly extending an individual so that it was interpreted as SELF in transitive contexts would not preserve the meaning of that individual. Thus a further condition on h is required.

In the present context there are several equivalent ways of giving this further condition. The one I prefer both for its intuitive nature and for purposes of extensions of the current treatment is the following: Observe that the set of individuals *individuates* P, the set of properties. That is, whenever p and q are distinct properties then there exists an individual I such that $I(p) \neq I(q)$. In general where K is a set of functions from A into B we shall say that K <u>individuates</u> A iff whenever a and a' are distinct elements of A then there is a function k in K such that k(a) $\neq$ k(a'). And we shall require that the set of extensions of individuals individuates R, the set of binary relations. Writing 2 for {0,1} we now define:

(47) <u>Def</u>: A function h from [P --> 2] into [R --> P] is a <u>logically faithful embedding</u> iff

(a) h is a complete homomorphism and
(b) h is automorphism invariant and
(c) h preserves the <u>logical character</u> of the inds, i.e.

(i) {h(I):I an individual} individuates R and
(ii) for each individual I, h(I) is a c-hom

(48) <u>The Embedding Lemma</u>

A function h from [P --> 2] into [R --> P] is a logically faithful embedding iff either

a. for all basic F, h(F)(R) = {b:F(R^b) = 1} or

b. for all basic F, h(F)(R) = {b:F(R_b) = 1}

Let us (here) write TYPE-1 for the set of functions which take properties to truth values and binary relations to properties. (So the domain of a type-1 function is P $\cup$ R and its range is included in {0,1} $\cup$ P). Then,

(49) <u>Def</u>: A function K from [P --> 2] into TYPE-1 is a <u>logically uniform extension</u> iff

a. K(F) extends F, all basic F and

b. the function K* from [P --> 2] into [R -->P] given by K*(F) = K(F)$\upharpoonright$R is a logically faithful embedding

(50) a. NOM is that function from [P --> 2] into TYPE-1 defined by: NOM(F)(R) = {b:F(R^b) = 1} and

b. ACC is that function from [P --> 2] into TYPE-1 defined by: ACC(F)(R) = {b:F(R_b) = 1}

(51) <u>The Argument Structure Theorem</u> (AST)

NOM and ACC are the only logically uniform extensions from the set [P --> 2] of basic functions into TYPE-1

<u>Remarks</u> The Embedding Lemma extends in the obvious way to the case where h takes basic functions into [R_{n+1} --> R_n], there being n+1 logically faithful embeddings in this case. The extensions of the semantic cases NOM and ACC however are not so trivial once even three place relations are

considered. The general constraint here is that all scope ambiguities must in principle be allowed without inducing argument ambiguities, and this turns out to impose some additional structure on the class of semantic cases.

Footnotes

1. These are the only two possibilities when the two NPs act independently with the P_2. Another option arises however by interpreting the pair of basic functions as a single operator sending binary relations directly to truth values. Under this rubric for example will fall branching quantifier analyses. This option is ignored here but discussed in detail in Keenan (1987b).

2. I simplify here in two respects which do not materially affect the later discussion. First in certain cases -mo is used instead of -ga. Second, normally in main clauses one of the NPs will be topicalized, i.e. fronted with its -ga or -o replaced by -wa. Crucially for our examples the result of topicalizing either NP in double -ga Ss preserves the argument ambiguity. The two Ss only differ with regard to which NP is "topic".

3. Hinds (1973) argues that no NP in transitive Ss in Japanese forms a syntactic constituent with the verb to the exclusion of the other.

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AMBIGUITY: SYNTACTIC AND PRODOSIC FORM IN EMPIRICAL SEMANTICS

Netta Koene

Abstract:
Question: how does natural language manage to convey unambiguous information using ambiguous syntactic forms?
Hypothetical answer: syntax offers a structured set of possible interpretations [an NP can be interpreted in four ways, resulting from two oppositions: '± name' and '± general'] and prosody triggers the one interpretation that is meant [using two minimal pairs of disambiguating prosodic features in the final syllable of the NP].

0. INTRODUCTION

Is semantics an empirical science, does it propose hypotheses about an actually existing semantic system, does it explain how form and content are related in natural language? This question is particularly interesting in the case of ambiguous syntactic form - is there a system at all?

Against the background of this methodological question I will present some semantic observations concerning the following empirical question: how does natural language manage to convey different information using the same syntactic form?

Observation suggests that the lack of information in ambiguous syntactic form is directly and systematically made up for in prosodic form (pitch, rhythme). I will argue that there is a simple, observable pattern in form-content relations if 'form' is understood to be 'syntactic + prosodic form'. Many well-known and seemingly diverse ambiguities will be illustrated to fit this pattern.

Some methodological remarks will be made about one of these phenomena, namely, 'scope of negation'.

1. AMBIGUITY OF SYNTACTIC FORM

1.1. INDEFINITE DESCRIPTIONS

1.1.1. '± NAME'

Syntactic form of natural language is highly ambiguous. This fact can already be illustrated for very simple subject-predicate structures. Take for a start sentences with an indefinite description in subject position. Then compare (1) against (2), (3) and (4):

(1) (a big crowd stood in front of the building)
a woman stepped forward [interpretation I]

against

(2) a problem arises [interpretation II]
(3) a star is born [interpretation II]
(4) one of us is too much [interpretation II]

Compare them asking the question: how is the information conveyed, what is the process of interpretation?

There is a characteristic observational difference in the way the information is processed: in (1), directly after having heard 'a woman', the hearer can take a referent in mind - some woman from the crowd - and about her the sentence goes on to give information - she stepped forward. The sentence is interpreted in two rather independent steps.

This course of interpretation is not possible for the other sentences. So, (2) does not say about some problem that it arises, (3) does not say about some star that he/she/it is born, and (4) does not say about one of us that he/she is too much. Note that these sentences also are not 'about an unspecific referent', they are not 'about' at all.

I will refer to these interpretations as '+ name' and '- name' respectively, and take as observational characteristic: 'the NP can/cannot in isolation from the rest of the sentence be connected with an object talked about'.

I will argue that this is a fundamental distinction.

Next to these '± name' interpretations, there is the general interpretation, as in

(5) a cat is an individualist [interpretation III]

I will return to generics, but first I will address negation.

1.1.2. NEGATION

Add negation to this simple syntactic form, and compare then, for instance,

(6) (four people were killed) a woman is not yet identified [interpretation I]

against

(7) a woman is not yet present (only men arrived until now) [interpretation II]

The resulting ambiguity of syntactic form is generally taken to be one of 'scope': in (6) 'a woman ... not' and in (7) 'not ... a woman'. But there are two good reasons to suppose that this is the '± name' difference again. One reason I will give when addressing intonation, the other argument is a semantic one, namely: the same characteristic observational difference applies as in the positive sentences: in (6) 'a woman' can, in isolation from the rest of the sentence, be connected with an object talked about, one of the victims, and then, a negative fact - 'not identified' - is given about her. This course of interpretation for (7) is impossible. In (7), the sentence as a whole states a negative fact.

1.1.3. 'GENERICS'

The same simple syntactic form can be used to make general statements. But here again, a distinction has to be made. Compare (8) and (9), both having a general interpretation:

(8) a tomcat is a good mouser [interpretation III]

(9) a tomcat is a male cat [interpretation IV]

The truthconditional difference between these sentences may be rather subtle (say: 'accidentally generic' versus 'essentially generic'), but they certainly are very different in the way they are processed. This can be illustrated by the following stories: Because I have mice, I decide to take a cat, preferably a tomcat. So I choose the beautiful red cat from a just born litter of cats in my neighbourhood, because, as you know,

(10) a red cat is a tomcat [interpretation III]

I call him Tom.

At this point, the story has two continuations:

First continuation: To my disappointment, my Tom turns out to be a poor mouser. So, there is a clash between (8) 'a tomcat is a good mouser', and the evidence, my Tom. Now in the future, I will not be so sure of (8) any more. Tom clearly is a counterexample to this rule.

Second continuation, skip the mouser part: To my surprise, after some time my Tom himself has a litter of cats, so she cannot be a male cat. So again, there is a clash between the general rule, in this case (9) 'a tomcat is a male cat', and the evidence, my Tom. Now, will I in the future distrust (9) as I distrusted (8)? Of course not. What we have to conclude instead is, that (9) does not apply to my Tom, she is not a tomcat after all. (9) is a general statement that does not allow exceptions.

Characteristically, the article 'a' in (8) can be replaced by 'every' or 'any', not changing the information very much:

a tomcat is a good mouser

every tomcat is a good mouser.

Replacing the article 'a' by 'every' in (9), however, has an awkward result:

every tomcat is a male cat.

This may be as true as (9) is, but it is strangely beside the point, and it certainly is not a paraphrase of (9).

Rather than stating something about every object that can be independently identified as a tomcat, (9) is understood as a condition to be called 'a tomcat' (to be a tomcat, the object has to be a male cat), or a definition (to be a tomcat is to be a male cat).

This difference is not caused by accidental factors like word meaning, compare the ambiguous (11)

(11) a lady is polite [interpretation III or IV]

which is either: every lady is polite, or: to be a lady, one has to be polite. (For this example, compare also 2.2.2. below.)

Now note the following: the characteristic observational difference I presented for the '± name' difference was: the NP can/cannot in isolation from the rest of the sentence be connected with an object, and about this object the sentence makes a statement. And here, the characteristic observational difference between the two generic interpretations is, that the article 'a' can/cannot be replaced by 'every' or 'any'. But this is in fact the generic version of the '± name' difference. In (8) 'a tomcat is a good mouser', I can isolate the NP 'a tomcat' from the rest of the sentence, connect it with whatever object / any object that fits the description, and about this object the sentence makes a statement. The fact that I process the information this way, is the reason I can replace 'a' by 'every'.

In (9), characteristically, I cannot do that. (9) does not inform me that I, after having found a - whatever - tomcat, can be sure that this tomcat is a male cat. It is the other way around: to know whether I can call an animal 'a tomcat', I will have to make sure that it is a male cat first.

Summarizing: indefinite descriptions, in both positive and negative sentences, can be used '+ name' (interpretation I), '- name' (interpretation II), 'general, + name' (interpretation III), and 'general, - name' (interpretation IV).

1.2. OTHER NOUN PHRASES

1.2.1. DEFINITE DESCRIPTIONS

This much for indefinite descriptions. The following step will incorporate other NPs. Exactly the same observations concerning the ambiguity of syntactic form can be made for sentences having some other NP in subject position, like a definite description, a mass term, or even a proper name. I will illustrate the case of definite descriptions here, and that of mass terms in 1.2.2.

Compare, for positive sentences, (12) against (13) through (16).

(12) the queen of Holland is blond [interpretation I]

against

(13) the Loch Ness Monster exists [interpretation II]

(14) the president is elected (in yesterday's election) [interpretation II]

(15) the tide is coming in [interpretation II]

(16) the winner finishes [interpretation II]

(16), for instance, is not interpreted by first picking a referent for 'the Loch Ness Monster', this monster itself, and then adding the information that this monster exists.

Adding negation, we get, for instance, Russell's ambiquity between primary and secondary occurrence of definite descriptions. Compare

(17) the king of France is not bald [interpretation I]
against
(18) the king of France is not bald because the king of France does not exist [interpretation II]
Note, by the way, that both the positive and the negative 'existence' sentences (13) and (18) are regular examples of '- name' interpretation of the NP: the NP cannot in isolation from the rest of the sentence be connected with an object talked about.

As for general interpretations, compare
(19) the winner gets the pool [interpretation III]
that is: everyone who wins gets the pool,
against
(20) the winner finishes first [interpretation IV]
that is: to be the winner, one has to finish first.
And compare:
(21) the president appoints the ministers [interpretation III]
that is: every president appoints the ministers,
against
(22) the president is elected [interpretation IV]
that is: to be the president, one has to be elected as president.

1.2.2. MASS TERMS
The same points can be made for mass terms. Well-known examples of mass terms in subject position are:
(23) arsenic is poisonous [interpretation III]
and
(24) water is H_2O [interpretation IV]
These sentences parallel the indefinite generics. So, (23) parallels (8) 'a tomcat is a good mouser': they are about any quantity of arsenic and any tomcat respectively, and (24) parallels (9) 'a tomcat is a male cat': they concern any quantity of water and any tomcat respectively, but they are not about them. They are definitions of what it is to be water, to be a tomcat.

Non-generic interpretation of mass terms is very well possible, also in subject position. Compare:

(25) (the wheather was horrible) rain poured down [interpretation I]

This is about a certain quantity of rain, and

(26) soap is in stock [interpretation II]

This concerns a certain quantity of soap, but it is not about it.

So-called 'scope'-ambiguities also are possible, compare:

(27) rain did not stop him (wet to the bone, he kept on trying) [interpretation I]

(28) rain did not stop him (it was dry all afternoon, something else must have happened) [interpretation II]

1.3. COMMUNICATION

This much for the illustration of this empirical fact: syntactic form of natural language is highly ambiguous.

But there is another empirical fact I will just mention here: these ambiguities of syntactic form do not cause mis-communication. It is observably part of everyone's semantic competence to use and understand all the possibilities illustrated above, and one as easily as the others. But, at the moment one uses an NP to say something, one only uses one of the possibilities, and the hearer almost unerringly picks that one out. Both speaker and hearer are not aware of the existence of other possibilities than exactly that one that is used. So, despite the apparent lack of information in syntax, natural language succeeds very well as a communicative devise. The question is: how does it work?

2. HYPOTHESES

2.1. A PATTERN

My hypothetical answer to this question consists of two parts.

Firstly, a simple pattern can be recognized in the different interpretations. The four possibilities observed are the result of the combination of two minimal pairs of semantic features of NP's: '± name' and '± general'. Hypothetically, this scheme holds for positive as well as negative sentences, and for whatever NP.

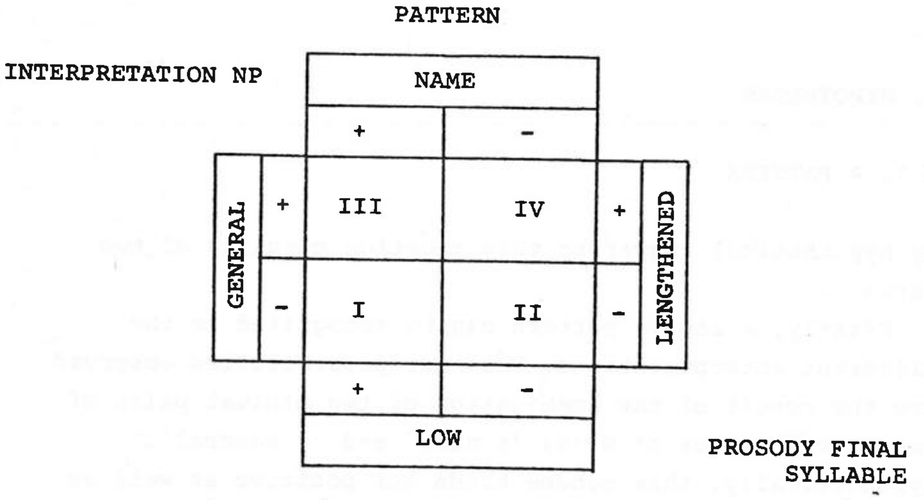
So, the syntactic information offers a structured set of possible interpretations, but it does not offer the information which of the possible interpretations is to be chosen at a certain moment.

2.2. PROSODY

The other part of the answer is, that prosody (pitch and rhythm) directly makes up for the lack of information in syntax. I think it is a case of division of labour: where syntax offers the set of possible interpretations, prosody triggers the one interpretation that is meant. And that at the moment the NP is spoken.

Observation of prosody confirms the pattern. Both the semantic differences made are marked by a minimal pair of prosodic features. One pair signals '± name', the other pair signals '± general'. The first pair is a pitch pair, the second one is a rhythmic pair, and both pairs are situated in the final syllable of the NP.

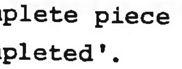
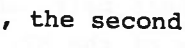
I made my observations for the Dutch language. Intonation patterns for Dutch and English show differences. So, maybe the hypothesis I will formulate to cover the observations for Dutch will have to be reformulated to be applicable to English.



2.2.1. PITCH: '± NAME'

If you drop your voice to base level at the end of an interpretable whole (a phrase, or a sentence), the perceptual effect is that some relatively independent part of the information is finished. This is very perceptible at the end of a sentence.

Now, the same can be observed for the end of the NP: there is a clear difference between, for instance,

 and 

een dominee (a clergyman) — een dominee (a clergyman)

(Stylized pitch contours: 'Dutch School' notation, as developed by Cohen, 't Hart and Collier.)

The first signals: 'a clergyman' has to be taken as a complete piece of information, the second signals: 'not completed'.

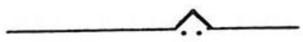
HYPOTHESIS:

In Dutch, the semantic feature '+ name' is signalled by low pitch in the final syllable of the NP: if the pitch is not low already, it is dropped to base level between the top of the final syllable of the NP and its end. The NP is '- name' if that is not the case.

According to this hypothesis, if I say

een dominee
(a clergyman)

or likewise,



een van de dominees
(one of the clergymen)

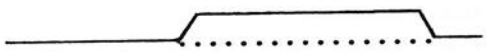
I signal: I am going to talk about someone to whom I refer using the rather arbitrary description 'een dominee (a clergyman)' or 'een van de dominees (one of the clergymen)'. For example, take a clearly ambiguous sentence like

(29) een van de dominees is welkom
(one of the clergymen is welcome)
[interpretation I or II]

(29) will be disambiguated by this pair of pitchfeatures:

een van de dominees is welkom
(one of the clergymen is welcome) [interpretation I]

This means: there is some clergyman, this man is welcome. The contour divides the sentence into two rather independent parts. Compare:



een van de dominees is welkom
(one of the clergymen is welcome) [interpretation II]

This states something about the fact that one or another - one or another - clergyman is welcome. The contour makes this into one fact, takes is all together.

2.2.1.1. THREE REMARKS

First remark. The positive-negative parallel.

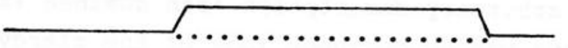
Above, I said that the '± name' difference was present in both positive and negative sentences. I offered a semantic reason. Now I will give the prosodic reason: add a negation to the sentence, do not change pitchcontours, and the 'scope' ambiguity will automatically turn up. Compare:

(29) 

een van de dominees is welkom
(one of the clergymen is welcome
[interpretation I]

(30) een van de dominees is niet welkom
(one of the clergymen is not welcome)
[interpretation I]

Both: about some person, and (30): 'narrow scope negation'.
Against:

(29) 

een van de dominees is welkom
(one of the clergymen is welcome)
[interpretation II]

(39) een van de dominees is niet welkom
(one of the clergymen is not welcome)
[interpretation II]

Both: not about some person, and (30): 'wide scope negation'.

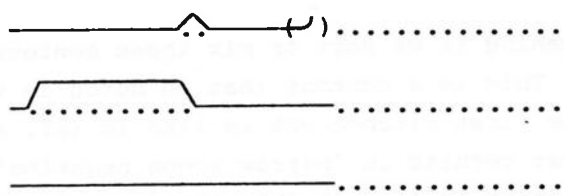
In the pattern, this is the minimal semantic/prosodic difference between I (- general, + name) and II (- general, - name).

Second remark. What the feature is not.
The feature '± low' is a pitchfeature, but it is independent from pitchaccent, or prominence. The distribution of pitch-accents has a function in signalling what is old, and what is new information, topic, focus, etc. Now this is another informative function of intonation. When I say that '+ name / + low' signals that the NP is about an object, I do not mean 'about' in the sense of 'already mentioned'. This is an important point, but I will not go into these questions here.

Third remark. Predictions.
The hypothesis is very general. It predicts the semantic/

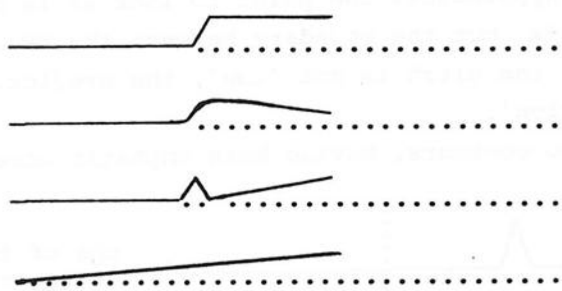
prosodic connection both for positive and negative sentences, in both generic and non-generic interpretations, for any pitchcontour, given whatever distribution of prominence. For Dutch, in their impressive studies, Cohen, 't Hart, and Collier made an exhaustive inventory of the perceptually relevant pitchmovements and pitchcontours. Among the great many ways to say (30), for instance, there is a well-defined number of varietions that are perceptually relevant.

Now, according to the hypothesis, the interpretation of the NP is '+ name' for all those possible contours where the final syllable is '+ low'. That is, for instance, in the following cases:



(30) een van de dominees is niet welkom
(one of the clergymen is not welcome)

And the interpretation is '- name' in, for instance, the following cases:



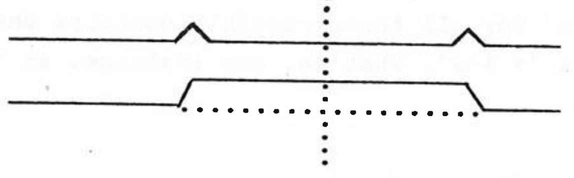
(30) een van de dominees is niet welkom
(one of the clergymen is not welcome)

Together with the idea that 'scope of negation' is the result of the '± name' difference in negative sentences, this leads, for instance, to the following predictions/explanations of pitch/scope connections.

(As can be seen, the same scope interpretation is compatible with a number of rather different pitch contours. That is, because there are many factors contributing to the total information, and the factor in case, the ± name, ± low feature, is just one of these factors.)

Compare the following contours, with two pitchaccents on the same syllables:

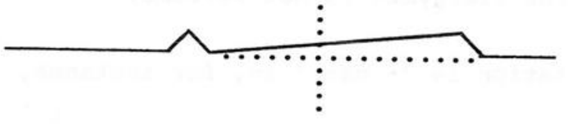
een van de dominees is niet welkom 'PREDICTED SCOPE'
(one of the clergymen is not welcome)



(a) one of the clergymen ... not

(b) not ... one of the clergymen

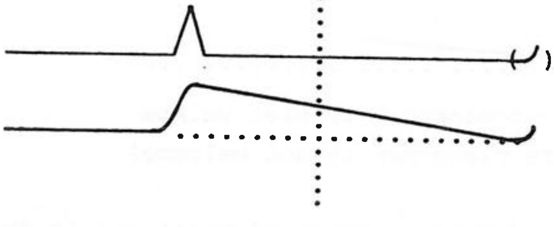
Look what is happening if we sort of mix these contours to form contour (c). This is a contour that in Dutch is very well possible. The first pitchaccent is like in (a), and (a) is the contour that results in 'narrow scope negation', and the second pitchaccent is like in (b), the contour that results in 'wide scope negation':



(c) not ... one of the clergymen

According to the hypotheses, the point to look at is not one of the pitchaccents, but the boundary between the NP and the VP. Because here, the pitch is not 'low', the prediction is: 'wide scope negation'.

And compare two contours, having both emphatic accent on 'do (cler)':

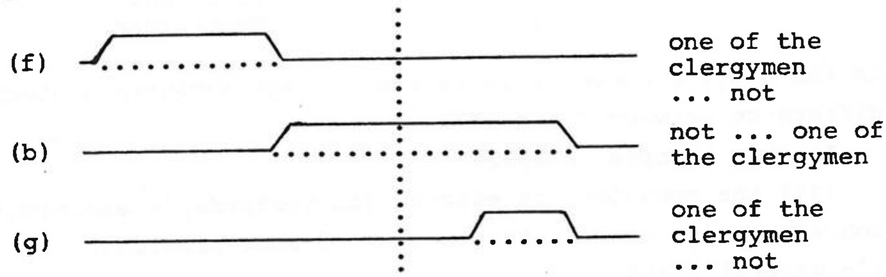


(d) one of the clergymen ... not

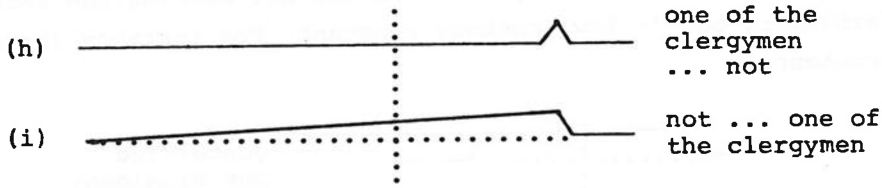
(e) not ... one of the clergymen

If this is correct, it is not the emphasis that causes 'wide scope negation', nor emphasis plus final rise.

And compare the same contour with different distribution of pitch accent:



And compare the following contours, where the NP does not have any pitchaccent at all, possible, e.g., in the contexts where 'one of the clergymen' has been mentioned before:



2.2.2. RHYTHM : '± GENERAL'

HYPOTHESIS: The ± general interpretation is signalled by a rhythmic minimal pair, which is also situated in the final syllable of the NP. An NP of which the final syllable is lengthened gets a general interpretation. This feature may be perceived as a small pause after the NP.

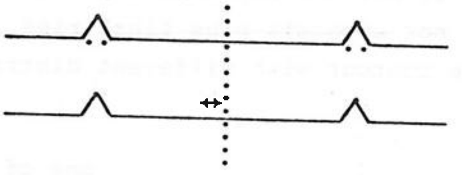
I think, the perceptual effect is something like turning the NP into a conditional: are the conditions for the possible interpretation of the NP fulfilled? [small pause] If so, go ahead.

For instance,

(31) de schoonheidskoningin is aantrekkelijk
(the beautyqueen is attractive)

may be used to make a statement about ('+ name') one beauty-queen ('- general'), or it may be used to make a statement about ('+ name') any beautyqueen ('+ general'). According to the hypothesis, the statement about one beautyqueen can be turned into the statement about any beautyqueen by just lengthening the final syllable ('queen'), keeping the rather

arbitrary but '+ low' contour constant.
For instance:



about one beautyqueen

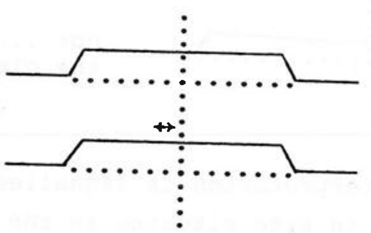
about any beautyqueen

In the pattern above, this is the minimal semantic/prosodic difference between I and III.

Another example, compare

(14) the president is elected (in yesterday's election) concerning ('- name') one election of some president ('- general') and

(32) the president is elected concerning ('- name') the election of the president in general ('+ general'). Again, the difference can be made by lengthening the final syllable of the NP, keeping the rather arbitrary but '- low' contour constant. For instance (Dutch contours):

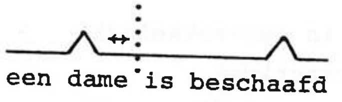


concerning one president

concerning any president

In the pattern above, this is the minimal semantic/prosodic difference between II and IV.

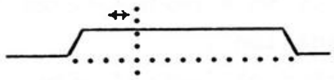
In that pattern, the one minimal difference left to be illustrated is that between III and IV, the two generics. Here, in both cases, the final syllable is lengthened, and it is the contour again that makes the difference ('± name / ± low'). Compare:



(11) een dame is beschaafd
(a lady is polite)

this is about any lady,

and



(11) een dame is beschaafd
(a lady is polite)

this is: to be a lady, one has to be polite.
This may seem a very subtle difference, but there is a crucial difference in what I say, in the same situation, depending on the intonation used. For instance, suppose some woman just made a rude remark, and I react by saying (11). If I use the first contour, the message is: you are a lady allright, but do not do that again. If, however, I use the second contour, the message is: you are not a lady.

If the hypotheses are correct, these subtle nuances are as much part of the semantic system of natural language as for instance 'scope of negation' is.

3. METHODOLOGICAL REMARKS

The hypotheses are on an observational level. This requires some explanation.

In the first place, this does not preclude them from being highly hypothetical. By calling them observational I do not claim truth or self evidence for them. What I do claim, however, is testability over a wide range of data. They predict many ambiguities and semantic/prosodic connections. So, the evidence for the hypotheses has to be of a deductive kind. There is much more to be said about this topic, but I cannot go into detail here.

What I mean by calling the hypotheses nevertheless 'observational' is that they do not offer a semantic theory. All I said about interpretation was highly informal. But I think I did give an indication that language does have an adequately functioning informative form of its own. What I claim is, that if semantics is to have empirical value, then this pattern - if corroborated - has to be accounted for in semantic theory. That is: a semantic theory is not empirically adequate if its interpretation rules do not cover the parallels observed.

4. 'SCOPE' OF NEGATION

To conclude this paper, I want to elaborate this methodological point by applying it to a much debated topic in semantics, namely, 'scope of negation'.

First, some remarks on the notion of 'scope'. The ambiguity of sentences like (30) 'one of the clergymen is not welcome', is generally described in terms of 'scope of negation'. But, at least in cases like this, the notion of 'scope' is not very revealing. In the first place, it does not really explain things in any interesting sense of 'explain': it may give a description of the two possible interpretations of this one syntactic form, but it does not explain the mechanism of language: 'how' is this one syntactic form connected with these two different interpretations?

An if - to bridge the gap - somewhere in the grammar there is supposed to be a level where these sentences are structurally disambiguated, then a fundamental question has to be answered: what is the status of this unobservable level, is it supposed to be a level <u>of</u> natural language, and if so, is it a mentalistic level, and if so, is there any independent evidence for it?

I do not think the notion of 'scope' in connection with negation has explanatory value. I do not deny that it has descriptive value, but also in this respect, it is not as adequate as one might wish. If something like 'narrow scope' exists, which may become 'wide scope', and vice versa, why not in generic sentences? And why not in sentences with preceding negation?

It is a well-known fact that sentences like

(33) a lady is not rude

a negative generic, and

(34) no counterexample was mentioned

a sentence with preceding negation, do not show 'scope' ambiguity. And these are facts any scope-theory has to come to terms with. But there is still another remarkable fact to be observed and explained in sentences like (33) and (34). According to the hypotheses, 'scope' ambiguity is a consequence of the '± name' difference. Now, sentence like

(33) and (34) do not show 'scope' ambiguity, but they do show this more subtle '± name' ambiguity, which in these sentences cannot be described in terms of 'scope'. In (33), exactly the same ambiguity can be observed as in (11), the positive generic.

The same goes for sentences with preceding negation: no 'scope', but a subtle '± name' ambiguity: if 'no counterexample' is '+ low', (34) is about the counterexamples, they exist, but they are not mentioned, and if 'no counterexample' is '- low', (34) states that there has been no mentioning of counterexamples, maybe there are no counterexamples at all. This difference may seem too subtle to mention, but compare

(35) no movement was uncontrolled

This cleary is about the movements, and

(36) no movement betrayed his inner feelings

Here, there are no movements about which any statement can be made.

What is the picture from the perspective of the hypotheses?

That is: there is this very basic, prosodically marked ambiguity of '± name' interpretation for NPs. This '± name' ambiguity may, depending on additional information, surface as a nuance you might want to describe in terms of specificity (compare (29) 'one of the clergymen is welcome'), or it may surface as the difference between accidentally versus essentially generic readings (as in (11) 'a lady is polite'). And only in rather special circumstances this '± name' ambiguity results in something that could be described as an inversion of scope. So, firstly, the presence of 'scope' ambiguity in some negative sentences, secondly, the absence of 'scope' ambiguity in generics and other negative sentences, and thirdly, the presence of this more subtle ambiguity in exactly those cases where there is no 'scope', are seen as consequences of one basic ambiguity in the interpretation of NPs: they name, or they do not name.

I claimed above, that a semantic theory only is empirically adequate, if its interpretation rules cover the parallels observed. In the case of 'scope of negation', that means, that the theory has to offer one pair of interpretation rules covering all these nuances and ambiguities, and predicts the inversion of scope exactly in that small area of its range.

I claim that only if semantic theory meets this criterium, it can hope to offer a real explanation of these phenomena, in the sense that it will really connect observable forms of natural language with their interpretations.

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Nominal Reference and Temporal Constitution:

Towards a Semantics of Quantity

Manfred Krifka

Forschungsstelle für natürlich-sprachliche Systeme

Universität Tübingen

This paper treats important parts of the semantics of nominal constructions (mass nouns, count nouns, measure constructions, plurals) and the temporal constitution of verbal expressions (activities, accomplishments). A theory will be developed which handles the well-known influence of the reference type of NPs in argument position on the temporal constitution of the verbal expression. The distribution of temporal adverbials will be explained.

0. Introduction

In recent years, two topics have been examined in model-theoretic semantics which have been considered to be interrelated, but which nevertheless have escaped a treatment general enough to grasp the interrelation formally.

The first one is the semantics of mass terms and plural terms. Here I will concentrate on some basic facts. Most important, I think, one should not compare mass nouns like *wine* with count nouns like *apple*, because they have different syntactic categories; the first can serve as an NP, whereas the second cannot. One should compare instead expressions like *wine* and *an apple*, or *apples* and *five apples*, or *wine* and *a glass of wine*. The first element in each pair has the property of referring cumulatively (cf. Quine 1960); e.g. if there are two entities to which *wine* applies, this predicate applies to their collection as well. The second member in each pair does not have this property; e.g. if there are two (different) entities to which *an apple* applies, this predicate does not apply to their collection. Let us subsume these properties under the heading of **nominal reference**. Predicates like *wine* will be called **cumulative**, and predicates like *five apples* will be called **quantized**.

The second topic is the semantics of so-called "aspect" or "aktionsarten". As these terms were originally coined to name related, but different phenomena in the morphology of the Slavic and Germanic languages, I prefer a neutral term, namely **temporal constitution**, which was invented as the German term "Zeitkonstitution" by François (1985). Most influential has been Vendler (1957). I will concentrate here on what Vendler calls **activities** and **accomplishments**, which I call **atelic** and **telic expressions**, following Garey (1957). To give a preliminary definiton: A verbal expression is atelic if its denotation has no set terminal point; an example is *run*. On the other hand, a verbal expression is telic if it includes a terminal point; an example is *recover*. This well-known semantic distinction is parallelled by a battery of syntactic tests (cf. Dowty 1979). Most notably, in ordinary, e.g. non-iterative interpretations, atelic expressions allow for durative adverbials like *for an hour*, but do not allow for time-span adverbials like *in an hour*, whereas with telic expressions the situation is reversed.

1.a) John ran (for an hour)/(*in an hour).
b) John recovered (*for an hour)/(in an hour).

That nominal reference and temporal constitution are related became clear in two ways. First, the two concepts have been felt to be semantically parallel. For example, a quantized NP like *an apple* denotes an object with precise limits, just as *recover* denotes an event with precise limits. On the other hand, a cumulative NP like *wine* denotes something without clear limitation, just like what *run* denotes also has no clear limitation. Secondly, it was observed that the reference type of verbal arguments often controls the temporal constitution of the complex verbal expression. Typically, a quantized argument yields a telic verbal predicate, and a cumulative argument yields an atelic one.

2.a) John drank wine (for an hour)/(*in an hour).
b) John drank a glass of wine (*for an hour)/(in an hour).

The first to investigate this effect of the verbal arguments in detail was Verkuyl (1972). He tried to deal with it in the spirit of Generative Semantics with the help of features like [+SPECIFIED QUANTITY], which are projected from the argument to the verb. But Dowty (1979) rightly criticized the feature-based approach: It merely describes the facts, but does nothing to explain them.

Dowty himself, as well as Hoepelman (1976) and Hoepelman & Rohrer (1980), developed theories in the paradigm of model-theoretic semantics to capture the facts in a more explanative way. But it seems to me that the general insight of the feature-based approach, that the arguments and the complex expression have something in common, is lost in the approaches made by Dowty and Hoepelman. Another model-theoretic approach, which is somewhat similar to the one that will be presented here, is Hinrichs (1985). But Hinrichs works in the framework developed by Carlson (1977), whose elaborate ontological structure of stages, objects and kinds leads to rather complicated and non-intuitive formalizations. Furthermore, it can be shown that Carlson's theory falls short in explaining many phenomena of genericity, for which it was developed in the first place.

I will show that a more revealing approach is possible. I will consider only non-generic NPs, because generic NPs have to be handled differently. Furthermore, I restrict the discussion to NPs which are not quantified, although the approach can be extended to cover quantified NPs as well (cf. Krifka 1986 for a more detailed treatment). My main interest here is, so to speak, not the semantics of quantification, but the semantics of quantity.

1. The semantics of nominal reference types

Let us start with a sketch of the syntax and semantics of nominal reference. I draw heavily on the theory given in Link (1983), perhaps the most satisfying one taken from a formal viewpoint. But I will simplify Link's approach to concentrate on aspects relevant to my argument; for example, I will not distinguish individual entities and quantities of matter. On the other hand, I will extend Link's approach to cover quantized predicates and event predicates as well.

1.1 The formal representation language

In the following, I assume a type-theoretic language with function symbols and identity. It is assumed to be extensional to avoid unnecessary complications. I will not characterize it in advance, but will introduce its features step by step when necessary.

First of all, in order to treat distinctions like cumulative and quantized reference, the collection of objects must be captured in a formal way. To do this, let us assume that the realm of objects, including quantities of matter, is characterized by the predicate O. The extension of O has the structure of a complete complementary join semi-lattice without the 0-element. Let $\sqcup_O$ be a two-place operation (the join of objects), and $\sqsubseteq_O$, $\sqsubset_O$, $\circ_O$ two-place relations (part, proper part, and overlap of objects). Then the following postulates must hold for any admissible interpretation:

(P 0)	$\forall x \forall y \forall z[x \sqcup_O y = z \rightarrow O(x) \,\&\, O(y) \,\&\, O(z)]$	(restriction to O)
(P 1)	$\forall x \forall y[O(x) \,\&\, O(y) \rightarrow \exists z[x \sqcup_O y = z]]$	(completeness)
(P 2)	$\forall x \forall y[x \sqcup_O y = y \sqcup_O x]$	(commutativity)
(P 3)	$\forall x \forall y[x \sqcup_O x = x]$	(idempotency)
(P 4)	$\forall x \forall y \forall z[x \sqcup_O [y \sqcup_O z] = [x \sqcup_O y] \sqcup_O z]$	(associativity)

(P 5)	$\forall x \forall y [x \sqsubseteq_o y \leftrightarrow x \sqcup_o y = y]$	(part)
(P 6)	$\neg \exists x \forall y [x \sqsubseteq_o y]$	(no 0-element)
(P 7)	$\forall x \forall y [x \sqsubset_o y \leftrightarrow x \sqsubseteq_o y \;\&\; \neg x = y]$	(proper part)
(P 8)	$\forall x \forall y [x \circ_o y \leftrightarrow \exists z [z \sqsubseteq_o x \;\&\; z \sqsubseteq_o y]]$	(overlap)
(P 9)	$\forall x \forall y [x \sqsubset_o y \rightarrow \exists x' [\neg x \circ_o x' \;\&\; x \sqcup_o x' = y]]$	(complementarity)

The join operation can be generalized to the fusion operation, which maps a set to its lowest upper bound.

(P 10) $$\forall x \forall P [FU_o(P) = x \leftrightarrow \forall x' [P(x') \rightarrow x' \sqsubseteq_o x] \;\& \; \forall x'' [\forall x' [P(x') \rightarrow x' \sqsubseteq_o x''] \rightarrow x \sqsubseteq_o x'']]]$$

It is now possible to define some higher-order predicates and relations to characterize different reference types.

(P 11) $\forall P [CUM_o(P) \leftrightarrow \forall x,y [P(x) \;\&\; P(y) \rightarrow P(x \sqcup_o y)]]$
(P has cumulative reference)

(P 12) $\forall P [SCUM_o(P) \leftrightarrow CUM_o(P) \;\&\; \exists x,y [P(x) \;\&\; P(y) \;\&\; \neg x = y]]$
(P has strictly cumulative reference)

(P 13) $\forall P [QUA_o(P) \leftrightarrow \forall x,y [P(x) \;\&\; P(y) \rightarrow \neg y \sqsubset_o x]]$
(P has quantized reference)

(P 14) $\forall P [SQUA_o(P) \leftrightarrow QUA_o(P) \;\&\; \forall x [P(x) \rightarrow \exists y [y \sqsubset_o x]]]$
(P has strictly quantized reference)

(P 16) $\forall P [SNG(P) \leftrightarrow \exists x [P(x) \;\&\; \forall y [P(y) \rightarrow x = y]]]$
(P has singular reference)

(P 17) $\forall x \forall P [ATOM_o(x,P) \leftrightarrow P(x) \;\&\; \neg \exists y [y \sqsubset_o x \;\&\; P(y)]]$
(x is an P-atom)

(P 18) $\forall P [ATM_o(P) \rightarrow \forall x [P(x) \rightarrow \exists y [y \sqsubseteq_o x \;\&\; ATOM_o(y,P)]]]$
(P has atomic reference)

The last definition says that if P is atomic, then every x which is P contains a P-atom. The following theorems hold, as can be easily checked:

(T 1)	$\forall P [SNG_o(P) \rightarrow QUA_o(P)]$	(T 3)	$\forall P [QUA_o(P) \rightarrow \neg SCUM_o(P)]$
(T 2)	$\forall P [SNG_o(P) \rightarrow CUM_o(P)]$	(T 4)	$\forall P [QUA_o(P) \rightarrow ATM_o(P)]$

In order to treat expressions like *three ounces of gold* or *three rings*, we need a means to represent numbers and measure functions. The representation language, therefore, must contain names for the real numbers and for the common arithmetical operations and relations. Let **R** be a predicate which holds for x iff x is a real number. Then the predicate **AAM_O** can be defined as representing an interesting class of **measure functions**, that is, functions from objects to real numbers, which are **additive** with respect to $\sqcup_O$ and have the **Archimedian property** with respect to $\sqsubseteq_O$, both well-known concepts in measure theory. Let **m** be a variable of one-place individual relations, and n a variable ranging over numbers. Additivity says that m is a extensive measure function with respect to $\sqcup_O$ as the concatenation operation. The Archimedian property says that $\sqsubseteq_O$-parts have to be commensurable to each other.

(P 19) $\forall m[\mathbf{AAM_O}(m) \rightarrow \forall x[R(m(x)) \ \& \ x \geq 0]]$
(mapping to positive real numbers)

(P 20) $\forall m[\mathbf{AAM_O}(m) \rightarrow \forall x,y[\neg x \circ_O y \rightarrow m(x)+m(y) = m(x \sqcup_O y)]]$
(additivity)

(P 21) $\forall m[\mathbf{AAM_O}(m) \rightarrow \forall x,y[\neg m(x)=0 \ \& \ y \sqsubseteq_O x \rightarrow \exists n[n>0 \ \& \ n \cdot m(y) \geq m(x)]]]$
(Archimedian property)

1.2 The semantics of nominal predicates

We will leave the development of the representation language for a while in order to show how it can capture the semantics of nominal predicates. Here, I will not give a formal syntax, but only hint at some conditions the syntax has to meet.

Mass nouns like *gold* clearly should be translated as cumulative predicates, e.g. **gold'**, with **CUM_O(gold')**. It is unclear whether more restrictive translations can be assumed. It has somtimes been claimed that at least some mass nouns refer divisively as well, that is, e.g., that all parts of gold are gold. I do not see any evidence which corroborates this claim. On the other hand, sometimes it has been claimed that mass terms are atomic. I do not see linguistic evidence for this either. I think that the question whether mass nouns are atomic or not should simply be left open.

There is a construction which derives quantized predicates from mass nouns, the so-called **measure construction**, exemplified by *five ounces of gold*. The analysis which is semantically most plausible is that *five ounces*, call it the **measure phrase**, is an operator to the mass noun. Measure phrases, in turn, can be translated on the basis of a number, represented by the numeral (e.g. *five*) and a measure function, represented by the measure word (e.g. *ounces*). But before I give a detailed semantics of the construction, one should note the following:

3.a) five ounces of gold
b) *twenty carat(s) of gold
c) *hundred meters of fifteen ounces of wool

(3.b) shows that the measure function must be extensive. This can be captured in the formal representation if we assume that the admissable measure function must be in the extension of $\mathbf{AAM_o}$.

(3.c) shows that the head noun must meet certain conditions, too. One could, of course, exclude (3.c) syntactically by not allowing two measure phrases within the same level of an NP, but we will see that an exclusion on semantic principles is more general, insofar as it will carry over to adverbial modification (cf. section 3). The reason why (3.c) is bad can be intuitively characterized as follows: The measure phrase serves to "cut out" entities of a certain size from the continuum of entities which fall under the head noun. For my purposes, it suffices to spell out this intuitive characterization with two conditions: The first is that the head noun predicate must refer cumulatively. The second is that the entity to which the whole construction, e.g. *five ounces of gold*, is applied to must have parts which fall under the head noun, e.g. *gold*, but which are measured as being less, e.g. less than five ounces. To capture this notion I introduce a relation $\mathbf{CONT_o}$ (for "continuous"):

(P 22) $\forall x \forall m \forall P[\mathbf{CONT_o}(x,m,P) \leftrightarrow \mathbf{CUM_o}(P) \ \& \ \exists y[y \sqsubset_o x \ \& \ P(y) \ \& \ m(y) < m(x)]]$

A measure phrase like *five ounces (of)* can then be analyzed as in (4); applied to a predicate like gold', this yields (5). The syntactic construction itself is represented by a semantic expression which combines a number and a measure phrase to a predicate operator. Parts of the formula which do not belong to the assertion, but establish some semantical well-formedness conditions, are written after a slash.

4) *five ounces*
$\lambda m \lambda n \lambda P \lambda x[P(x) \ \& \ m(x)=n \ / \ \mathbf{AAM_o}(m), \ \mathbf{CONT_o}(x,m,P)](oz')(5)$
$= \lambda P \lambda x[P(x) \ \& \ oz'(x)=5 \ / \ \mathbf{AAM_o}(oz'), \ \mathbf{CONT_o}(x,oz',P)]$

5) *five ounces of gold*

$\lambda x[\mathbf{gold'}(x) \ \& \ \mathbf{oz'}(x)=5 \ / \ \mathbf{AAM_o}(\mathbf{oz'}), \ \mathbf{CONT_o}(x,\mathbf{oz'},\mathbf{gold'})]$

The first well-formedness condition is satisfied, because *ounce* should be translated by an measure function which is extensive relative to the concatenation of objects, $\sqcup_o$. The second one is satisfied if **gold'** is cumulative, x is not an atom of the predicate **gold'** and has parts which measure less than five ounces, all assumptions that should be uncontroversial. - It can be shown that predicates like (5) are quantized. It suffices to show the following:

(T 5) $\forall m \forall n[\mathbf{AAM_o}(m) \rightarrow \mathbf{QUA_o}(\lambda x[m(x)=n])]$

Proof: Assume to the contrary that $\lambda x[m(x)=n]$ is not quantized, that is, there are two individuals x_1, x_2 with $x_2 \sqsubset x_1$, $m(x_1)=n$, $m(x_2)=n$. Because of complementarity, there is an x_3 with $\neg x_2 \circ_o x_3$ and $x_2 \sqcup_o x_3 = x_1$, and because of additivity, it holds that $m(x_1)=m(x_2)+m(x_3)$. On the other hand, according to our assumption it holds that $m(x_2)=n$, and because of $x_3 \sqsubset_o x$ and Archimedian property, $m(x_3)>0$, and therefore $m(x_2)+m(x_3)=m(x_1)>n$. Thus, we arrive at the contradiction $m(x_1)=n$ and $m(x_1)>n$.

There are more types of nominal constructions which can be analyzed similar to *five ounces of gold,* e.g. *five glasses of wine* or *five spoonful of flour.* Here, the measure function is perhaps not as standardized as *ounce,* but it nevertheless satisfies additivity and the Archimedian property, at least in principle. But then there are so-called **classifier constructions** like *five head of cattle,* which are rare in European languages but abound in languages like Chinese. The main difference from measure constructions is that in classifier constructions, the measure function depends on the head noun. I assume that the representation language has a function symbol **NU**, for "Natural Unit", which yields additive and Archimedian measure functions when applied to nominal predicates. To give an example (without the well-formedness conditions):

6) *five head of cattle* $\lambda P \lambda x[P(x) \ \& \ \mathbf{NU}(P)(x)=5](\mathbf{cattle'})$

$= \lambda x[\mathbf{cattle'}(x) \ \& \ \mathbf{NU}(\mathbf{cattle'})(x)=5]$

Here, *head* bears no semantic information, but is triggered syntactically by *cattle*, a fact which is more obvious in classifier languages. It seems to be redundant to demand both cattle'(x) and NU(cattle')(x)=5. But it is reasonable to assume that NU yields the same measure functions for similar entities. For example, the unit for all living beings is constituted by the organism. Then, NU(cattle') and NU(game') would be the same measure functions, and it makes sense to let the head noun distinguish between (6) and *five head of game*.

We now arrive at **count noun constructions**, like *five rings*. As languages like Chinese use classifier constructions to express these predicates, they should be represented in a similar way. Both constructions are, so to speak, different syntactical means to arrive at the same semantic end. The main difference to classifier constructions is that the reference to a natural unit is built into the head noun, making it a count noun. Compare (7) with (6). Here, COW' is a nominal predicate similar to cattle', which underlies the English count noun *cow*, but which has no direct representation in English.

7) *five cows* $\lambda n \lambda x[\mathrm{COW}'(x) \ \& \ \mathrm{NU}(\mathrm{COW}')(x)=n](5)$
$= \lambda x[\mathrm{COW}'(x) \ \& \ \mathrm{NU}(\mathrm{COW}')(x)=5]$

Count nouns usually come in two morphological forms, singular and plural. But in examples like (7), the plural is triggered syntactically and has no semantic effect at all. This can be seen in expressions like *0 cows* and *1.0 cows*, which have nothing to do with the semantic concept of plurality, but are easily explained if one assumes that *0* and *1.0* trigger syntactic plurality.

But there are **bare plurals** like *cows*, and here the plural has at least the effect of binding the number argument of count nouns. It is clear that the number variable n should be existentially quantified. It can be argued that it should be furthermore specified as greater than 1. But there are examples which show that bare plurals can be used also in case the number of objects is one, and even less then one. For example, if I ate half an apple yesterday, I cannot answer the question *Did you eat an apple yesterday?* with *no*. The single restriction, it appears, is that the entity a bare plural applies to must be "more than 0". We therefore get the following representation:

8) *cows* $\lambda x \exists n[\mathrm{COW}'(x) \ \& \ \mathrm{NU}(\mathrm{COW}')(x)=n \ \& \ n>0]$

But why, then, does a speaker of English use the singular form *a cow* if he has enough evidence that the number of entities he has in mind is one? This can be explained by the following pragmatic rule:

Pragmatic Rule I: If two expressions are of equal complexity, choose the one which is more specific.

With our analysis, *a cow* (to be represented like *one cow*) is semantically more specific than *cows*. On the other hand, one can argue that *cows* and *a cow* are of equal syntactic complexity: although *a cow* consists of two words, *cows* is morphologically marked. Therefore one may implicate that the speaker does not have in mind a single cow when he uses *cows* and has enough evidence for the number of the entities.

It is easy to show that bare plurals come out as cumulative predicates in this approach. For example, it holds that $\mathbf{KUM}_o(\lambda x \exists n[\mathrm{COW}'(x) \ \& \ \mathbf{NU}(\mathrm{COW}')(x)=n \ \& \ n>0])$. This corresponds to the well-known fact that mass nouns and bare plurals behave semantically similar. For example, bare plurals meet the well-formedness conditions for measure phrases; and indeed, measure phrases are allowed, e.g. *five herds of cows*.

I will conclude the discussion of nominal reference with **definite NPs** like *the gold* and *the five ounces of gold*. They pose a problem for the standard analysis of the definite article because the condition of uniqueness is not met with expressions like *the gold*. The valid generalization is that the definite article can be used with cumulative predicates if they have a non-empty extension, and it can be used with quantized predicate if they have a non-empty singular extension. This can be captured by the following analysis:

9) *the gold* $\lambda P \iota x[x=\mathbf{FU}_o(P) \ \& \ P(x)](\mathbf{gold}')$

In this analysis, definite NPs are translated by formulae like $\iota x[x=\mathbf{FU}_o(\delta) \ \& \ \delta(x)]$, where δ is the nominal predicate. This expression refers to the maximal individual, so to speak, to which δ can be applied. If δ is cumulative and has a non-empty extension, then this maximal individual necessarily exists because $\mathbf{u}_o$ is complete. If δ is quantized, then it exists only if δ has singular reference. That is, the condition of uniqueness emerges as a special case which only holds for quantized predicates. Of course, NPs like *the cow* require that the

determiner fills the free number argument of *cow* as well, with the number 1.

2. The semantics of temporal constitution

2.1 A sketch of the underlying semantics of events

We now turn to the semantics of verbal predicates. In order to capture the well-known parallelism between nominal reference and temporal constitution, it is necessary to provide a denotation structure for verbal predicates which is similar to the denotation structure of nominal predicates. This can be done in a semantic framework in the tradition of Davidson (1967), who takes events as basic entities. On these events, a lattice structure similar to the lattice structure for objects can be defined. The following example shows some fundamentals of the semantic representation I have in mind.

10) ***drink*** $\lambda e[\mathbf{drink'}(e) \,\&\, \mathbf{AG}(e,z) \,\&\, \mathbf{PAT}(e,z')]$

↓ ***water*** ↓ **water'**

drink water $\mathbf{COMB}(z')(\lambda e[\mathbf{drink'}(e) \,\&\, \mathbf{AG}(e,z) \,\&\, \mathbf{PAT}(e,z')])(\mathbf{water'})$

$= \lambda e \exists z'[\mathbf{drink'}(e) \,\&\, \mathbf{AG}(e,z) \,\&\, \mathbf{PAT}(e,z') \,\&\, \mathbf{water'}(z')]$

Here, a verb is a one-place predicate of events (I use variables like e, e' to represent events, and I disregard tense). The syntactic arguments (which I call valencies) have no direct counterpart in the semantic representation of the verbal predicate, e.g. in drink'. Therefore, they must be related to the event by thematic relations such as AG and PAT (Agent, Patient). A technical means to achieve this is by use of free variables, which are assigned in a standard way to valencies; e.g. subject to z, object to z'. The syntactic combination of a verb like *drank* and an object like *water* has its semantic counterpart in the combinator COMB, which is to be relativized to the standard variable of the valency which is being bound. COMB then takes a verbal predicate and a nominal predicate, yielding a complex verbal predicate. The semantics of COMB can be given as follows. Here, the variable x is simply existentially quantified, because we only consider valency fillers which can be represented by predicates.

(P 23) $\forall x \forall P \forall Q[\mathrm{COMB}(x)(P)(Q) = \lambda e \exists x[P(e) \;\&\; Q(x)]]$

When all free variables are bound, we get a predicate on events without free variables, the sentence radical. This can be transformed to a sentence by the application of a sentence mood operator, e.g. the declarative operator, which simply binds the event variable with an existential quantifier.

Events are represented by individuals, and they are characterized by the predicate **E**, which is supposed to be disjunct from **O**. I assume that **E** is structured like **O** by a complete complementary join semi-lattice without 0-element, with join $\sqcup_E$ and part $\sqsubseteq_E$; the other definitions of section (1.1) should also apply to **E** in an obvious way.

2.2 The influence of objects

The intuitive insight that atelic expressions are similar to mass nouns and bare plurals, whereas telic expressions are similar to measure constructions and count noun constructions, now can be captured in the formal representation. Basically, telic predicates are quantized, and atelic predicates are cumulative. This corresponds to the fact that, e.g. a proper part of an event of recovering will not be considered as an event of recovering, whereas a proper part of an event of walking will be considered as an event of walking in normal cases, except when it is too small to count as walking. Here, the problem of minimal parts raises its head again, another parallelism to the semantics of nominal predicates.

I will now show how the influence of the reference types of nominal predicates on the temporal constitution of the verbal predicates can also be captured formally. The idea is that, with certain thematic relations, reference properties of the valency fillers affect reference properties of the complex construction. Therefore, one has to assume certain transfer properties of the thematic relations. The following predicates should characterize these properties.

(P 24) $\forall R[\mathbf{SUM}(R) \leftrightarrow \forall e \forall e' \forall x \forall x'[R(e,x) \;\&\; R(e',x') \rightarrow R(e \sqcup_E e', x \sqcup_O x')]]$
(Summativity)

(P 25) $\forall R[\mathbf{UNI\text{-}O}(R) \leftrightarrow \forall e\forall x\forall x'[R(e,x) \;\&\; R(e,x') \rightarrow x=x']]$
(Uniqueness of Objects)

(P 26) $\forall R[\mathbf{UNI\text{-}E}(R) \leftrightarrow \forall e\forall e'\forall x[R(e,x) \;\&\; R(e',x) \rightarrow e=e']]$
(Uniqueness of Events)

(P 27) $\forall R[\mathbf{MAP\text{-}O}(R) \leftrightarrow \forall e\forall e'\forall x[R(e,x) \;\&\; e'\sqsubseteq_E e \rightarrow \exists x'[x'\sqsubseteq_O x \;\&\; R(e',x')]]]$
(Mapping to Objects)

(P 28) $\forall R[\mathbf{MAP\text{-}E}(R) \leftrightarrow \forall e\forall x\forall x'[R(e,x) \;\&\; x'\sqsubseteq_O x \rightarrow \exists e'[e'\sqsubseteq_E e \;\&\; R(e',x')]]]$
(Mapping to Events)

The following postulate covers the notion of iterativity. It is a relation between an event e, an object x and a thematic relation R saying that at least one part of x is subjected to at least two different parts of e.

(P 29) $\forall e,x,R[\mathbf{ITER}(e,x,R) \leftrightarrow R(e,x) \;\&$
$\exists e',e'',x'[e'\sqsubseteq_E e \;\&\; e''\sqsubseteq_E e \;\&\; \neg e'=e'' \;\&\; x'\sqsubseteq_O x \;\&\; R(e',x') \;\&\; R(e'',x')]]$

I assume that expressions like *read a letter* is translated by formulae Φ,

11) $\Phi = \lambda e\exists x[\alpha(e) \;\&\; \delta(x) \;\&\; \theta(e,x)]$

where α represents the verbal predicate (*read*), δ represents the nominal predicate (*a letter*), and θ represents a thematic relation (here, a specific patient relation). In the following, I will examine the effects of some properties of δ and θ on Φ. The verbal predicate α will be considered to be cumulative throughout.

We start with the question: what are the conditions for Φ to be cumulative? Most importantly, Φ is cumulative if δ is cumulative and θ is summative (an example is *read letters*). Proof: Assume e_1, e_2 (not necessarily distinct) with $\Phi(e_1)$, $\Phi(e_2)$. According to the definiton of Φ, there are two objects x_1, x_2 with $\alpha(e_1)$, $\delta(x_2)$, $\theta(e_1,x_1)$ and $\alpha(e_2)$, $\delta(x_2)$, $\theta(e_2,x_2)$. Because α and δ are cumulative, it holds that $\alpha(e_1 \sqcup_E e_2)$ and $\delta(x_1 \sqcup_O x_2)$, and because θ is summative, it holds that $\theta(e_1 \sqcup_O e_2, x_1 \sqcup_O x_2)$. But then $\Phi(e_1 \sqcup_E e_2)$ also holds, and it follows that Φ is cumulative.

(T 6) $\forall P\forall Q\forall R[\mathbf{CUM}_E(P) \;\&\; \mathbf{CUM}_O(Q) \;\&\; \mathbf{SUM}(R) \rightarrow$
$\mathbf{CUM}_E(\lambda e\exists x[P(e) \;\&\; Q(e) \;\&\; R(e,x)])]$

As singular predicates are cumulative as well, albeit in a somewhat pathological way, this result holds for them, too. An example is *read the letter*, which can be analyzed as an activity if the letter is read in an iterative way. This can be captured formally: if Φ is strictly cumulative, θ is summative, and δ has singular reference, then we get an iterative interpretation. Proof: If $\mathbf{SCUM_E}(\Phi)$, then we have two distinct e_1, e_2 with $\Phi(e_1)$, $\Phi(e_2)$. According to the definiton of Φ, there are two objects x_1, x_2 with $\delta(x_1)$, $\theta(e_1,x_1)$ and $\delta(x_2)$, $\theta(e_2,x_2)$. Because δ has singular reference, it holds that $x_1=x_2$, and because θ is summative, it holds that $\theta(e_1 \sqcup_O e_2,\ x_1 \sqcup_O x_2)$. With $\theta(e_1 \sqcup_E e_2,x_1)$, $\theta(e_1,x_1)$, $\theta(e_2,x_1)$ and $\neg e_1=e_2$, the conditions for iterativity are met. Therefore the following theorem holds:

(T 7) $\quad \forall P \forall R[\mathbf{SNG}(P)\ \&\ \mathbf{SUM}(R)\ \&\ \mathbf{SCUM_E}(\lambda e \exists x[P(x)\ \&\ R(e,x)]) \rightarrow \mathbf{ITER}(e,x,R)]$

If we exclude iterative interpretations, then Φ cannot be strictly cumulative. The iterative interpretation can be excluded by claiming uniqueness for events with θ. Then it can be shown that Φ has singular reference, if δ has singular reference. Proof: Suppose to the contrary that there are e_1, e_2 with $\Phi(e_1)$, $\Phi(e_2)$ and $\neg e_1=e_2$. Then there are x_1, x_2 with $\delta(x_1)$, $\theta(e_1,x_1)$ and $\delta(x_2)$, $\theta(e_2,x_2)$. Because θ is unique for events, we have $\neg x_1=x_2$. But this contradicts singular reference for δ. Therefore, the resulting predicate Φ has singular reference, and cannot be strictly cumulative.

(T 8) $\quad \forall P \forall R[\mathbf{SNG}(P)\ \&\ \mathbf{UNI\text{-}E}(R) \rightarrow \mathbf{SNG}(\lambda e \exists x[P(x)\ \&\ R(e,x)])]$

In some cases the iterative interpretation is excluded in the first place, namely with **effected** or **consumed** objects, as in *write the letter* or *drink the wine*. The reason is that an object can be subjected to an event of drinking or writing a maximum of one time in its career. Therefore, uniqueness of events should be postulated for their thematic relations.

Let us now examine the influence of quantized nominal predicates like *a letter*. Under which conditions can we assume that they cause the complex verbal predicate to be quantized as well? One set of conditions is that the thematic role θ must satisfy uniqueness of objects, uniqueness of events and mapping to objects. Proof: We assume to the contrary that δ is quantized, $\Phi(e_1)$, $\Phi(e_2)$ and $e_2 \sqsubset_E e_1$. Then there are x_1, x_2 with

$\delta(x_1)$, $\theta(e_1,x_1)$, $\delta(x_2)$, $\theta(e_2,x_2)$, according to the definition of Φ. Because $e_2 \sqsubset_E e_1$ and θ satisfies mapping to objects, there is an x_3 such that $x_3 \sqsubseteq_O x_1$ and $\theta(e_2,x_3)$. Because uniqueness of objects, it holds that $x_3 = x_2$, and therefore $x_2 \sqsubseteq_O x_1$. Because $\neg e_2 = e_1$ and uniqueness of events, it holds that $\neg x_2 = x_1$, and therefore $x_2 \sqsubset_O x_1$. But this contradicts the assumption that δ is quantized.

(T 9) $\quad \forall P \forall R[\mathbf{QUA_O}(P)\ \&\ \mathbf{UNI\text{-}O}(R)\ \&\ \mathbf{UNI\text{-}E}(R)\ \&\ \mathbf{MAP\text{-}O}(R) \rightarrow \mathbf{QUA_E}(\lambda e \exists x[P(x)\ \&\ \theta(e,x)])]$

This explains why with effected and consumed objects, quantized nominal predicates yield quantized complex verbal predicates, e.g. *write a letter, drink a glass of wine.* If the object is neither effected nor consumed, then quantized noun predicates yield quantized complex verbal predicates only with additional assumptions, e.g. that the relation between e, x and θ is not iterative. This is adequate, as e.g. *read a letter* is not a telic predicate if iterative readings are allowed.

But it does hold even in the iterative case that examples like *read a letter* are atomic, as the respective events are composed from non-iterative parts. The conditions for thematic relations which are relevant to reach this result are that they satisfy uniqueness of objects and mapping to events. With our postulates, we have to assume δ to be strictly quantized, which is not a substantial limitation. Proof: Assume an e_1 with $\Phi(e_1)$. Then there is an x_1 with $\delta(x_1)$ and $\theta(e_1,x_1)$, according to the definition of Φ. Because δ is strictly quantized, x_1 contains a proper part x_2, that is, $x_2 \sqsubset_O x_1$. Because δ is quantized, it holds that $\neg\delta(x_2)$. Because of mapping to events, there is an e_2 with $e_2 \sqsubseteq_E e_1$ and $\theta(e_2,x_2)$. Because of uniqueness for objects, x_2 is the only object with this property. Therefore, there is no x with $\delta(x)$ and $\theta(e_2,x)$. But then $\neg\Phi(e_2)$ holds, and this means that e_1 contains an Φ-atom.

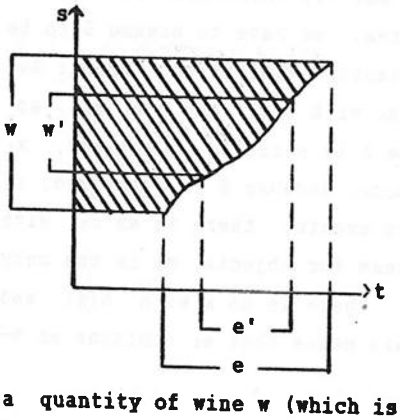
(T 10) $\quad \forall P \forall R[\mathbf{SQUA_O}(P)\ \&\ \mathbf{MAP\text{-}E}(R)\ \&\ \mathbf{UNI\text{-}O}(R) \rightarrow \mathbf{ATM_E}(\lambda e \exists x[X(x)\ \&\ R(e,x)])]$

To conclude this section, I will show in a table the properties of the different patient relations. Here, graduality comprises uniqueness of objects, mapping to objects, and mapping to events; it says that the object is subjected to the event in a gradual manner.

example	summa-tivity	gradual-ity	uniqu. events	label
write a letter	X	X	X	gradual effected patient
eat an apple	X	X	X	gradual consumed patient
read a letter	X	X	-	gradual patient
pat a cat	X	-	-	affected patient
see a horse	X	-	-	stimulus

The most general condition is **summativity**; I assume it for all patient relations, and indeed for all thematic relations whatsoever. By this assumption, so-called cumulative readings can be treated in a simple and intuitive appealing manner. For example, if there are two events, one to be described with *John saw three horses*, the other with *Mary saw four horses*, and if the horses John and Mary saw do not overlap, than the sentence *John and Mary saw seven horses* can be derived if one assumes summativity for the experiencer relation and the stimulus relation.

Graduality seems to be a sound condition, too. Note that not all object relations meet this condition. For example, if I see a horse, I can see the mane of the horse in the same act of seeing, which contradicts uniqueness of objects. But graduality holds for events like reading a book: the book is subjected to the event of reading in a gradual way.



There is a way to visualize graduality, namely by space-time diagrams. In these diagrams, space is represented by one axis, and time by the other. Objects can be represented as lines, or more correctly as bands, because their spatial extension matters. Events can be mapped to the time axis, which will be captured formally in the next section. Now consider e, the event of drinking a quantity of wine w (which is disappearing during the drinking). By this picture, idealized though it is, the intuitive notion that the object is subjected to the event in a gradual manner should become clear. Now consider two possible descriptions of w and, consequently, e. First, let w be described as *wine*, and e consequently as *drink wine*. As *wine* is cumulative, it is normally the case that it can be applied to proper parts of w, like w', too. But then *drink wine* is applicable to the corresponding proper part of e, namely e', as well. Secondly, let w be described as *a glass of wine*, and e consequently as *drink a glass of wine*. As *a glass of wine* is quantized, no proper part of w can be described with *a glass of wine*. But then no proper part of e can be described as *drink a glass of wine* either.

There is a problem, however, with **mapping to objects**. For example, consider *build a house*. There are surely parts of the event of building a house which cannot be mapped to parts of the house. An example is the erection of the scaffold, which is clearly part of building the house, but the scaffold is not a part of the house, and even vanishes when the house is finished. Therefore, mapping to objects does not hold in a strict sense for complex events. In a more detailed formalization, predicates like *build a house* should be analyzed as referring to events consisting of events which fall under different quantized predicates; e.g. the building of a house consists in raising a loan, buying a place, and so on. It can be shown that predicates which are defined in this way, i.e. as referring to fusions of events falling under specific quantized predicates, are quantized, too.

Uniqueness of objects, finally, characterizes those patient relations which describe the coming into being and disappearing of objects. Note that this only holds for object tokens, and not for object types. For example, it is possible to write the same letter many times, if one refers to the letter type, not to a letter token, so to speak. The approach outlined here can be extended to type reference. Types may be considered as abstract entities with a part relation induced by the concrete part relation we considered so far. The verb, then, describes the realization of a type, and this can happen many times. Performance verbs such as *play* in *play a sonata* should be analyzed in the same manner. I will not formalize this in the present paper.

3. Temporal adverbials

In this final section, I want to show how it arises that durative adverbials like *for an hour* and time-span adverbials like *in an hour* are diagnostic contexts for telic and atelic expressions. To do this, I have to introduce **times** into the model structure.

I assume an predicate **T**, extensionally disjunct from **O** and **E**, which characterizes times. The variables which range over the extension of **T** will be given as t, t', etc. The extension of **T** should carry a complementary complete join semi-lattice without 0-element, just like **O** and **E** do; I will assume the same relations, functions and predicates, indexed with **T**. In addition, I assume that this lattice is atomic, with $\mathbf{T}_a$ as the set of **T**-atoms.

(P 30) $\mathbf{ATM}_T(\mathbf{T})\ \&\ \forall t[\mathbf{T}_a(t) \leftrightarrow \mathbf{ATOM}_T(t,\mathbf{T})]$

Furthermore, I assume a relation of temporal precedence. This can be defined as follows: Let $\mathbf{T}_a$ be linearly ordered by $\ll$.

(P 31) $\forall t\forall t'\forall t''[\mathbf{T}_a(t)\ \&\ \mathbf{T}_a(t')\ \&\ \mathbf{T}_a(t'') \rightarrow$
$[t \ll t' \vee t' \ll t \vee t=t']\ \&\ \neg[t \ll t]\ \&\ [t \ll t'\ \&\ t' \ll t'' \rightarrow t \ll t'']]]$

This order can then be extended to **T** in an obvious way: A time t temporally precedes a time t', if every part of t precedes every part of t' (P 32). Now we can define convex times, or **time intervalls** (P 33).

(P 32) $\forall t\forall t'[t \ll t' \leftrightarrow \forall t''\forall t'''[\mathbf{T}_a(t'')\ \&\ \mathbf{T}_a(t''')\ \&\ t'' \sqsubseteq_T t\ \&\ t''' \sqsubseteq_T t' \rightarrow t'' \ll t''']]$

(P 33) $\forall t[\mathbf{CONV}(t) \leftrightarrow \forall t\forall t''\forall t'''[t' \sqsubseteq_T t\ \&\ t'' \sqsubseteq_T t\ \&\ t' \ll t'''\ \&\ t''' \ll t'' \rightarrow t''' \sqsubseteq_T t]]$

I further assume a symbol τ denoting a function from the extension of **E** into the extension of **T**. This function maps an event to its **running time**. It is a homomorphism relative to $\sqcup_E$ and $\sqcup_T$:

(P 34) $\forall e\forall e'[\tau(e) \sqcup_T \tau(e') = \tau(e \sqcup_E e')]$

We start with **durative adverbials**. They can be considered as the adverbial counterpart to measure phrases, i.e. as operators which transform cumulative predicates into non-cumulative ones. They differ from adnominal measure phrases insofar as there seem to be no measure functions which can be applied to events directly, but only measure function which can be applied to entities which bear a relation to events, most notably times (as in *sing for an hour*) and, with movement verbs, distances (as in *run a mile*). I will concentrate here on the first case, which can be modelled with the running-time function τ. In all other respects, we can analyze adverbial measure phrases just like adnominal ones. To give an example, look at the representation of *for an hour*. Here, **h'** represents the measure function of *hour*, which applies to times, and $\lambda e[\mathbf{h}'(\tau(e))]$ is the derived measure function which applies to events.

12) *for an hour*
$\lambda P \lambda e[P(e)\ \&\ \mathbf{h}'(\tau(e))=1\ /\mathbf{AAM}_E(\lambda e[\mathbf{h}'(\tau(e))]),\ \mathbf{CONT}_E(e,\lambda e[\mathbf{h}'(\tau(e))],P)]$

Here, the first well-formedness constraint says that the measure function $\lambda e[\mathbf{h}'(\tau(e))]$ must be additive and archimedian. Provided that **h'** is an additive and Archimedian measure function for times, this is true for events which do not overlap temporally. Take for example additivity; it holds that

(T 11) $\forall e \forall e \forall m[\mathbf{AAM}_T(m)\ \&\ \neg\tau(e) \circ_T \tau(e') \rightarrow [m(\tau(e \sqcup_E e')) = m(\tau(e)) + m(\tau(e'))]]$

The second constraint claims continuity. This is the case if P is cumulative, and if there are parts of e which measure less than one hour and to which P applies. This explains the distribution pattern in (2), because *drink wine* is strictly cumulative, whereas *drink a glass of wine* is not.

I now turn to **time-span adverbials** like *in an hour*. The semantics of these adverbial modifiers can be characterized as follows: They say that an event is located in a convex time with a given length.

13) *in an hour* $\lambda P \lambda e[P(e)\ \&\ \exists t[\mathbf{CONV}(t)\ \&\ \mathbf{h}'(t)=1\ \&\ \tau(e) \sqsubseteq_T t]]$

Why have time-span adverbials, then, the well-known effects with telic and atelic verbal predicates? First, note that time-span adverbials are upward-entailing operators. Consider for example *drink a glass of wine in n hour(s)*. If this predicate can be applied to an event, then the predicate *drink a glass of wine in n' hour(s)*, with n'>n, can be applied to this event, too. This is obvious if one considers examples like (14).

14) Ann drank a bottle of wine in one hour; in fact, she did it in 53 minutes.

This upward entailing property of time-span adverbials predicts their combinatorial behaviour. If one has a sentence pattern like *drink δ in n hour(s)*, the pragmatic rule we stated above enforces the value of n to be as small as possible, in order to be maximally informative. But n can have a smallest value only if the predicate *drink δ* is atomic; otherwise it is possible to take smaller and smaller events which still fall under *drink δ*. Now, if δ is quantized, then the predicate *drink δ* is atomic; this we showed in (T 10). On the other hand, if δ is not quantized, then the atomicity depends on the position we take towards the minimal part problem. Normally, natural language refrains from referring to minimal parts of cumulative predicates, be it mass nouns, bare plurals, or atelic verbal predicates. But it is exactly in contexts like this that we find examples like *Ann drank wine in 0.43 seconds*, which can be read as report from some unusual competition, and which are possible if minimal events are referred to.

Expressions like *drink wine in an hour*, which cannot be reasonably construed as referring to minimal events, are avoided, simply because the application of the time-span adverbial does not lead to a more specific meaning and is, therefore, redundant.

4. Extensions

In Krifka (1986), I showed how this approach can be extended to cover **quantified NPs** and **negated sentences** as well.

Furthermore, it was applied to explain the different ways **progressivity** is encoded in natural languages. Basically, progressivity can be a verbal operator, as in English, or it can be coded by partitive case marking of a valency, as in Finnish or, less prominently, in German.

15.a) John *is drinking* a glass of wine.

b) Hans trinkt *an einem Glas Wein*.

The progressive operator can be analyzed as referring to parts of events, and the partitive operator as referring to parts of objects. It can be shown easily that with event-object relations which meet graduality, the semantic effect is about the same.

Here we have an example how a prima facie verbal category is encoded with an NP. On the other hand, there are cases where a prima facie nominal category is encoded with the verb. An example is **definiteness** in Slavic languages. Slavic languages do not mark definiteness regularly, but they do mark perfective aspect (or aktionsart). Now, if one assumes that aspect marking has scope over the verb with its valencies, and that perfectivity presupposes that the complex verbal predicate is quantized, it can be explained that in the following Czech example, *víno* has to be interpreted as definite in (16.b).

16.a) Ota pil víno. 'Ota drank (imperfective) wine'

b) Ota vypil víno. 'Ota drank (perfective) the wine'

The reason is that for *drink δ* to be quantized, δ has to be quantized as well, and this is the case if δ is interpreted as having singular reference, i.e. as being definite.

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Production grammars revisited

J. Lambek
McGill University

We present a grammar as an unordered set of rewriting rules, not enhanced by rules of inference, and show how to program them into a three-tape machine, essentially two pushdown automata. Equal attention is paid to syntax and morphology from the start.

0. Introduction.

Considering the exciting work being done today in semantics, I feel somewhat embarrassed to be concentrating on form rather than meaning. The kind of modest question I would like to consider is why one says

I like her

and not

**I likes she.*

It seems to me that a grammar of English ought to handle this sort of thing right at the beginning, putting syntax and morphology on the same footing.

The type of grammar I wish to push has been called production grammar (also rewriting system or semi-Thue system). It is essentially what Chomsky calls generative grammar (of type 0), but lacks the emphasis on structural descriptions, which I feel should be viewed as a by-product and not as the aim of grammar.

As all (and only) recursively enumerable sets of strings of symbols can be generated by production grammars, it has "always" been known that the latter are suitable for generating the sentences of natural languages. Yet, arguments have been given against the description of natural languages in terms of production grammars unrestricted and unadulterated. While these arguments do not convince me, I shall refrain from discussing them here. At any rate, I suspect that the biggest objection to production grammars has always been the fear that no laurels can be gained by belabouring the obvious.

Our leading grammarians have favoured sytax over morphology, emphasizing grammatical rules which generate phrase structure, but with additional machinery superimposed. Thus, Chomsky (1957) in his pioneering "Sytactic Structures" introduced "transformations" and Gazdar (1982) more recently introduced "metarules". As I pointed out in my JSL review of Lees (1960), the transformations then in use could be viewed as rules of inference:

$$\frac{\Gamma_1 \longrightarrow \Delta_1, \ldots\ldots, \Gamma_n \longrightarrow \Delta_n}{\Gamma \longrightarrow \Delta} .$$

Not surprisingly, Gazdar's matarules may also be viewed as such.

While contextfree productions of the form $A \longrightarrow BC$ play a leading rôle in syntax, it is productions of the form $AB \longrightarrow C$ which predominate in morphology, for example,

Plur *man* $\longrightarrow$ *men* ,

where Plur (= plural) is what I call an "inflector". Of course, we can get rid of the production $AB \longrightarrow C$ in favour of a rule of inference

$$\frac{S \longrightarrow \Gamma A B \Delta}{S \longrightarrow \Gamma C \Delta} ,$$

which relates contextfree productions only, but I see no advantage in doing so.

After this informal introduction, let us define some of the terms that have been used. A <u>production grammar</u> is a quadruple $\mathscr{G} = (\mathscr{V}, \mathscr{V}_i, \mathscr{V}_t, \mathscr{P})$, where

(i) $\mathscr{V}$ is a finite set, the <u>vocabulary</u> (sometimes called "alphabet");

(ii) $\mathscr{V}_i$ and $\mathscr{V}_t$ are subsets of $\mathscr{V}$, the <u>initial</u> and <u>terminal</u> vocabularies respectively;

(iii) $\mathscr{P}$ is a finite (or at least recursive) set of pairs (Γ, Δ), where Γ and Δ are strings of elements of $\mathscr{V}$, the <u>productions</u> (or "rewriting rules").

In this article, the terminal vocabulary $\mathscr{V}_t$ will consist essentially of English words, while the initial vocabulary $\mathscr{V}_t = \{S, Q, C, \ldots\}$ will consist of certain symbols representing types of English sentences, namely

S = statement,
Q = question,
C = command,

etc. This is because we are interested in generating English sentences. Were we interested in translating from French to English, we would have chosen $\mathscr{V}_i$ to be the set of French words.

At this point we should emphasize the symmetry of our definition. From any production grammar $\mathscr{G} = (\mathscr{V}, \mathscr{V}_i, \mathscr{V}_t, \mathscr{P})$ one may obtain the dual grammar $\mathscr{G}^d = (\mathscr{V}, \mathscr{V}_t, \mathscr{V}_i, \mathscr{P}^d)$, where $\mathscr{V}_i$ and $\mathscr{V}_t$ have been interchanged and $\mathscr{P}^d$ is the set of all pairs (Δ, Γ) such that (Γ, Δ) is in $\mathscr{P}$. In line with what we said about $\mathscr{G}$ above, $\mathscr{G}^d$ would be a grammar for recognizing English sentences as sentences or for translating from English to French.

It is customary to write

$$\Gamma \longrightarrow \Delta$$

in place of $(\Gamma, \Delta) \in \mathscr{P}$ and to think of this formula as an axiom in a deductive system, which also contains the axiom

$$\Gamma \longrightarrow \Gamma \quad \text{(reflexive law)}$$

and the rules of inference

$$\frac{\Gamma \longrightarrow \Delta \quad \Delta \longrightarrow \Theta}{\Gamma \longrightarrow \Theta} \quad \text{(transitive law)}$$

and

$$\frac{\Gamma \longrightarrow \Delta \quad \Gamma' \longrightarrow \Delta'}{\Gamma\Gamma' \longrightarrow \Delta\Delta'} \quad \text{(substitution rule)}$$

or, equivalently,

$$\frac{\Gamma \longrightarrow \Delta}{\Phi\Gamma\psi \longrightarrow \Phi\Delta\psi} .$$

One may even transmute this deductive system into a category in which $\Gamma \longrightarrow \Delta$ is viewed as a morphism, but this is neither here nor there.

A production $\Gamma \longrightarrow \Delta$ is called <u>context-sensitive</u> if the string Γ has at most the same length as the string Δ; it is called <u>contextfree</u> if Γ has length 1 and Δ is not the empty string. A production $\Gamma \longrightarrow \Delta$ is called <u>normal</u> if both Γ and Δ have length 1 or 2. There are exactly four kinds of normal productions:

$$B \longrightarrow C,\ B \longrightarrow CD,\ AB \longrightarrow CD,\ AB \longrightarrow C,$$

where A, B, C and D are elements of the vocabular $\mathcal{V}$. Only the first two of these are contextfree and all but the last are context-sensitive.

One may assume, without loss in generality, that all productions are normal. For example, ABC $\longrightarrow$ D may be replaced by two normal productions involving a new symbol E, to be added to the vocabulary, namely

$$AB \longrightarrow E,\ EC \longrightarrow D.$$

It is often convenient to acknowledge <u>context restrictions</u> explicitly by saying

$\Gamma \longrightarrow \Delta$ before ψ in place of $\Gamma\psi \longrightarrow \Delta\psi$.
$\Gamma \longrightarrow \Delta$ after Φ in place of $\Phi\Gamma \longrightarrow \Phi\Delta$.

The purpose of this brief exposition is twofold. First, we illustrate how a production grammar can be programmed into a simple machine, essentially consisting of two pushdown automata, together equivalent to a Turing machine. To this end we look at a production grammar for a tiny fragment of English to account for such sentences as *I like her*.

Secondly, to convince the reader that production grammars lend themselves to the description of natural languages in an easy and straightforward fashion, we shall expand this tiny fragment to a somewhat larger one, within the limits allowed here. We confine ourselves to written rather than spoken English, mainly because the author has no competence in phonology, so that also such competence by the reader need not be presupposed. At any rate, I am convinced that the spoken language can be handled analogously.

This article presents an expansion and refinement of the method developed in an undergraduate course "Computability and Mathematical Linguistics", which I have been teaching at McGill University for the last 15 years or so. In published papers, this method has been applied to French and Latin conjugation (1975, 1979) and to the kinship terminology of Malagasy and Hindi (1981, 1983). The development of a more complete grammar of English is in progress.

I take this opportunity to thank my students, who have helped me to clarify these ideas, in particular Norman Phillips and David Caldwell, who has checked some of my work on the computer.

1. A tiny fragment of English.

The English verb has essentially 6 finite forms, of which usually only three are distinct. Given a verb V, we posit $C_{ik}V$ to generate the conjugation matrix associated with V, where $k = 1,2,3$ refers to person and $i = 1,2$ to tense, present and past respectively. We have taken advantage of the fact that Enlish verbs take the same form for the three persons of the plural as for the second person singular. A more refined analysis would allow k to range from 1 to 6, as it does in other European languages. We have ignored the two subjunctive tenses, which are almost obsolete in English, otherwise i would range from 1 to 4.

Here is an example of how the 2×3 conjugation matrix is generated:

$$\begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \end{bmatrix} come \longrightarrow \begin{bmatrix} come & come & comes \\ came & came & came \end{bmatrix} .$$

For the moment, we shall assume that this information is stored in the dictionary (long term memory), but later we shall show how these 6 forms can be calculated from more basic data. The corresponding conjugation matrix in French has $7 \times 6 = 42$ entries, in Latin it has 90 and in Arabic and Sanskrit many more.

Our provisional production grammar has an auxiliary vocabulary $\mathcal{V} - (\mathcal{V}_i \cup \mathcal{V}_t)$ consisting of the following symbols:

Subj = subject,
Pred = predicate,
NP_k = k-th person noun phrase $(k = 1,2,3)$,
P_k = a marker indicating the k-th person,
T_i = a marker indicating the i-th tense $(i = 1,2)$,
C_{ik} = an inflector for conjugating the verb,
VP = verb phrase,
V_{intr} = intransitive verb,
V_{tr} = transitive verb,
Obj = object,
Acc = accusative case.

It will be seen that we have unashamedly borrowed our terminology from traditional grammar.

In addition to the productions involving $C_{ik}V$, assumed to be stored in the dictionary, we shall require the following:

S $\longrightarrow$ Subj Pred,
Subj $\longrightarrow NP_k P_k$ $(k = 1,2,3)$,
$NP_1 \longrightarrow$ *I*,
$NP_2 \longrightarrow$ *you*, *we*, *they*,....,
$NP_3 \longrightarrow$ *he*, *she*, *it*, *one*,....,
Prod $\longrightarrow T_i$VP $(i = 1,2)$,
VP $\longrightarrow V_{intr}$, V_{tr}Obj,....,

Obj $\longrightarrow$ Acc NP_k,

$V_{intr} \longrightarrow$ *work*, *come*,...,

$V_{tr} \longrightarrow$ *like*, *call*,...,

$P_k T_i \longrightarrow C_{ik}$,

Acc W $\longrightarrow$ W usually, but:

Acc *I* $\longrightarrow$ *me*,

Acc *he* $\longrightarrow$ *him*,

Acc *she* $\longrightarrow$ *her*,

Acc *we* $\longrightarrow$ *us*,

Acc *they* $\longrightarrow$ *them*.

The dots in this preliminary list indicate that there are many other ways of forming noun phrases and verb phrases and that there are lots of intransitive and transitive verbs other than those listed. All the productions or production schemes listed are normal, but only the first 10 are contextfree.

Here is how our provisional grammar will generate the sentence *I come*:

S $\longrightarrow$ Subj Pred

$\longrightarrow NP_1\ P_1$ Pred

$\longrightarrow$ *I* P_1 Pred

$\longrightarrow$ *I* $P_1\ T_1$ VP

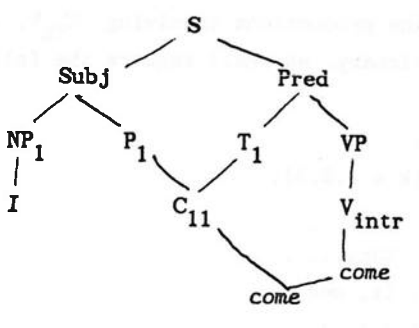
$\longrightarrow$ *I* C_{11} VP

$\longrightarrow$ *I* $C_{11}\ V_{intr}$

$\longrightarrow$ *I* C_{11} *come*

$\longrightarrow$ *I* *come*.

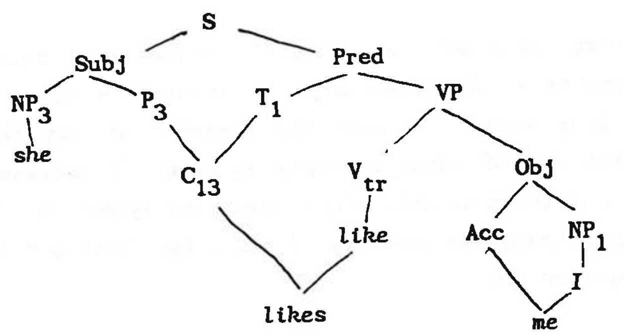
Diagrammatically, this may be represented thus:



Note that the diagram is not a tree, although it contains one, accounting for the syntactic structure of *I* P_1 T_1 *come*, which is generated by contextfree productions only. From this one computes the actual sentence *I come*, using productions of the form $AB \longrightarrow C$. In this paper, we shall ignore the semantics, but it seems clear that the meaning should be calculated from *I* P_1 T_1 *come* rather than from the actual sentence.

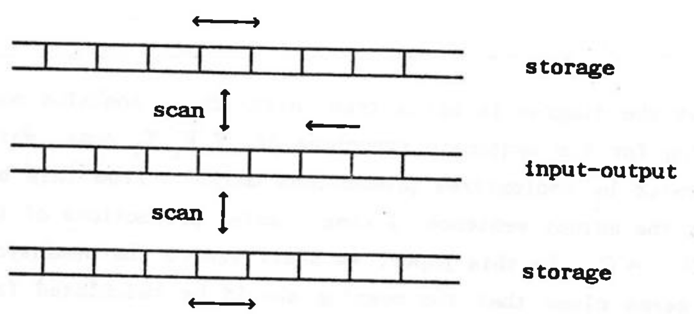
I do not believe that such diagrams and the trees they contain have any psychological reality. I conceive a situation where a person might utter the word *I* before deciding that the predicate should have the form T_1VP and that the verb phrase should consist of the intransitive verb *come*.

Here is another example of such a diagram accounting for the sentence *she likes me*:



2. A machine for generating and recognizing sentences.

We shall construct a simple machine capable of generating and recognizing sentences, presumably simulating what goes on in a person's brain when he utters a sentence or recognizes what he hears as a sentence. The machine consists of three potentially infinite tapes, two storage tapes and one input-output tape, subdivided into squares. Exactly one square of each tape is being scanned at any given time. The two storage tapes can move in either direction, the input-output tape can only move to the left. Here is a picture:



As will be seen after the moves have been described, during any calculation the left half of the upper storage tape and the right half of the lower storage tape will remain empty. The right half of the input-output tape is reserved for input; it remains empty when sentences are being generated. The left half of the input-output tape is reserved for output; it remains empty when strings are received as input. Presumably, the machine can be modified to handle translation from one language to another.

At any stage of a calculation, a finite number of squares will have elements of the vocabulary V printed on them. In depicting such a stage, we show the contents of the three scanned squares and of other nonempty squares, if necessary. Empty squares, if shown at all, will contain the symbol 0. For example, in generating the sentence *I come*, the first and last stages are depicted thus:

```
S                        0
0 ——————————→ I come     0 .
0                        0
```

In recognizing the same string as a declarative sentence, the first and last stages are depicted thus:

```
0                        0
0  I come ——————————→    0 .
0                        S
```

We shall now describe seven kinds of moves which the machine can make:

(I) $$\begin{array}{c} C \\ 0 \\ (A) \end{array} \longrightarrow \begin{array}{c} 0 \\ C \\ (A) \end{array} .$$

(II) $$\begin{array}{c} 0 \\ B \\ 0 \end{array} \longrightarrow \begin{array}{c} \text{left} \\ 0 \\ B \end{array} .$$

(III) $$\begin{array}{c} C \\ B \\ (A) \end{array} \longrightarrow \begin{array}{c} \text{right} \\ \text{stay} \\ \text{stay} \end{array} .$$

(IV) $$\begin{array}{c} 0 \\ B \\ A \end{array} \longrightarrow \begin{array}{c} \text{stay} \\ \text{stay} \\ \text{left} \end{array} .$$

(V) $$\begin{array}{c} 0 \\ B \\ (A) \end{array} \longrightarrow \begin{array}{c} (D) \\ C \\ \text{right } 0 \end{array} , \text{ if } (A)B \longrightarrow C(D) \text{ is a production.}$$

(VI) $$\begin{array}{c} 0 \\ D \\ 0 \end{array} \longrightarrow \begin{array}{c} \text{left} \\ D \text{ left} \\ \text{stay} \end{array} , \text{ if } D \text{ is in the terminal vocabulary.}$$

(VII) $$\begin{array}{c} 0 \\ 0 \\ (A) \end{array} \longrightarrow \begin{array}{c} \text{stay} \\ \text{left} \\ \text{stay} \end{array} .$$

I hope all this is self-explanatory; but, for the sake of illustration, I shall elaborate on move (V). Suppose the symbol B and possibly the symbol A have been written on the indicated squares. Suppose further that one of the following is a production of our grammar:

$$AB \longrightarrow CD,\ B \longrightarrow CD,\ AB \longrightarrow C,\ B \longrightarrow C.$$

Then the machine erases B and A, if necessary, and writes C and, in the first two cases, also D on the indicated squares. Finally, it moves the lower storage tape one square to the right.

It is useful to impose some restrictions on these moves (which may still require some checking):

(II) should not be made if (V) or (VI) can be made; (IV) should not be made during sentence generation if (V) can be made; (VI) should not be made during sentence recognition; (VII) should not be made during sentence generation.

While these restrictions will eliminate many useless moves, they do not render the machine deterministic. During sentence generation this is only to be expected, as there are many (even infinitely many) English sentences. But even in attempting to recognize a string of words as a sentence the machine is not forced to make a unique calculation, as will be seen.

Here is what the machine can do. It can generate the sentence *I come* in 22 moves, after which it comes to a stop, in view of the restriction on (VII). Using the dual grammar, with all arrows reversed, the machine can also recognize the string *I come* as a statement in 23 moves, after which it comes to a stop, in view of the restriction on (VI).

On paper, the last calculation looks like this:

$$
\begin{aligned}
\textit{I come} &\longrightarrow NP_1\ \textit{come} \\
&\longrightarrow NP_1\ C_{11}\ \textit{come} \\
&\longrightarrow NP_1\ P_1\ T_1\ \textit{come} \\
&\longrightarrow \text{Subj}\ T_1\ \textit{come} \\
&\longrightarrow \text{Subj}\ T_1\ V_{intr} \\
&\longrightarrow \text{Subj}\ T_1\ VP \\
&\longrightarrow \text{Subj Pred} \\
&\longrightarrow S
\end{aligned}
$$

Note that, however, an alternative calculation was possible without recognizing a sentence:

$$
\begin{aligned}
\textit{I come} &\longrightarrow NP_1\ \textit{come}\\
&\longrightarrow NP_1\ V_{intr}\\
&\longrightarrow NP_1\ VP
\end{aligned}
$$

Actually, the successful analysis of *I come* as a statement was only one of many parallel unsuccessful calculations. Perhaps some of these can be eliminated by imposing suitable context restrictings on the productions involved.

3. <u>More about the verb phrase</u>.

It is my belief that the small fragment of English grammar presented in Section 1 can be expanded to comprise all that is usually included in a grammar of English. Obviously, such a project cannot be carried out here, but we shall take some tentative steps in that direction.

We shall say a bit more about the verb phrase, revising the productions

$$VP \longrightarrow V_{intr},\ V_{tr}\ Obj$$

to allow for compound tenses and showing in detail how $C_{ik}V$ may be calculated instead of leaving this to the dictionary. But first we extend our auxiliary vocabulary to include some new symbols:

V_{mod} = modal verb,
Inf = infinitive,
Imp = imperative,
Asp = aspect,
Perf = perfect (= past participle),
Part = (present) participle.

We shall also admit the following morphemes:

+ *s*, + *ed*, + *ing*.

Here then are the revised productions for the verb phrase:

$VP \longrightarrow (V_{mod})$ Inf,
$V_{mod} \longrightarrow$ *can, may, shall, will, must,*
Inf $\longrightarrow$ (Asp) Imp,
(Asp) $\longrightarrow$ (*have* Perf) (*be* Part),
Imp $\longrightarrow V_{intr}, V_{tr}$Obj,... .

With the help of contextfree productions only, we may now obtain, for example:

$S \longrightarrow$ *I* P_1 T_1 (*may*) (*have* Perf) (*be* Part) *come*.

As before, we apply $P_1 T_1 \longrightarrow C_{11}$, and it remains to determine the effect of the inflectors C_{11}, Perf and Part. To this purpose we postulate the following morphological productions. It is assumed that V is any verb and that, for any irregular verb V, its past participle V^q is listed in the dictionary.

$$C_{11}V \longrightarrow \begin{cases} \textit{am} & \text{if } V = \textit{be}, \\ V & \text{otherwise;} \end{cases}$$

$$\text{Perf } V \longrightarrow \begin{cases} V^q & \text{if } V \text{ is irregular}, \\ V + \textit{ed} & \text{if } V \text{ is regular;} \end{cases}$$

Part V $\longrightarrow$ V + *ing*.

We can now derive the following:

$S \longrightarrow$ *I may come*,
$S \longrightarrow$ *I have come*,
$S \longrightarrow$ *I am come + ing*,
$S \longrightarrow$ *I have been come + ing*,

etc., with the help of dictionary entries

$come^q$ = *come*, be^q = *been*.

It remains to calculate the exact written form of the morpheme + *ing*. The rule for doing this is a bit tricky, and I have not seen it stated correctly in any of the texts I have consulted. Here is my attempt at stating it:

V + *ing* ⟶ V*ing* usually, but:	
X*e* + *ing* ⟶ X*ing*	if *e* is silent and X does not end in *i* or *e*,
X*ie* + *ing* ⟶ X*ying*,	
X*ic* + *ing* ⟶ X*icking*,	
XC + *ing* ⟶ XCC*ing*	if C is a consonant other than *x*, *y* or *w* and X ends in a single stressed vowel.

Here are some illustrations:

> *working*, *coming* (but *being*, *seeing*), *dying*, *panicking*, *betting* (but *boxing*, *laying*, *rowing*, *traveling*).

Some variations to the rule do occur. Thus, British English requires *travelling*, even though the *e* is not stressed, and American English permits *kidnapping*.

The morphemes + s and + *ed* are calculated similarly. Other values of $C_{ik}V$ are calculated similarly to $C_{11}V$, e.g.

$$C_{31}V \longrightarrow \begin{cases} \textit{is} \text{ if } V = \textit{be}, \\ \textit{has} \text{ if } V = \textit{have}, \\ V \text{ if } V \text{ is a modal verb}, \\ V + s \text{ otherwise}. \end{cases}$$

4. Some transformations.

Traditionally, the conjugation of a verb may also include a passive voice. In Chomsky's early work (1957), the passive was introduced by a so-called transformation which was then expressed as a kind of rule of inference. I think the following captures the spirit of Chomsky's original treatment of the passive transformation in the framework of the limited grammar of Section 1:

$$\frac{S \longrightarrow XP_k\ T_i V\ \text{Acc}\ Y,\ NP_k \longrightarrow X,\ V_{tr} \longrightarrow V,\ NP_l \longrightarrow Y}{S \longrightarrow YP_l\ T_i\ \textit{be}\ \text{Perf}\ V\ (\textit{by}\ \text{Acc}\ X)}$$

This rule of inference allows one to derive the sentence *she is loved (by me)* from the underlying structure of *I love her*, by taking $X = I$, $k = 1$, $i = 1$, $l = 3$, $V \doteq$ *love* and $Y =$ *she*. Quite formally, the derived sentence could also be obtained with the help of a production

$$VP \longrightarrow \textit{be}\ \text{Perf}\ V\ (\textit{by}\ \text{Obj}),$$

at the cost of sacrificing the special relationship between the passive sentence and the active sentence from which it is derived. Nonetheless, this is a sacrifice we have to make if we want to make do without rules of inference.

We shall now present our treatment of the <u>passive transformation</u> in the framework of the expanded grammar of Section 3. We shall do this with the help of a new symbol

$$\text{Pass} = \text{passive},$$

a production for introducing it:

$$\text{Imp} \longrightarrow \text{Pass Imp}\ (\textit{by}\ \text{Obj}),$$

and a production scheme for eliminating it:

$$\text{Pass V Obj} \longrightarrow \text{be Perf V} — ,$$

where V is any verb. We have put the bar — for what Chomsky (1982) calls a trace, although the reader may ignore it within the limited context of this paper.

We can now form the passive of any sentence containing a transitive verb and obtain such sentences as:

she is (*was*, *has been*, *may be*) *loved* — (*by me*).

Unfortunately, we can also form:

**she is resembled* — (*by me*).

To prevent this, we must impose a context restriction on such productions as

$$V_{tr} \longrightarrow \textit{resemble, last,...}$$

to ensure that they are not applied after Pass.

Our passive productions also allow the attempt at forming the passive of a sentence containing an intransitive verb, as in the derivation:

$$\begin{aligned} \text{Imp} &\longrightarrow \text{Pass Imp} \\ &\longrightarrow \text{Pass } V_{intr} \\ &\longrightarrow \text{Pass } \textit{come}. \end{aligned}$$

We are now at an impasse, since no further productions will apply. If we wish to rule out such blind alleys, we can do so by imposing a context restriction on the production

$$\text{Imp} \longrightarrow V_{intr}$$

to ensure that it is not applied after Pass.

The passive construction in English has a much wider range than that in other European languages. To fully appreciate this, we shall presuppose some productions which are outside the scope of the present paper, for instance productions which will generate the following sentences:

she gives him books,
she gives books to him,
she believes him to come,
she sees him coming,
she knows that he comes,
she appreciates his coming.

For example, we might presuppose the production

Imp ⟶ *give* Obj Obj

to generate the first of the above sentences. Our passive productions now yield:

he is given - books (by her),
books are given - to him,
he is believed - to come,
he is seen - coming,
that he comes is known - ,
his coming is appreciated - .

Here we have admitted as noun phrases the expressions

that he comes, his coming.

One may even have two or more passives in the same sentence, as in:

she was believed - to have been loved - .

Another transformation is the <u>negative transformation</u>, which assigns to any sentence its grammatical negation (not necessarily its logical negation).

We shall use a new symbol

Neg = negation,

a production for introducing it:

$$VP \longrightarrow Neg\ VP,$$

and a production scheme for eliminating it:

$$Neg\ V \longrightarrow \begin{cases} V + \textit{not} & \text{if } V \text{ is an auxiliary verb,} \\ \textit{do} + \textit{not}\ V & \text{otherwise.} \end{cases}$$

Here + *not* is a morpheme to be calculated by such productions as

can + *not* ⟶ *cannot*, *can't*,
will + *not* ⟶ *will not*, *won't*,
do + *not* ⟶ *do not*, *don't*,
does + *not* ⟶ *does not*, *doesn't*,

etc., with suitable context restrictions to ensure e.g. that the inflector C_{ik} applies to *do* and not to *don't*.

The elimination rule for Neg mentions auxiliary verbs. These are the modal verbs, the verb *be* and the verb *have* when followed by Perf (but not when followed by Obj).

Our rules allow us to form, for example:

I do not go,
I did not go,
I have not gone,
I may not go,
I am not going.

Closely related to the negative transformation is the interrogative transformation. This may be stated in terms of a new symbol

Int = interrogative,

a production for introducing it:

$$Q \longrightarrow \text{Int } S \text{ ?}$$

and a production scheme for eliminating it:

$$\text{Int } NP_k \; C_{ik}V \longrightarrow \begin{cases} C_{ik} \; V \; NP_k & \text{if } V \text{ is auxiliary.} \\ C_{ik} \; \text{do} \; NP_k \; V & \text{otherwise.} \end{cases}$$

This will account for such questions as:

do I go?
did I go?
have I gone?
may I go?
am I going?

Alternatively, the elimination rule for Int may be stated in a way which exploits its similarity to that for Neg as follows:

$$\text{Int } NP_k \; C_{ik} \; V \dotplus \textit{not} \longrightarrow C_{ik} \; V \; NP_k \; .$$

with appropriate context restrictions.

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GROUPS, PLURAL INDIVIDUALS AND INTENTIONALITY

Fred Landman

Department of Linguistics

University of Massachusetts at Amherst

ABSTRACT

This paper discusses various aspects of the lattice theoretic approach to plurality developed by Godehard Link. Special attention is paid to the distinction that is made between sums and groups and the three way ambiguitity between distributive, collective and group readings that results from it. It is argued that the distinction between sums and groups does not correspond with an ambiguity between collective and group readings, and an alternative is proposed that makes this distinction the basis of the contrast between distributive and collective readings. Next, the 'non-extensionality' of groups is discussed, and it is argued that this phenomenon is not restricted to group expressions, but occurs with normal singulars and plurals as well. A solution to this problem is formulated which assumes that depending on the context, properties are not simply predicated of objects, but of objects under certain aspects.

INTRODUCTION

This paper consists of three parts. In the first part I will briefly introduce some of the crucial aspects of the theory of plurality developed by Godehard Link in a series of recent papers (Link 1983, 1984, to appear). In the second part I will propose some changes in the architecture of this theory. In Link's theory a non-extensional notion of group plays an important role. The third part of this paper deals with the nature of the non-extensionality involved here.

The present paper is a condensed version of Landman 1987, and due to the space limits it cannot be more than 'highlights from' that paper. Since it would be tiresome to refer to the longer paper every other sentence, such references are suppressed with the following general warning: for more exposition, discussion, examples, arguments, and formal details, see Landman 1987.

1. GODEHARD LINK'S LOGIC OF PLURALITY

1.1. Singular and plural terms

A first aspect of Link's theory is that there is no distinction in semantic **type** between singular terms like **the boy** and plural terms like **the boys**. In previous semantic theories it was often assumed that singular terms are interpreted as (concrete) **individuals**, while plural terms are interpreted as (abstract) **sets** of such individuals. Link gives various arguments that the basis for the semantic differences between singulars and plurals should not be the type distinction between individuals and sets, but a sortal distinction between concrete singular individuals and **equally concrete** plural individuals.

One of his arguments is the following. Take sentence (1):

(1) Who made a mess of the living room?

This sentence can as easily be answered with a singular: **John**, as with a plural: **my kids**. It seems awkward to assume that (1) is **ambiguous** between (1a) and (1b):

(1a) Which individual made a mess of the living room?
(1b) Which set of individuals made a mess of the living room?

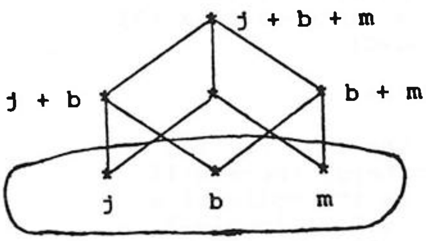
If we assume that **my kids** denotes a concrete individual as much as **John** does, we do not have to postulate such an ambiguity.

To achieve this, Link postulates **one** domain of singular and plural individuals; structured as a complete atomic join semi-lattice by a **part of** relation $\sqsubseteq$ (expressing that John is part of the plural individual John and Bill), and a **sum** operation +. + gives you for

every two individuals j and b their sum j + b; + serves as the interpretation of term conjunction:
⟦John and Bill⟧ = ⟦John⟧ + ⟦Bill⟧.

In general, plural individuals are **sums** of singular individuals. Singular individuals are individuals that have no proper parts: **atoms** in the structure.

This structure is illustrated in the following picture:



= ⟦John and Bill and Mary⟧

atoms: singular individuals

In sum: there is one, structured, domain of individuals and whether you are singular or plural depends on your place in the structure.

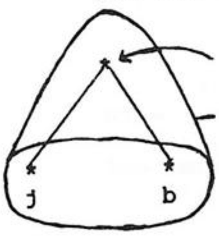
1.2. Cumulative reference

A second aspect of Link's theory is that it is made to deal with **cumulative reference**, which is the validity of the inference shown in (2):

(2) If John is a judge and Bill is a judge then John and Bill are judges.

To achieve this, Link makes the following assumptions.
-basic predicates, like **Judge**, are interpreted as sets of (singular or plural) individuals.
-there is a plural operator, *, which maps one place predicates onto one place predicates. ***Judge** is the closure of **Judge** under sum. In English, * corresponds with the plural morphology.
-there is a description operator σ, corresponding to the plural definite article **the**: σx.*Judge(x) (**the judges**) gives you the maximal sum in ***Judge**. Roughly, **the judges** denotes the sum of all the individuals that are judge.

All this is illustrated in the following picture:



=	**⟦σx.*Judge(x)⟧**	= j + b	**the judges**
=	**⟦*Judge⟧**	= {j, b, j + b}	**judges**
=	**⟦Judge⟧**	= {j, b}	**judge**

Note that in this theory, **the** is a generalization of **and**: **John and Bill** denotes the sum of John and Bill;

The judges denotes the sum of all the judges. Further, the singular **the** is a special case of plural **the**: in the case of a singular, the sigma operator boils down to the standard iota operator.

The theory deals with cumulative reference. The representation of (2) in this theory, (2a), is logically valid:

(2a) **Judge**(j) ∧ **Judge**(b) → ***Judge**(j + b)

1.3. The distributive/collective distinction

The theory has to deal with the distibutive/collective distinction, i.e. with the fact that a sentence like (3) can be interpreted in two different ways:

(3) The boys carry a piano upstairs.

On the distributive reading, each of the boys carries a piano upstairs (and if there are four boys, there will normally be four piano's upstairs). On the collective reading, the boys are collectively, together involved in carrying a piano upstairs (and there will normally be one piano upstairs).

Link treats this distinction as an ambiguity of certain verb phrases, like **carry a piano upstairs**. The collective reading is represented as (3a):

(3a) **Carry**(σx.***Boy**(x))

This means that the sum of boys is in the extension of the predicate **carry a piano upstairs**, and there is no implication that therefore each one (or any one, for that matter) of the boys is in the extension of that predicate as well.

For the distributive reading, Link introduces a second one place predicate operator, the distributive operator D, which is defined as:

^{D}P := λy.∀x[x is singular part of y → P(x)]

So, ^{D}**Carry a piano upstairs** is the property that you have as a plural individual if all your singular parts carry a piano upstairs. The distributive reading is represented as (3b), which is equivalent to (3c):

(3b) ^{D}**Carry**(σx.***Boy**(x))
(3c) ∀x[**Boy**(x) → **Carry**(x)]

1.4. The distinction between sums and groups

In the later papers, Link argues that the domain of individuals and their sums is not sufficient to deal with all aspects of plurality and that among the plural individuals a distinction has to be made between **sums** and **groups**. Since the ambiguity between distributive and collective readings involves sums only, adding groups to the ontology and group readings to the semantics is going to mean that we have to recognize a three way ambiguity between distributive, collective and group readings.

The main arguments for introducing groups are the following.

1.) **Committees**

Committees are typical plural individuals. But two committees can have the same members, even necessarily have the same members, without being the same committee. So a committee has to be more than the sum of its members: if committee A and committee B have the same members, then the sum of their members obviously is the same. Hence, committees are not sums.

I will postpone the discussion of this problem to the third part of this paper, which is devoted to it.

2.) **Complex noun phrases**

There are problems with noun phrases that are conjunctions of plural noun phrases. Consider example (4):

(4) The cards below 7 and the cards from 7 up are separated.

Take this example in the reading where the cards are separated into two piles, those below seven and those from seven up; the cards below seven are put aside, because in the particular card game we are going to play, one only plays with the cards from seven up. We cannot represent this reading with sums only. (4) would have to be represented as (4a):

(4a) **Sep**($\sigma x.{*x} < 7 \ + \ \sigma x.{*x} \geq 7$)

i.e. we take the sum of the cards below seven and the sum of the cards from seven up, and sum these. That gives us, of course, all the cards. But we can do the same for the cards below ten and the cards from ten up, summing these we get all the cards as well:

$$\sigma x.{*x} < 7 \ + \ \sigma x.{*x} \geq 7 \quad = 2 + .. + 6 + 7 + .. + \text{ace} = \sigma x.{*x} < 10 \ + \ \sigma x.{*x} \geq 10$$

But this means that (4a) and (5a) are logically equivalent on the reading given, which means that in this situation (4) entails (5). Obviously, a wrong result.

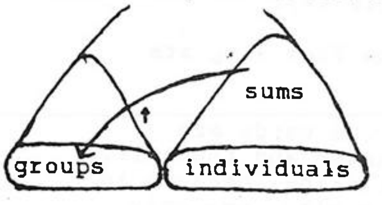
(5a) **Sep**($\sigma x.{*x} < 10 \ + \ \sigma x.{*x} \geq 10$)
(5) The cards below 10 and the cards from 10 up are separated.

The same problem can be observed in Link's example (6).

(6) The Leitches and the Latches hate each other.

Here the Leitches and the Latches are two families that bear a grudge against each other. Avoiding the problems with providing a semantics for reciprocles, let us assume that this means that sufficiently many pairs of individuals of which one is a Leitch and the other a Latch stand in the hate relation. Now, whatever 'sufficiently many' means, one thing is crucial: the pairs that are in the extension of **hate** consist of a Leitch and a Latch. But again, this information is lost if we only have sums. If (6) means that the sum of the Leitches and the Latches is in the extension of **hate each other**, then we cannot relate that to the proposed analysis of **each other**, because in the sum we do not keep track of who is a Leitch and who is a Latch. We can at most say that sufficiently many pairs in this sum stand in the hate relation, and that will not give us the requirement that these pairs consist of one Leitch and one Latch.

Link proposes a group forming operator, mapping terms onto terms, which I will write as ↑( ). The model structure is extended in the following way. Besides singular individuals and their sums, Link introduces new **atomic plural** individuals: **groups**. The group forming operation maps **sums** of individuals onto **groups**. The whole model structure now contains individuals and their sums, groups and their sums and mixed sums of groups and individuals, as in the following picture:



The group forming operation takes a sum of individuals, so to say wipes out its sum structure, and turns it into an atomic individual in its own right: a group that is more than the sum of its parts.

We can now deal with the problem of complex noun phrases in the following way. The relevant reading of example (4) should not be analyzed as saying that the sum of the **sum** of the cards below seven and the **sum** of the cards from seven up is separated, but rather we consider the cards below seven as a group, and similarly with the cards from seven up: (4) expresses that the sum of those two groups is separated:

(4b) **Sep**($\uparrow(\sigma x.{}^*x < 7) + \uparrow(\sigma x.{}^*x \geq 7)$)

Now even though the sum of the sum of the cards below seven and the sum of the cards from seven up is the same entity as the sum of the sum of the cards below ten and the sum of the cards from ten up, there is no reason to expect that if you turn the cards below seven and the cards from seven up into groups, and you take the sum of those two groups, you will get the same entity as you get when you do the same for the cards below ten and the cards from ten up:

$\uparrow(2+...+6) + \uparrow(7+...+ace) \neq$
$\uparrow(2+...+9) + \uparrow(10+...+ace)$

and hence (4b) does not entail (5b):

(5b) **Sep**(↑(σx.*x < 10) + ↑(σx.*x ≥ 10))

Similarly, if we interpret (6) as claiming that the sum of the **group** of Leitches and the **group** of Latches is in the extension of **hate each other**, we have a sum of two groups, rather than the sum of all their members, and in this way we can keep track of who are Leitches and who are Latches.

2. A REVISED LOGIC OF PLURALITY

After having introduced Link's theory in the previous section, in this section I will pose some problems and argue in favour of certain revisions.

2.1. Group formation and set formation

We have seen that we need a level of groups besides the level of singular individuals and their sums. We have also seen how this level of groups is introduced. Link claims (without giving arguments, though) that only one level of groups is needed: there is no need for introducing groups of groups, groups of groups of groups, etc.

It can easily be shown that this is wrong. Plurals tend to shift in context easily from a sum interpretation to a group interpretation, and higher to groups of groups.

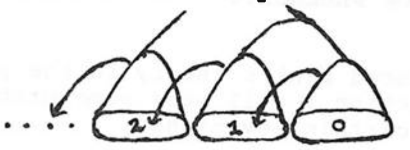
A group level expression like **the state** can easily shift its consistency from individuals (we, the people, make up the state) to groups of individuals (the farmers, the clergy, the nobility and the citizens make up the state), to groups of those (the working classes and the exploiting classes make up the state). There is no upper limit to this process.

Further, Link's own arguments for introducing groups in the first place can be used to show that the notion of group formation has to be **iterative**. The complex noun phrase argument can be repeated at the level of groups, of groups of groups, etc. **Committee** is a group level predicate: it doesn't take individuals in its extension, but only groups. The complex noun phrase construction is a recursive construction: it can be applied wherever we can conjoin plural noun phrases. We can pluralize **committee**, so we get sentences like (7):

(7) The committees of the CIA and the committees of the State Department control each other.

And again, for the same reasons as before, we cannot get the right reading if we assume that the complex noun phrase denotes the sum of the sum of the committees of the CIA and the sum of the committees of the State Department. Link's own reasoning forces us to assume that on the reading where the controling takes place between and not among CIA committees and State Department committees, the noun phrase denotes the sum of two groups of committees, i.e. the sum of two groups of groups. And of course, we cannot stop here either, because also at the level of groups of groups, we can repeat the same argument, leading to groups of groups of groups, etc.

What we observe is that, if we put aside the non-extensionality of groups like committees for a moment, group formation is strikingly close to set formation as it is traditionally conceived. Already the intuitive interpretation of group formation--you get a group by collecting some individuals together and regard the result as an entity in its own right--is precisely the intuition that led to the development of set theory in the first place. Further, we see now that groups form a cumulative hierarchy in very much the same way as sets do:



Given this, a natural question to ask is: what happens if we assume that groups **are** just sets, and group formation is just set formation, and we give the logic of plurality the obvious set theoretic interpretation? One advantage of that is that we do not have to wonder about how we are going to introduce an iterative notion of group formation into the theory, i.e. how we construct the cumulative hierarchy of groups, because that hierarchy is of course given.

Here is the obvious set theoretic interpretation.

The set theoretic interpretation

1. individuals and groups are **singleton sets** (atoms)
2. + (sum) = $\cup$ (union)
3. *P is the closure of P under union
4. $\sigma x.{*P(x)} = \bigcup {*P}$ (= the maximal union)
5. $\uparrow(s) = \{s\}$: group formation is singleton set formation.
6. $\downarrow(\{s\}) = s$ (this is an operation of membership specification, which will be used later)

We now have an iterative notion of group formation. At any level $\uparrow$ maps a sum onto the singleton set containing that sum, which is an atomic individual at the next level. In fact, apart from the non-extensionality of the committees (which is of course lost in an extensional set theoretic interpretation), everything carries over straightforwardly.

For example, as a sum of sums, **the cards below seven and the cards from seven up** is interpreted as {2...ace}, and so is **the cards below ten and the cards from ten up**. But as sums of groups they are respectively {{2..6},{7..a}} and {{2..9},{10..a}} and the wrong inferences are blocked as before.

Given all this, I will assume from here on the above given set theoretic interpretation (and, as said before, ignore the non-extensionality until part three).

2.2. The three way ambiguity

We have seen that the introduction of groups leads to a three way ambiguity of a sentence like (8):

(8) John and Mary carry a piano upstairs.

a distributive reading: ^{D}**Carry**(j + m); a collective reading: **Carry**(j + m); and a group reading: **Carry**(↑(j + m)).

Of this three way ambiguity, the distinction between distributive and collective readings is a strong and well motivated one. Further, I think that the arguments that were presented above strongly argue in favour of the sum/group distinction. But to motivate a three way ambiguity, there should be arguments as well that there is a distinction between collective and group readings. These are hard to get; the distinction between collective and group readings, if it exists, seems to be much weaker that the other two distinctions. In fact, I will argue that this distinction which is made in Link's theory is **not** well motivated, leads to problems, and should be given up. I will discuss two problems.

1. An ontological problem
In the first part of this paper I mentioned the messing up of Link's living room as one of Link's arguments that plural individuals are **concrete** entities of the same type as singular individuals. Now I am willing to assume that this holds for **groups**, but things are different for **sums**. Sums are not concrete in the same way as singular individuals and groups are. If concrete entities are the things that we recognize to exist in a domain of discourse as the relevant objects we talk about, then they are the things that we quantify over and that we count in that domain. We indeed quantify over singular individuals and groups and we count them, but we do not quantify over sums and we do not count them. If so, then sums are not concrete in the same way as individuals and groups are. Here is an example.

Suppose (for dramatic purposes) that Link has three children, and his three children messed up his living room. Let us bluntly ask: How many concrete things were involved in messing up Link's living room?

I think that the answer 'three individuals' is acceptable, counting the singular individuals. I am willing to count the answer 'one group of three individuals' as acceptable as well. But I think that the answer 'seven concrete individuals were involved in messing up Link's living room' is unacceptable. Still, that is the answer that you get if the sums of Link's children count as concrete entities. We see that in some sense singular individuals and groups are more robust than sums are. We need sums as entities in a compositional semantic analysis, but ontologically, in some sense they are not there.

This discussion is only meant to bring us into the direction of where I want to go. Let me continue with a semantic problem.

2. Cumulative reference and distributivity

Consider sentence (9).

(9) John is a judge and Bill is a judge iff John and Bill are judges.

The inference from left to right is cumulative reference, the inference from right to left is distributivity. (9) is valid, and in Link's theory both the validity of cumulative reference and of distributivity follow from the way the * operator is defined. Distributivity and cumulative reference are, for these examples, just two sides of the same coin. (9) is represented as the valid (9a):

(9a) **Judge**(j) $\wedge$ **Judge**(b) $\leftrightarrow$ ***Judge**(j + b)

We observe the same relation between distributivity and cumulative reference in example (10):

(10) John carries a piano upstairs and Bill carries a piano upstairs iff John and Bill carry a piano upstairs.

that is, both directions of (10) are valid if the second part of the sentence is given a distributive reading. So also here there seems to be a close connection between distributivity and cumulative reference. It seems that we can make the following generalization:

generalization: j has P and b has P iff j + b has P on the distributive reading of P.

In Link's theory, distributivity and cumulative reference in (10) are indeed two aspects of the same coin, but a different coin than in (9): it is the definition of the D operator in this case that takes care of both: (10) is represented as the valid (10a):

(10a) **Carry**(j) $\wedge$ **Carry**(b) $\leftrightarrow$ ^{D}**Carry**(j + b)

A problem is that this connection between distributivity and cumulative reference also holds intuitively for predicates that distribute down to collections, but not further down. (11) and (12) should be equivalent, but on Link's theory they are not.

(11) The boys meet and the girls meet.
(12) The boys and the girls meet (but not in the same room)

(The addition between parentheses is meant to stress the distributive reading.)
(11) and (12) are represented as (11a) and (12a) and (12a) is equivalent to (12b):

(11a) $\mathbf{Meet}(\sigma x.{}^*\mathbf{Boy}(x)) \wedge \mathbf{Meet}(\sigma x.{}^*\mathbf{Girl}(x))$
(12a) $^{D}\mathbf{Meet}(\ \uparrow(\sigma x.{}^*\mathbf{Boy}(x)) + \uparrow(\sigma x.{}^*\mathbf{Girl}(x))\ )$
(12b) $\mathbf{Meet}(\ \uparrow(\sigma x.{}^*\mathbf{Boy}(x))\ ) \wedge \mathbf{Meet}(\ \uparrow(\sigma x.{}^*\mathbf{Girl}(x))\ )$

But (11a) and (12b) are only equivalent if $\mathbf{Meet}(\sigma x.{}^*\mathbf{Boy}(x)) \Leftrightarrow \mathbf{Meet}(\uparrow(\sigma x.{}^*\mathbf{Boy}(x)))$ (and similarly for the girls), which is unacceptable by Link's own arguments for the distinction between sums and groups.

What we observe is that the theory clearly misses a generalization. The strong connection between distributivity and cumulative reference is dealt with in two different ways, in some cases with a *, in some cases with a D, and in some cases, the theory does not capture the connection at all. What we need is a theory where this connection is dealt with in one general way.

A small step for me...

The revision I will propose is technically very slight, but amounts to a radical conceptual difference with Link's theory. I will reduce the three way ambiguity to a two way ambiguity by assuming that the distributive/collective distinction **is identical to** the sum/group distinction.

The only change in the theory is the following:

All basic predicates denote sets of singletons only.

That is, a basic predicate can denote a set of singular individuals, like the predicate **boy**, it can denote a set of groups, like the predicate **meet**, it can denote a set of both singular individuals and groups, like **carry a piano upstairs**, but it does not take **sums** in its extension. Apart from this, nothing changes: for instance, *P is, as before, the closure of P under sum.

Consequences

Let me list some of the consequences.
1. *P is **always** distributive: $^*P(j + b) \Leftrightarrow P(j) \wedge P(b)$ is valid for all basic predicates P. In Link's theory j + b could be in *P because j + b was already in P. That is no longer possible. In the revised theory, the only way j + b can get to be in *P, is if it is the sum of elements that are already in P, i.e. if both j and b are already in P.

This means that predicates can only be applied **distributively** to sums: applying a predicate to a sum **is** applying it to its atomic parts (individuals or groups).
2. The distributive/collective distinction coincides with the sum/group distinction. If a predicate is starred, you know that it is distributively applied to a sum; if it is not starred, you know it is applied to an atomic singular individual or a group (individual level or collective).

In this way, the distributive/collective distinction coincides with the ontological distinction between sums and individuals/groups that I made before. In some sense, indeed, sums are not there. You can never say that a sum has a certain property: ascribing a property to a sum **is** ascribing it to its atomic parts. In this sense, ontologically, sums are not there, do not count, because we never directly apply properties to them. On the other hand, we do not distribute if we apply a predicate to a singular individual or to a group: we directly ascribe properties to them, and in that sense they do count, and are more robust than sums.

3. We have one general way of dealing with the relation between cumulative reference and distributivity, that works in all cases. In fact, this is another simplification of the theory: the D operator is superfluous, because * takes over its work in all cases.

The distributive and the collective reading of (3) are given in (3d) and (3e) respectively. The validity of (10) of course follows from the definition of the * operator in the same way as the validity of (9):

(3) The boys carry a piano upstairs.
(3d) ***Carry**(σx.***Boy**(x))
(3e) **Carry**(↑(σx.***Boy**(x)))

In (11) both **the boys** and **the girls** are taken collectively, which now means that they already denote groups. The reading of (12) that we are interested in is the one where we distribute down to collections, which means that **Carry** is applied distributively to the sum of two groups. (11) is represented as (11b) and (12) is represented as (12c) and indeed these are equivalent.

(11) The boys meet and the girls meet.
(11b) **Meet**(↑(σx.***Boy**(x))) ∧ **Meet**(↑(σx.***Girl**(x)))
(12) The boys and the girls meet.
(12c) ***Meet**(↑(σx.***Boy**(x)) + ↑(σx.***Girl**(x)))

The complex noun phrase cases like (13) that were discussed before are now represented as in (13a):

(13) The boys and the girls are separated.
(13a) **Sep**(↑(↑(σx.***Boy**(x)) + ↑(σx.***Girl**(x))))

4. Finally, it is important to note that the distributive/collective distinction is not itself a lexical distinction, something that has to be marked in the lexicon; i.e. we do not mark **meet** in the lexicon as a collective predicate. The above example (12) shows that that would be wrong, because **meet** can be distributive as well. What should be marked in the lexicon is just what kind of entities a predicate takes in its extension. Distributivity is **always** possible, it is always possible to give a sentence a distributive reading, because there are grammatical and contextual devices that trigger distributivity. But a predicate can only distribute to the kinds of things that it takes in its extension.
A predicate like **be pop star** only takes individuals in its extension and no groups, consequently **be pop stars** can

only have a distributive reading. **Meet**, on the other hand, does not take individuals in its extension, and consequently it cannot have a reading where it distributes down to individuals. It does have a collective reading, of course, because it does take groups in its extension, and indeed it can have a reading where it distributes down to groups, as we have seen. **Carry a piano upstairs**, finally, takes both individuals and groups in its extension and consequently shows distribution to individuals, collective readings, and distribution down to groups.

One potential counterexample against the present revision of Link's theory has to do with mixed collective/distributive predicates as in (14):

> (14) The boys met at school and were wearing their green sweaters.

If distributive predicates are applied to sums and collective predicates to groups, then there is not one interpretation of **the boys** in (14) that the conjunctive predicate can be applied to. In Link's theory this was not a problem, because **the boys** denoted a sum also on the collective reading. This is not much of an advantage of Link's theory, however, because of the existence of examples like (15):

> (15) The boys and the girls had to sleep in different dorms, met in the morning for breakfast, and were then wearing their green sweaters.

Although the last two conjuncts in this predicate in Link's theory both apply to the sum of all the boys and girls, the first conjunct has to apply to the sum of the group of boys and the group of girls. So also in Link's theory there is not a single object to which the predicate in (15) can be applied. A general solution for these problems is needed.

I noted earlier that plural noun phrases shift easily in context from an interpretation as a sum to a group to a group of groups, etc. From this we can expect that a type (or sort) shifting analysis can not only easily deal with these problems, but is the natural road to follow. Such an analysis is given in Landman 1987.

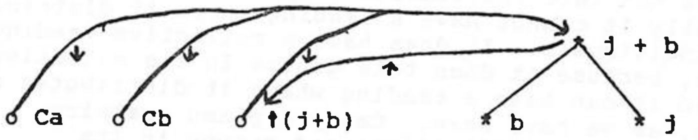
3. GROUPS AND INTENTIONALITY

Two committees can have the same members, even necessarily the same members, without being the same committee. Even if committee A and committee B have the same members, we cannot infer (17) from (16):

> (16) Committee A paid an official visit to South Africa.

(17) Committee B paid an official visit to South Africa.

How does Link deal with this? The following picture shows how:



Committee A and **Committee B** are interpreted directly at the group level. They are related to their members j and b in an **indirect** way, through the membership specification operation. They have the same members, j and b, but they are more than the sum of their members: they are entities in their own right and there is no reason to infer from the fact that one of them has a property, that the other has that property as well.

This is not possible in the set theoretic model, here Ca = Cb = {j+b}.

This seems to be a great advantage of Link's theory over the set theoretic one. Things are more subtle, however.

A crucial observation to be made is that the same lack of substitutivity that we find for committees in (16) and (17) can be observed for normal plurals and singulars as well.

Suppose we are in one of those unfortunate countries where the judges are the hangmen. Those awaiting their trial will be very glad to hear (18):

(18) The judges are on strike.

But those who are already condemned to death would be foolish to infer (19) from this:

(19) The hangmen are on strike.

only to find out that the strike is restricted to the court room.

Similarly, John is the judge, but in his spare time he has a job cleaning the court room. On the pay role we read (20) and (21):

(20) The judge earns exactly $50,000.
(21) The janitor earns exactly $10,000.

and from this we do not want to infer that John earns exactly $50,000, nor that he earns $10,000, but rather that he earns at least $60,000.

Also with singulars, we find examples exactly similar to the committee examples above: if committee A and B have the same chairman, we do not want to infer (23) from (22):

(22) The chairman of committee A paid an official visit to South Africa.
(23) The chairman of committee B paid an official visit to South Africa.

The problem is that in Link's theory, if the judges are the hangmen as sums, the judges as a group is the same as the hangmen as a group:

$\sigma x{*}J(x) = \sigma x{*}H(x) \rightarrow \uparrow(\sigma x.{*}J(x)) = \uparrow(\sigma x.{*}H(x))$

So Link's theory may bring us somewhere in the right direction, but not far enough: what Link can do for committees, he cannot for plurals and singulars.

We observe that the non-substitutivity phenomena do not form a problem that is restricted to group terms, but have to be regarded as a general problem of intentionality (non-extensionality).

In recent theories, a more finegrained notion of meaning is developed than the classical notion of an intension as a function from possible worlds to extensions. An example of this is Thomason [1980]'s intentional logic.

The semantics can be made more intentional in different ways. For instance, in Landman 1986, **intentional individuals** are introduced in the context of propositional attitudes, epistemic modals and identity statements. In Chierchia 1984, **intentional properties** are introduced. Chierchia observes that two properties can necessarily apply to the same individuals without being the same property:

(24) Everything that is bought is necessarily sold. Being a marxist at heart, John objects to things being sold, but knowing that people have to eat, he does not object to things being bought.

Note, by the way, the similarity between this case and the intentionality of the committees discussed above.

There are two ways we can approach the group intentionality. We can either introduce groups as new primitive intentional individuals, as Link does, but now do the same for plurals and singulars as well; or we can try, taking the similarity between the two cases as our guide line, to reduce the group intentionality to property intentionality.

I will follow the second line here. I don't have space to argue for this in detail. Roughly, there are two problems with the first approach. In the first place, by postulating a domain of intentional groups, besides the extensional domain, we assume that there is a clear ambiguity between the intentional and the extensional readings of these expressions, while, as I will discuss later, the group intentionality is not a matter of sharply distinguished readings, but something that comes in degree. Secondly, there is a problem with compositionality: if we interpret plurals directly at the intentional level, then **the judges as a group**, and

John and Bill as a group are at the same time atomic individuals, more than the sums of their part, and a function from the meaning of **the**, and **and** respectively. The problem is that we then need operators **the** and **and** at the intentional level, which cannot be systematically related to Link's extensional **the** and **and**. So this leads to giving up the heart of Link's theory.

The reduction to property intentionality
What would your reaction be if after uttering (25):

(25) The judges are on strike, the hangmen are not on strike.

I object: 'That is a contradiction, because the judges are the hangmen.' Probably your reaction would be something like this: 'Well, that is not what I meant. What I meant, when I said that the judges are on strike is that the judges are on strike **as judges, in their function of judges**, and the hangmen are not on strike **as hangmen**. There is no contradiction there.' What you do in this explanation is make explicit that you meant sentence (25) to be understood as containing an **implicit restriction** which is made explicit in (26), where there is no danger of contradiction:

(26) The judges are on strike **as judges**; the hangmen are not on strike **as hangmen**.

The same thing can be observed for the judge/janitor case in (20) and (21). We understand (20) and (21) as (27a) and (27b) respectively, and the financial conclusion that we can draw is (27c):

(27a) **As a judge**, John earns $50,000.
(27b) **As a janitor**, John earns $10,000.
(27c) **As judge and janitor**, John earns $60,000.

We do not just ascribe properties to people that apply to all of their personality, but certain properties we ascribe to them only under certain aspects of their character. There may be something morally incompatible in John's character, if (28) is true, but there is certainly not a logical inconsistency:

(28) John is corrupt, but as a judge he is trustworthy.

We see that often we attribute a property to an individual or a group not as such, but **under a certain (implicit) aspect** of the 'character' of that person or group. This will be our guide line for the formal theory. For the discussion to follow, it will be important to note from the start the following things:
1. Aspects of John's character are of course properties that John has.
2. Restriction of some individual or group to some of its aspects is a highly contextual matter.

3. Given that, in a context the natural aspect to do the restriction, if a definite like **the judge** is used, is the property **judge**, the descriptive content of the noun phrase, because that is a property that is obviously available and relevant in that context, because it is explicitly mentioned. But contextual clues may indicate that some other aspect should be used.

I will introduce restriction with properties by introducing **restricted terms**: j↾J stands for **John as a judge**. The intentionality of such terms comes in through the property intentionality: J will be an intentional property, and if J and H are different intentional properties, j↾J and j↾H can be different restricted individuals (i.e. John restricted to different aspects).

A reasonable question to ask is: Why analize a sentence like (29):

(29) As a judge, John is corrupt.

with a restricted term **John as a judge** and not with a restricted predicate **be corrupt as a judge**? I cannot go into this matter here, but let me say the following. In fact, it can be argued that both types of restriction are needed, and the semantic restrictions that I will impose on the term restriction will be inherited on predicate restriction by a simple correspondence principle. For the cases I will discuss here, term restriction will suffice, though.

The theory that I propose has the following structure. It is a combination of the logic of plurality with Thomason's intentional logic: it is based on two primitive types e and p:

- -type e will be the **extensional** cumulative hierarchy of individuals and groups as introduced in part two.
- -type p is a domain of primitive propositions with logical operations on them.
- -further as usual, function type <a,b> is the type of functions from a to b.

In this theory **properties** are propositional functions, function of type <e,p>. So the property **walk** maps every individual on the proposition that that individual walks.

The semantic interpretation of sentences goes in two steps. A model is a tuple <e,p,⟦ ⟧,h>, with e and p as above. ⟦ ⟧ is an interpretation function, a function from formulas to propositions: so sentences are first interpreted as propositions. h is a truth function, a homomorphism from propositions to truth values 0 and 1. Propositions are assigned truth values. In this way, in two steps, sentences are assigned truth values.

I will assign restricted terms the type of generalized quantifiers:

-j↾J is of type <<e,p>,p>

So, in the same way as we interpret **John** as λP.P(j), roughly, the set of properties that John has, **John as a judge**, j↾J, will be interpreted as the set of properties that John as a judge has.

So John as a judge is a set of properties. But which set of properties? Some plausible requirements on such sets are given in the following postulates:

Requirements:

1. $j \upharpoonright J\ (\lambda x.x = j)$

This postulate says that, although John as a judge may have different properties than John unrestricted has, it's still John, and not someone else.

2. $j \upharpoonright J\ (J)$
3. $j \upharpoonright (\lambda x.x = j) = \lambda P.P(j)$

(2.) is self evident. (3.) says that if you don't restrict John you get John. This one is not essential, but leads to nice reductions.

4. $j \upharpoonright J\ (P) \wedge j \upharpoonright J\ (Q) \rightarrow j \upharpoonright J(\lambda x.P(x) \wedge Q(x))$

If John as a judge is corrupt and John as a judge is well paid then John as a judge is corrupt and well paid.

5. $j \upharpoonright J\ (P) \wedge P \Rightarrow Q \ \rightarrow\ j \upharpoonright J\ (Q)$

If John as a judge takes bribes and taking bribes implies being corrupt, then John as a judge is corrupt.

6. $\forall P\!: j \upharpoonright J\ (\lambda x.P(x) \vee \neg P(x))$

This is an internal law of the excluded middle: as a judge John either has a property or he doesn't. If this is regarded as too strong it can be omitted.

7. $\neg \exists P\!: j \upharpoonright J\ (\lambda x.P(x) \wedge \neg P(x))$

This is an internal law of non-contradiction. It says that, though **between** aspects John may have properties that are mutually inconsistent, **within** one aspect he is consistent.

8. $j \upharpoonright J\ (P) \rightarrow J(j)$

This, finally, says that aspects that are used to restrict John are properties of John.

Conditions (4.)--(7.) make restricted terms $j \upharpoonright J$ **ultrafilters** of properties, corresponding to one individual j. Such ultrafilters abound in an intentional theory (but not in an extensional theory). Representation (30a) of (30) is not a contradiction:

(30) John is corrupt, but as a judge he is not corrupt.
(30a) **Corrupt**$(j) \wedge j \upharpoonright$**Judge** $(\lambda x.\neg$**Corrupt**$(x))$

(31) and (32) are represented as (31a) and (31b), and these are compatible (I do not have the space here to go into the precise analysis of the distributivity in these examples):

(31) The judges are on strike
(31a) $\sigma x.{*J}(x) \upharpoonright {*J}\ ({*S})$
(32) The hangmen are not on strike
(32a) $\neg \sigma x.{*H}(x) \upharpoonright {*H}\ ({*S})$

(33a) is equivalent to (34a), but not to (35a):

(33) The judge earns \$50,000
(33a) $\sigma x.J(x) \upharpoonright J$ (earn \$50,000)

(34) John as a judge earns $50,000
(34a) $j{\restriction}J$ (earn $50,000)
(35) John earns $50,000
(35a) $\lambda P.P(j)$ (earn $50,000)

Finally, (36a) and (37a) are also compatible (on the plausible assumption that the property of **being committee a** is an **intentional** property, **λx.Committee A**(x) (involving having certain responsibilities, playing a certain role in society, etc.) distinct from the **extensional** property **$\lambda x.\ x$ = Committee A**).

(36) Committee A visits South Africa.
(36a) $\sigma x.$**Ca**$(x){\restriction}\lambda x.$**Ca**$(x)$ (**Visit**)
(37) Committee B doesnt visit South Africa.
(37a) $\neg\sigma x.$**Cb**$(x){\restriction}\lambda x.$**Cb**$(x)$ (**Visit**)

Graduality of group intentionality
The present theory does not introduce groups directly as intentional entities. It combines the extensional set theoretic hierarchy with the idea that intentionality comes in through property restriction. In this sense, the theory that was presented in part two is preserved completely: the groups themselves are just extensional objects, but in context they can be restricted with a property to one of their aspects.

Let me repeat again the main idea of this restriction: in a context we often predicate properties under a certain aspect. The natural aspect is the descriptive content.

This theory makes certain predictions that are not made by a theory, like Link's, that introduces groups directly as a new type of intentional entities. The difference has to do with the fact that the particular intentionaliy involved in these examples is **a matter of degree**. If groups are just intentional entities as opposed to sets, then we expect all these examples to be intentional in the same way: we expect across the board the same lack of substitutivity.

The present theory reduces the intentionality to contextual restriction and predicts therewith that whether a restricted reading is assumed, and how much a restricted reading differs from an unrestricted one in a certain context is a matter of various factors, including the descriptive content of the restricting predicate, contextual clues, etc. In this way, the theory indeed predicts that there is not a sharp line between cases where we can and where we cannot substitute, but rather a floating scale.

Let me give some examples of things that are predicted.
1. We can expect that terms with hardly descriptive content like proper names, and conjunctions thereof, show less lack of substitutivity than terms with a descriptive predicate, because more work has to be done in a context to find a plausible predicate to do the restricting. Compare (38) and (39):

(38) **John and Bill** are well paid.
(39) **The judges** are well paid.

2. The meaning, or lexical content, of the predicate and its relation to the subject term are relevant. There is an obvious functional relation between **being chairman** and **being well paid**, a less clear relation between **being chairman** and **wanting to eat meat**, and in most contexts a very unlikely relation between **being chairman** and a physical property like **having a big nose**. It is not very likely (in most contexts) that someone has a big nose just on his aspect of being a chairman. Consequently, we expect that it is easier to get lack of substitution in (40) than in (41) and again much easier in (41) than in (42):

(40) The chairman **is well paid**.
(41) The chairman **wants to eat meat**.
(42) The chairman **has a big nose**.

3. We can expect that the lexical content of the descriptive term itself is important. A term like **the chairman** has a high functional content, is more involved in all sorts of intentional institutions, activities, etc, wears its intentional role more on its sleeves, than a term like **the drunk**, and again more than **the man with the big nose**, while, on the other end of the scale, proper names have hardly any functional content at all. Consequently, we expect lack of substitution to become harder to imagine from (43) to (46):

(43) **The chairman** is well paid.
(44) **The drunk** is well paid.
(45) **The man with the big nose** is well paid.
(46) **John** is well paid.

4. Human beings and human institutions have richer characters than, say, playing cards or appliances whose nature basically consists of the one role they play. We expect that we get more readily aspect restriction for entities that have a rich character than for lopsided individuals.
Compare (47) with (48) and (49) with (50):

(47) **The queen of Bessarabia** has to open the game.
(48) **The queen of Diamonds** has to open the game.
(49) **The queen of Bessarabia** does not work today.
(50) **The tap** does not work today.

We observe the same phenomenon with group level expressions. **Committees** are highly connotative human institutions. We expect more easily lack of substitution with them than with rather neutral terms like **groups** or **decks**.

For instance, suppose group A is group B and suppose group A visits Florence. It seems much harder than with committees to avoid the conclusion that hence group B visits Florence.

Similarly, suppose decks A and B have the same members. It seems very hard to deny than then they are the same deck.

All these phenomena are unexplained, if we assume that groups are just intentional entities. Decks of cards are groups, so we would expect them to be intentional in the same way as committees are. But in fact they are not, they are much more extensional than committees. And other terms are somewhere in between committees and decks.

Given all this, I conclude that in order to deal with these intentionality phenomena, we do not have to overload the extensional domain of groups and sums with intentional entities; it seems fruitful to avoid this and analyze these phenomena through contextual restriction with intentional properties.

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Identity and Common Nouns in Intensional Logic

Jacques van Leeuwen
Centrale Interfaculteit/ZWO
Universiteit van Amsterdam
Grimburgwal 10, gebouw 13
1012 GA Amsterdam

Henk Zeevat
Centre for Cognitive Science
University of Edinburgh
2 Buccleuch Place
Edinburgh EH8 9LW

Abstract

This paper contains a discussion of the relationship between the concept of identity across time and the notion of a sortal, and of the formalisation of this relationship in two systems of intensional logic, provided by Gupta and Montague respectively. It is argued that where Gupta's theory formalizes Geach's theory of this relationship, that leads to a relative identity concept, Montague formalizes the Aristotelian view, where the content of an identity statement derives from the sortal concept involved, but where identity itself remains an absolute notion.

Identity and Common Nouns in Intensional Logic

1. Introduction

This paper is concerned with the connection between identities and the meaning of common nouns. In particular we will discuss two formalizations in intensional logic of philosophical positions that take the thesis of an intrinsic connection between sortal concepts and identity as a point of departure. The first of these is Gupta's "logic of common nouns", which provides a syntax and a model theory that is a formalization of the position of relative identity formulated by Geach in Geach 1962.

Geach's thesis has been criticized by a number of authors. Most of them do not deny the connection between sortals and identity, but Geach's conclusion that identity is not a definite relation. According to Geach, there are only relations of identity with respect to sortals, so that there may be identity with respect to one sortal among objects given in different ways (e.g. given at different moments of time), but distinctness with respect to another sortal. The critics maintain that though the conceptual content of an identity is determined by the kind of the objects involved, there is always a single kind involved in a question of identity. In this way, identity remains an absolute relation. It is natural to wonder if the latter position can also be rendered in an intensional logic. We argue in this paper that such a formalization has indeed been given in the work of Montague. It is likely, that his treatment of identity has attracted no attention before (except from the formal point of view) because it is buried in an article which is primarily concerned with natural language semantics and does not give a philosophical motivation for it.

Section 2 is a philosophical introduction to identity and common nouns. Gupta's work is described in section 3 and discussed in section 4. In section 5 we introduce Montague's treatment and our interpretation and in section 6 both systems are compared.

2. Sortals and Identity: IS, ISR and ISA

The thesis IS states the intrinsic connection between identity and sortal concepts. A relatively neutral approximation is the following:

> The Connection between Identity and Sortals.(IS)
>
> It is not possible to have a criterion deciding on an identity between individuals given in different ways without invoking a sortal concept which applies to those individuals.

In contemporary philosophy, several writers [1] have stressed the role of sortal concepts in determining identity. To quote Strawson 1959:168:

> A sortal universal supplies a principle of identity for distinguishing and counting individual particulars which it collects. It presupposes no antecedent principle, or method, of individuating the particulars it collects. Characterizing universals, on the other hand, whilst they supply principles of grouping, even of counting particulars, supply such principles only for particulars already distinguished, or distinguishable, in accordance with some antecedent principle or method.

And he adds:

> Roughly and with reservations, certain common nouns for particulars introduce sortal universals, while verbs and adjectives applicable to particulars introduce characterizing universals.

Other writers make an analogous distinction with some variation in terminology; for example, substantival general terms versus adjectival general terms (Geach), individuative or sortal predicates (from the Aristotelian category of substance) versus predicates from the other categories that only give qualifications, relations, etc. (Wiggins). Geach and Dummett stipulate for the elements of the first class that they determine a criterion of identity, as well as a criterion of application. By contrast, with the general terms of the other class only a criterion of application is associated. Criteria of application (associated with all general terms) determine under what condition it is true to say of a particular that the general term applies to it (for example, that it is red, that it is a man). Criteria of identity determine our judgments about identity. For example, consider the criterion associated with the sortal *river* . This determines if something which is presented to us on one occasion is the same river as something given at a different occasion. Roughly speaking all common nouns are substantival general terms in this sense [2].

All writers we mentioned above state some version of thesis IS. Mostly, IS emerges in their attempts to characterize the class of sortal concepts. IS is quite general: it concerns the identity of all sorts of particulars whether they are concrete, abstract, natural or artefacts. For some abstract objects (especially from mathematics) the criterion may be quite precise. For example, for sets the criterion turns up as the well known extensionality principle. Another example is Peano arithmetic, where other axioms are used to give a precise characterization of identity between natural numbers.

Our focus, however, will be the more complicated case of concrete particulars, the socalled spatio-temporal continuants. It may be rather obscure what are the identity conditions for e.g., *horses*. But it is evident that they are not the same as for *ships* or *mountains*. This is what IS predicts: different principles of identity are associated with the sortals *horse*, *ship* and *mountain*.

In the case of continuants IS is supported by two general observations. First, mere pointing (using *this* or *that* accompanied by a pointing gesture) is in itself not sufficient for singling out a spatio-temporal continuant. Second, bare continuity is not a sufficient condition for deciding that something in the past and in the present is the same particular. Now, supplying a sortal concept makes the pointing effective or the continuity a sufficient condition for identity. For if the pointing gesture is guided by a sortal concept (e.g., in *this house*, *this cat*) it is determined what is the object that must be found in the region indicated by the pointing gesture.

In the case of identifying objects that are given at different moments of time continuity plays an important part. One can picture its contribution as follows: at one time a certain continuant occupies a spatial position and has certain qualities. If it persists in time all changes in position and in qualities must be continuous with respect to time. In that way it leaves a trace through time: its history. Thus, continuity is a necessary condition for identity of continuants. Nevertheless, continuity is not a sufficient condition. Consider a sequence of successive localized bundles of features. Is it sufficient that the sequence is continuous in time with regard to position and qualities for it to be the trace of a continuant ? The answer should be negative.

There are many continuous sequences which start with a continuant and end with a part of it or with something else which surrounds it (cf. Hirsch 1982:28ff). For example starting from a tree one can construct, by smoothly leaving out leaves, branches, trunk and finally roots until one is left with nothing at all. The sequence cannot be regarded as the history of one object, even though it is continuous in the relevant respects. So, continuity is not sufficient for being the history of one and the same object.

A sufficient condition is however obtained if we can find a sortal concept which covers the continuous sequence entirely: at any moment of time the sortal should apply to it. All the changes that the sequence passes through, must count as changes of an instance of the sortal as well. For example, a river is a continuous sequence of water. But the changes (the water flowing from its sources into the sea) do not count as changes of a quantity of water. The same sequence can however be covered by the concept river that allows the water that composes it to be replaced. It is essential that the covering concept is a sortal concept: a characterizing concept, which only supplies a criterion of application, would not do. For example, a continuous sequence from a man to his head, would not affect the property of having blue eyes: if it applies it continues to apply. This concludes our observations in favour of IS. More detail can be given (cf. Wiggins 1980,Hirsch 1982), but the above suffices for our purposes.

It is not surprising that some authors who accept IS have taken the further step of accepting a relative view of identity. Under IS, there is no such thing as the content of an unrestricted relation of identity: the relation always requires the presence of a sortal to determine its content in a particular situation. One way of stating this, is to say that there are many relations of identity, that differ from each other. Then it seems reasonable to accept that it may happen that one identity relation connects two objects given at a different occasion, while at the same time they differ according to another identity relation. The view that combines IS with a relative conception of identity will be labelled here as ISR. The other position, that combines IS with absolute identity will be referred to as ISA.

ISR may be summarized in the following theses:

1. The truthconditions of any statement of identity depend on a sortal concept. For example: the truthconditions of the two propositional functions

x is the same statue as y

and

x is the same lump of clay as y

may differ under the same assignment to the variables.

2. Identity is not a definite relation. There exist many relations of the form *being the same S as* where S is some sortal, but there does not exist one relation which embraces all these, and of which they all form restrictions. This follows directly from thesis (1).

3. The relations of identity *being the same S as* are necessarily equivalence relations, but they do not satisfy Leibniz' Law that identicals are indiscernable. For example, it is possible that (a), (b) and (c) are cosatifiable:

(a) x is the same statue as y
(b) x is the same lump of clay as x
(c) y is not the same lump of clay as x

Philosophers who accept ISA, the other position, hold that IS and absolute identity are compatible. They admit that principles of identity may be different for particulars of different kinds. But there cannot be objects that satisfy both *x is the same S as y* and *x is not the same S' as y*. The counterexamples, presented by proponents of ISR, are shown to be incoherent.

ISA can be summarized as follows:

1. Given any domain of particulars identity is a definite relation (the minimal equivalence relation). The relations *being the same S as* are restrictions of the identity relation to the extension of S.

2. The informative content of statements of identity varies with the kind of the particulars involved. Example: the relations: *being the same statue as* and *being the same lump of clay as* have different informative content. It is not accepted however that there are objects x and y that can be identical according to the one, but distinct according to another identity relation.

3. The relation of identity and its sortal restrictions are equivalence relations and satisfy Leibniz' Law that identicals are indiscernable. It follows that identity is a necessary condition: if x=y then Nx=y[3].

3. Gupta's Semantics of Common Nouns as a Formalization of ISR

Gupta 1980 is an attempt to represent the distinction between common nouns and verbs in a system of intensional logic. The goal of the formalization is to capture the idea that common nouns determine a criterion of identity as well as a criterion of application, whereas verbs only determine a criterion of application.

In order to represent this difference transworld identities are treated in combination with the interpretation of common nouns. In a model we have a set of worlds I and associated domains of objects U(i) for the elements $i \in I$.

A criterion of application can as usual be understood as a function that assigns to each world i of I a subset of its domain U(i). This suffices for the interpretation of verbs. Common nouns occur primarily as parts of quantifiers. These are written as:

$$(\forall K,x)$$
$$(\exists K,x)$$

where K is the formal counterpart of a common noun and x a variable. The common noun K determines both the range of quantification in a world (a subset of its domain) and for every individual in the range of K its counterparts in other worlds, i.e. the objects that are identical-with-respect-to-K in other worlds. In this way K determines the transworld identities of the individuals in its extension[4].

This is achieved by two requirements on the interpretation of common nouns[5]. Firstly, a common noun K denotes in every world a set of individual concepts (functions that assign to every world $i \in I$ some individual out of the domain U(i)). The idea is that the individual concepts in the set link counterparts in different worlds to each other, so that when *a* and *b* are denotations of some individual concept in the set, they are identical with respect to K. Secondly, these individual concepts, taken together, satisfy a demand of separation: individual concepts that are elements, maybe at different indices of the denotation of the common noun are either equal (i.e. coincide at every index) or separate (i.e. do not coincide at all). With these requirements the intended result is achieved. If K is a common noun the range of the Ks at an index $i \in I$ is determined as the values of the individual concepts in the set denoted by K at *i*. Further, if an object *b* from U(i) is a possible K, then in some world *j* the counterpart of *b* (relatively identical to *b* with respect to K) is determined as follows: consider the individual concept *f* in the denotation of K at *i* such that f(i) = b. By separation there is an unique individual concept with this property. The counterpart of *b* in *j* is now simply f(j). In this way we have a formalization of sortal dependent relative identities (position ISR): a sortal identifies an object *b* in a world with a unique object *c* in another world. But this does not entail that there is a unique object *c* in another world corresponding to *b* in the absolute sense: different sortals may identify *b* with different objects in the other world.

For example:(cf. Gupta 1980:93)

a in w is the same statue as b in w'

a in w is the same lump of clay as c in w'
b and c are distinct elements in the domain of w'

Here *statue* determines that *a* in *w* and *b* in *w'* are the same, and *lump of clay* that *a* in *w* and *c* in *w'* are the same, but *b* and *c* do not coincide in *w'*.

4. Arguments against ISR and Gupta.

As we saw in the last section, Gupta gives a formalization of ISR. This position has been criticized, primarily in response to Geach's expositions of ISR[6]. In our opinion all the difficulties can be ascribed to the incomprehensibility of the status (or the identity) of the objects between which relative identities may hold. This can be illustrated by studying the example from the last section more closely. What are the objects that are the same statue but different lumps of clay ? If they are determinate particulars they must have determinate identity conditions and these, according to thesis IS, would depend on some sortal concept. But in that case, as Dummett 1973:571 puts it: "there is no question of the object's standing either to itself or to some other object in some relativized identity-relation which corresponds to a different criterion of identity."

Let us illustrate this by pursuing the example from the last section a bit further: Suppose *a* and *b* are objects such that:

(1) a is the same statue as b
(2) a is not the same lump of clay as b.

And suppose further that a and b have determinate identity conditions, that are contained in the sortal concepts *statue* and *lump of clay*, respectively. Now, if both (1) and (2) were true, the identity principles contained in the sortal concepts *statue* and *lump of clay* must be different. Thus, a particular could not be both a *statue* particular and a *lump of clay* particular[7].

If (1) is true we must suppose that *a* and *b* are both statues. Thus they are not lumps of clay. But then (2) is senseless, because it does not make sense to state about particulars, that are not lumps of clay, that they are not the same lump of clay. Of course, the statement that *a* and *b* are not composed of the same lump of clay makes sense, but this is not expressed by (2). So the example is incoherent.

The crucial step in the argument is the statement that statues cannot be the same as lumps of clay. The relativist wants to conclude from examples like the one above that the relation of identity is not definite. But one need not follow him here: according to us, they show that a continuant is underdetermined by its spatial position at some moment of time. One needs a sortal determination, which says what kind of continuant is meant. It is not identity that is indefinite, but the particular itself if no sortal concept has been given. In other words, a sortal determination is part of the constitution of the particular.

The statue example only shows that it is possible, that different continuants coincide. The statue-particular and the lump-of-clay-particular coincide: they occupy the same place at some time. But coincidence of continuants does not entail identity.

Only coincidence of objects of the same kind entails that they are identical as well.

These considerations can be made more general: particulars are identical or distinct absolutely, because they possess principles of identity intrinsically. In other words, identity of particulars is a one of their necessary conditions (cf. section 2, ISA thesis 4). To summarize the criticism in some slogans: the relativist must expand Quine's maxim "no entity without identity" via "no identity without a sortal concept" to "no entity without a sortal concept". Adherence to this thesis about the constitution of genuine particulars makes position ISA inevitable.

By the same reasoning one can deal with the alleged counterexample to Leibniz' principle of indiscernability of identicals (cf. section 2, ISR thesis 3): the principle can be maintained, if one assumes that particulars come with definite identity conditions.

There is another interesting consequence of our argument against ISR. The distinction between criteria of application and criteria of identity suggests that they function independently. In particular it suggests that the meaning of a common noun can be split into two separate parts. We want to show that this suggestion is misguided. A principle of application includes a principle of identity. Dummett and Gupta take the view the criterion of identity is independent of the criterion of application. Dummett gives an example:

> If, for instance, it is asked how many books a library contains, the question is ambiguous: we have to know whether *book* is being used in the sense in which a writer may be said to have written sixteen books, or that in which someone may be said to be able to balance sixteen books on his head. Just the same ambiguity arises if I am asked: "Is that the book I saw you reading yesterday ?" I might reply, "Well, it is the same *work*, but not the same *copy* of it." In both cases the ambiguity arises solely because we have two different senses for the expression '*same book*' (counting of course involves identity, because it is part of the criterion of counting correctly, that the same object is not counted twice). The difference of sense concerns only the criterion of identity associated with the word *book*, not the criterion of application associated with it, where the criterion of application is that, which determines when it is correct to say , "That is a book": with sentences of this latter form there is no room for the ambiguity to arise -the criterion of identity is irrelevant to the truth or falsity of the statement (Dummett 1973:74).

Gupta does not share Dummett's interpretation of the example:

> ... despite the fact that the two senses of 'this is a book' have the same truth conditions, it does not follow that the two senses of *book* are true of the same objects, and hence it does not follow that they share a principle of application. In general, the identity of truth conditions of 'that is ϕ' and 'that is ψ' does not imply that ϕ and ψ have the same extensions: for a counterexample, let ϕ be *rabbit* and ψ be *undetached rabbit part.* The same observation applies to Geach's example of "type-word" and "token-word". (Gupta 1980:26)

Nevertheless in Gupta's opinion there are examples of common nouns, which share only a principle of application, not a principle of identity (cf. Gupta 1980:22ff). Such pairs as *statue* and *matter constituting a statue* are examples, as is the pair *passenger* and *person travelling in a vehicle.* We take it that Gupta's objection to

Dummett's example can be brought against his own first example as well. The second example is different. Here, indeed, a principle of application is shared, but, against Gupta, the principle of identity is also shared. Gupta's argument for a difference in the identity criterion is the following phallacy:

> National Airlines served two million passengers in 1975.
> Every passenger is a person.
> Ergo, National Airlines served two million persons in 1975.

It seems to us that this is not conclusive. According to Gupta, " the person who boarded flight NA 583 is a different passenger from the person who boarded flight NA 376, but the two passengers are the same person". The situation is not correctly represented: the persons are the same passenger as well, only counted twice for certain purposes. This should be clear, once one realizes that the passenger does not cease to exist on disembarking, but continues to exist for as long as he lives as a person. Therefore the syllogism is correct if the first premiss is understood just as it stands, and not as a loose way of saying that a NA plane has been boarded two million times. Perhaps a defender of ISR is not convinced by this. According to him the principles of counting and thereby the principles of identity involved in the first premiss and in the conclusion are different. But in that case the second premiss would become false or incomprehensible: false, because not every object that is a passenger would be identical with a person since different criteria of identity are involved; or incomprehensible, because the objects of quantification would not have definite identity conditions.

Continuing our discussion of ISR and Gupta, we compare the criteria of identity associated with sortal concepts that are related by restriction. It follows from the definition of restriction (see section 2.2.) that a restriction of a sortal concept shares its criterion of identity with the sortal concept it restricts. (for example *shoemaker*, *boy*, *man*, share their criterion of identity).

It is also a consequence of the requirements on the interpretation of common nouns in Gupta's system. If L and K are common nouns and L is a restriction of K, then an individual concept in the extension of L that denotes x at some index i is also an element of the denotation of K at i and by separatedness it cannot be different from the individual concept that denotes x as a K. Thus, the counterparts of x under L are the same as those under K and K and L determine the same criteria of identity. If Gupta would also consent to the proposition that all cosatisfiable sortal concepts are necessarily restrictions of some common general sortal concept, his position would collapse into an absolute one. This second proposition is plausible enough, but it is unlikely that Gupta would concede it. In the counterexamples to ISA we discussed above, there is not a common sortal concept of which both *statue* and *lump of clay* are restrictions, even though, on Gupta's view, these sortals are cosatisfiable.

The deficiency of ISR does not appear at the surface of Gupta's system. The dubious entities are the primitive objects which inhabit the domains at each index (cf. section 3). Nevertheless we think that there are two problems connected with the system. First of all, it is hard to see how proper names can be dealt with in the system. (Gupta does not discuss identity questions with proper names.) They are interpreted by individual concepts, but there are no further requirements on the individual concepts that fulfill this role. So it is not guaranteed that their denotations stand in some sortal dependent identity relation, as it should be in a system that gives a formalization of IS. It seems to be an improvement on Gupta's system if it is required that the intension of a proper name is always an element of the extension of a common noun at some index: in this way the denotations of the individual concept are identical with respect to a sortal[8]. The reasoning behind such a proposal may be developed as follows. A normal proper name is used just for tagging a particular. But the point is that anybody can use the name again if the particular is presented to him at another occasion. Recognition of the same particular at different occasions presupposes a criterion of identity and this is according to ISR dependent on a sortal. Thus a criterion of identity must be associated with a proper name. It seems natural to suppose that a proper name shares its associated criterion of identity with names of other particulars of the same kind (for example, "Jeremia" shares the criterion with other names of cats) and that the common criterion of identity is just the one associated with a sortal term for the kind.

However the proposal about the treatment of proper names in Gupta's system remains strange, if one assumes that sense can be made of the conjunction of (3) and (4), where *a* and *b* are proper names:

(3) a and b are the same statue.
(4) a and b are possibly different lumps of clay.

The example is highly similar to the one discussed above, but the situation is different by the use of proper names instead of variables. Since proper names are interpreted as individual concepts, they are supplied with a criterion of identity. If (3) is true, even a relativist would think it natural to assume not only that **a** and **b** are individual concepts that coincide at the point of reference but also that they are both in the extension of *statue*. But then, by the separatedness of the extension of statue, they coincide at every index and (4) cannot be true at all.

The point is that after the interpretation of a proper name, one can no longer associate criteria of identity with it at will: these already follow from the interpretation. In (3) and (4) an attempt is made to force two different associations of criteria with **b** but it seems that this attempt is not successful.

The second difficulty in the system is the treatment of common nouns like *thing, object, entity* and compounds out of them. (cf. Gupta 1980:34ff, 91ff) At first sight, *thing* must meet two requirements: all the objects of any sort must be in the extension of *thing* and the elements of the extension of *thing* must be separated, because it is a common noun. In Gupta's language:

(5) $(\forall K,x)\ (\exists T,y)\ N(x=y)$
(6) $(\forall T,x)\ (\forall T,y)\ (x=y \rightarrow N(x=y))$

Now these requirements are not consistent with instances of contingent identity, i.e. with a formula of the form:

(7) ($\exists$ S,x) ($\exists$ S',y) (x=y & ¬N(x=y))

Gupta therefore weakens (5) to allow for cases like (7).

(5') ($\forall$ K,x) ($\exists$ T,y) (x=y)

But it does not seem to us that this a fortunate choice: (5) is perfectly plausible. Consider two contingently identical objects like a lump of clay and a statue. The counterparts of the thing that they both are in the world in which they are the same, cannot simultaneously be lump of clay counterparts and statue counterparts. By separatedness (6) this would render the identity a necessary one. So *thing* must choose a criterion of identity and follow either *statue* or *lump of clay* or some different sortal.

In our opinion, (7) must be abandoned. It may seem plausible at first by a confusion of identity and coincidence. The common noun *thing* is not a normal sortal term, because coincidence of entities that fall under this common noun does not entail their identity. Nevertheless (6) is plausible if we distinguish both notions.

After all the phenomenon that nouns like *thing* behave as substantives counts against a relative view of identity. For it is clear that no specific principle of identity is determined by *thing*. The fact that we can use such a dummy substantive for purposes of reference and quantification can only be explained if it is assumed that for every particular object there is a unique principle of identity. If our use of *thing* would still depend on a choice between such principles it could not fulfill this function.

5. Montague's Meaning Postulate for Common Nouns as a Formalization of ISA.

In this section we argue, that a formalization of ISA is provided in (Montague 1973a). It is given by the second meaning postulate. As is well known, Montague interprets a fragment of English by way of a translation in a system of intensional logic. The second meaning postulate restricts the possible interpretations of common nouns. As in Gupta's system the extension of a common noun at an index is a set of individual concepts. If δ is the translation of a normal common noun[9] other than *price* or *temperature*, it satisfies:

MP2 $\forall x\, N\, (\delta(x) \rightarrow \exists u\; x = {}^\wedge u)$

In contrast to Gupta the extension of a verb at some index is also a set of individual concepts (or a relation over them). The intransitive verbs are governed by MP3:

If δ is the translation of a verb other than *rise* or *change*:

MP3 $\exists M\, \forall X\, N\, (\delta(x) \longleftrightarrow ext(M)\, (ext(x)))$
(M is of type <s,<e,t>>)

The technical implications of MP2 and MP3 have been studied extensively; and their formal significance has caused a certain amount of confusion [10]. It turns out that among the plausible candidates for MP2 and MP3 in the context of PTQ, these are the only ones that lead to acceptable results: the alternatives are easily refutable by counterexamples. Our interest is not so much in establishing the meaning postulates on quasi empirical grounds, but to explain why they are true. We believe that our interpretation explains why the MPs are as they are, and why they must be adopted. That one can argue for their validity by comparison with alternatives is only an extra analytical argument for the position ISA that underlies our interpretation.

Montague gives little explanation for the meaning postulates. The relevant passage:

> In view of MP2 "ordinary" common nouns(e.g. *horse*) will denote sets of constant individual concepts (e.g., the set of constant functions on worlds and moments having horses as their values; from an intuitive viewpoint, this is no different from the set of horses.

and

> The truth of MP3 is the natural requirement of extensionality for intransitive verbs.

The example of *horse* reveals how continuants are represented by individual concepts. If a concrete horse is represented by an individual concept *b*, then the denotation of *b* at some index is the continuant itself and not some state or stage of it at that index. Here, we have a situation where both the individual concept and its denotations represent a continuant (cf. the discussion in section 4). MP2 states that only individual concepts that denote the same continuant at every index, can be in the extension of a normal common noun.

MP2 is a formalization of thesis IS, the intrinsic connection between identity and sortal concepts, based on an absolute view of identity. We will argue for this interpretation in three ways. First by spelling out MP2 itself and an equivalent version of it. Secondly, by interpreting some scattered philosophical material by Montague (this only makes the interpretation plausible: it does not show that Montague intended MP2 to formalize IS) and thirdly in the next section by showing that MP2 makes Montague's intensional logic equivalent (in a sense to be spelled out there) to Gupta's formalization of IS.

Common nouns express sortal concepts and MP2 ties the meaning of common nouns to the identity of the particulars in their extension. As before, individual concepts can be seen as bridges between particulars in different worlds and MP2 states that the extension of a common noun can contain only individual concepts that connect identical particulars. Conversely, the connection is: identity (transworld identity) is tied to sortal concepts. Particulars at different indices that can be connected by an individual concept in the extension of a common noun are identical.

This converse principle is clearer in an equivalent [11] formulation of MP2:

if δ is the translation of a normal common noun:

MP2' $V x\ N\ V u\ V v\ ((\delta(x)\ \&\ P\ ext(x) = u\ \&\ P\ ext(x) = v) \rightarrow u = v)$

Intuitively: let two particulars be given at different worlds. They may have different features and can be totally dissimilar. If both however are denotations of the same individual concept falling in the extension of a common noun, then they must be identical. Since in Montague's model theory it is not assumed that every object is the denotation of an individual concept in the extension of a common noun we cannot take MP2' as a definition of identity, but only as a restriction on the identity relation, which is otherwise taken as primitive. However, in the next section, where we construct Montague style models from Gupta models, it turns out that we can use MP2 (and MP1) to define identity.

Verbs on the other hand do not have a special connection with the identity of objects. Therefore another meaning postulate must be used. According to MP3 it depends only on the denotation of an individual concept, whether it belongs to the extension of a verb or not. It follows indeed that the meaning of a verb does not have any bearing on the identity of objects, for questions of identity of continuants concern transworld identity or identity across time. Individual concepts in the extensions of verbs cannot determine transworld identities between objects because according to the postulate, the verb only makes demands on the current value of the individual concept and none on the other values.

MP2 and the first meaning postulates on proper names are strongly connected. If *a* is the kernel[12] of the translation of a proper name, it satisfies:

MP1 $\exists u \, N \, u = a$
u is a variable of type e

The intensions of individual constants like *a* are individual concepts. MP1 states that the intensions are constant functions. This amounts to Kripke's thesis, that proper names behave as rigid designators, i.e. if a proper name denotes some particular, it is required to denote the same particular at all indices. It follows, that a name can only be successful in naming the same individual over a period of time, if there exist determinate identity conditions for the individual it names.

MP2 guarantees, that things in the extension of some common noun satisfy this condition, and can therefore be named. In this manner the first meaning postulate can be related to the second. Kripke's work on rigid designation, identity and necessity is well known. It appears that the philosophical interpretation of the second meaning postulate requires a treatment of the same fundamental problems, but now in more detail and from a different angle.

We suggest a link with the Aristotelian tradition. If one defines primary substance as those concrete things that have definite identity conditions, MP1 requires that proper names for concrete things denote primary substances and MP2 requires that things in the extension of a common noun are likewise primary substances. Therefore common nouns are general names: they refer uniquely to a primary substance, once a location is determined (e.g., this horse here, or, the horse in the stable). General names express secondary substances (i.e. kinds of primary substances); verbs or adjectives are not general names.

Though Montague did not motivate his meaning postulates with philosophical argument, there is some evidence, that his ideas on these matters were similar to the line of thought we have sketched above. In a letter to Dana Scott of June 30 1968, he comments on Scott 1968. Part of the letter is quoted in an appendix to this article, another fragment is quoted by Montague in Montague 1973b. In the second fragment Montague sketches the construction of an ontology allowing for physical objects of different sorts, objects that may coincide without being identical. Montague introduces the quotation by:

> Let us for the present purposes suppose that our basic *objects* have no temporal duration, each of them existing only for a moment: they are accordingly what we might regard as temporal slice of 'ordinary objects', and might include such physical slices as heaps of molecules at a moment, and possibly such additional objects as instantaneous mental states. Then *ordinary objects* or *continuants* (for instance, physical objects, persons) would be constructs obtained by 'stringing together' various basic objects - or more exactly, certain functions from moments of time to basic objects. Two continuants K and L may be said to *coincide* at a moment *i* just in case the function values *f(i)* and *g(i)* are the same.
>
> To quote from my letter:
>
>> Now most pairs of ordinary objects are such that if they coincide at one moment, then they do so always.... But this is not true of all pairs of ordinary objects. There *are* different ways of stringing basic objects together.
>>
>> For instance, we are told that we change our bodies completely every so often. It follows that some living organisms 'correspond' at different times to two or more different heaps of molecules. Yet suppose we are materialists and do not believe in 'souls' or 'transcendent unities' or 'entelechies'. We should seem to be faced with an identity crisis.
>>
>> The solution is of course obvious. Both heaps of molecules and organisms are continuants made out of heaps-of-molecules-at-a-moment (Homaams). But they are pieced together in different ways: each heap of molecules consists of Homaams related in simple ways describable in physics, while organisms consist of Homaams related in certain functional or biological ways. Thus it may well be that no organism is a heap of molecules, but that materialism is nevertheless true in the sense that every organism coincides with a heap of molecules.... It may also be (though butterflies, caterpillars and divisions of protozoa give one pause) that whenever two *organisms* or two *physical objects* coincide, they are also identical. And indeed this may give some clue to *natural kinds*. For a set or property to be a natural kind it is probably necessary (though not sufficient) that for any two of its members, if they coincide, then they are identical.

It is clear, that Montague adheres to thesis IS: different sortal concepts, e.g. *organism* and *heap of molecules* give rise to different ways of stringing together the Homaams, i.e. to different principles of cross world identity. Indeed, there is a suggestion that Montague adheres to ISR here. This is due to his conception of continuants as strings of Homaams. In this way, continuants may share a Homaam in some world (they coincide), though only if they belong to the same natural kind they are in fact identical.

But it seems clear that this is not a version of ISR. On the latter position we would have to say that a Homaam, a heap of molecules and an organism are identical, without being necessarily identical. On Montague's view, the Homaam and the two continuants are three different objects, that coincide.

The second quotation makes use of some notation introduced by Scott in his paper. Scott distinguishes 'equality' (a logical notion) from 'incidence'. Incidence is explained as an equivalence relation that holds between two individuals if they share a fixed set of properties. Scott uses greek letters σ, τ,... for individual terms, = for equality, $\cong$ for coincidence and $\equiv$ for necessary equality:

$$\sigma \equiv \tau \longleftrightarrow N\,\sigma = \tau$$

Against the claim that equality can be defined in terms of incidence by:

$$N\,\sigma \cong \tau$$

he provides a counterexample. Montague comments:

> You raise the question of the intuitive meaning of $N\,\sigma \cong \tau$. Your example of 'the president' and 'the biggest crook' is unfortunate because both terms denote humans and hence continuants which (as you noticed) are identical if ever incident. But let's try σ = 'the president' & τ = 'the heap of molecules in the president's chair'. Then $\sigma \neq \tau$ is true because no organism is a heap of molecules; indeed the equality fails not only at present but at all times: $N\,\sigma \neq \tau$ is true. But suppose that the president (and nothing else) is now occupying the president's chair. Then $\sigma \cong \tau$ is true. If we also suppose that the presidency is so engrossing that at every time i, the president at time i (and nothing else) occupies the president's chair (so that every president sits at his desk continuously from the moment he is sworn in till the moment he leaves office), then $N\,\sigma \cong \tau$ is true. Thus $N\,\sigma \cong \tau$ is compatible not only with $\sigma \neq \tau$, but even with $N\sigma \neq \tau$.

This fragment contains some evidence [13] that Montague's position coincides with ISA. He argues that

$$N\,\sigma \cong \tau$$

is compatible with

$$\sigma \neq \tau$$

by means of an example. Two steps in the argument are crucial: first, that no organism can be identical to a heap of molecules, and, second, that necessary coincidence is not sufficient for equality. The second claim is an expression of IS: it is denied that necessary incidence is an independent and uniform criterion of identity for objects. Questions of identity, we can take from the first quotation, cannot be decided without recourse to the natural kind to which the objects belong, and the sciences (such as physics, biology) that study these natural kinds. The first claim expresses adherence to absolute identity. If identity is absolute, it cannot be allowed that two objects belonging to natural kinds with different identity conditions are contingently identical.

6. A Comparison of Montague and Gupta's Formalization

We have seen that Gupta's formal system is an attempt to characterize ISR, the combination of thesis IS and relative identity. Moreover, Montague's MP2 turns out to be likewise a formalization of IS, this time under the assumption of absolute identity. It will turn out that the model theory they provide is in fact equivalent, except for the assumption of absolute identity, in the sense, that whenever a formula is true with respect to a Gupta model with absolute identity, the corresponding formula is true with respect to the corresponding Montague model. Since absolute identity is valid in Montague style models, it is not possible to have a weaker condition. The rest of this section is devoted to the task of making the above claim precise and proving it.

It is convenient to interpret both authors as giving a semantics for the same formal language L. This language differs from predicate logic by the following two properties:

All quantification is restricted by special predicates called CNs.
There is one intensional operator N, for necessity.

If one compares L with PTQ, L is the (slightly reduced) image under the translation function of the fragment of PTQ English that contains only normal common nouns and verbs. Verbs like *rise* and *change* and nouns like *temperature* are hereby excluded. We assume that relational notation is introduced in the normal way [14]. Compared with Gupta, it is a fragment of his system, but for the fact that every occurrence of his quantifiers

$$(\forall K\, x)\, \phi$$
$$(\exists K\, x)\, \phi$$

are replaced by

$$\forall x\, (Kx \rightarrow \phi)$$
$$\exists x\, (Kx \,\&\, \phi)$$

respectively [15].

L has a set of CNs K, L, ..., a set of (n-place) predicate letters P, Q, R,... Moreover, individual constants c, d,... and variables x, y,... that together form the set of terms. From these the set of formulae is defined as follows.

1. If t_1 and t_2 are terms than $t_1 = t_2$ is a formula.
2. If $t_1,...,t_n$ are terms and P is an n-place predicate letter $t_1,...,t_n$ is a formula
3. If ϕ is a formula both $\neg\, \phi$ and N ϕ are formulae.
4. If ϕ and ψ are formula, then so are $\phi \,\&\, \psi$ and $\phi \rightarrow \psi$
5. If ϕ is a formula, x a variable and K a CN then both $\forall x\, (Kx \rightarrow \phi)$ and $\exists x\, (Kx \,\&\, \phi)$ are formulae.

6.1. Gupta Interpretation

A Gupta model is triple <I, U, F> where I is a non empty set of indices, U a function defined on I that assigns to every $i \in I$ a non empty domain of objects and F a function that assigns interpretations to the non logical constants of L. Let S (the set of individual concepts) be defined as follows:

$$S := \{ f : \text{dom } f = I \text{ and } \forall i\ f(i) \in U_i \}$$

F must obey the following restrictions:

1. $F(c,i) \in U_i$
2. $F(K,i) \subseteq S$
3. $F(P^n,i) \subseteq U_i$
4. (Separation) For all CNs K:
$\forall f, g \in \bigcup_{i \in I} F(K,i) (\exists j \in I\ f(j) = g(j) \Rightarrow f = g)$

An assignment g is a function from the set of variables to S. t^g is as usual defined as F(t) if t is a constant and g(t) otherwise.

Satisfaction can now be defined as follows:

1. $G \models P^n t_1,\ldots,t_n\ [g,i]$ $\iff$ $\langle t_1{}^g(i),\ldots,t_n{}^g(i)\rangle \in F(P,i)$
2. $G \models t_1 = t_2\ [g,i]$ $\iff$ $t_1{}^g(i) = t_2{}^g(i)$
3. $G \models Kx\ [g,i]$ $\iff$ $g(x) \in F(K,i)$
4. $G \models \neg \phi\ [g,i]$ $\iff$ $G \not\models \phi\ [g,i]$
5. $G \models N \phi\ [g,i]$ $\iff$ $\forall j \in I\ G \models \phi\ [g,j]$
6. $G \models \phi \ \&\ \psi [g,i]$ $\iff$ $G \models \phi\ [g,i]$ and $G \models \psi\ [g,i]$
7. $G \models \phi \rightarrow \psi\ [g,i]$ $\iff$ $G \not\models \phi\ [g,i]$ or $G \models \psi\ [g,i]$
8. $G \models \forall x\, \phi\ [g,i]$ $\iff$ $\forall g' \sim_x g\ G \models \phi\ [g',i]$
9. $G \models \exists x\, \phi\ [g,i]$ $\iff$ $\exists g' \sim_x g\ G \models \phi\ [g',i]$

6.2. Montague Interpretation

A Montague model is a triple <I, U, F> where I and U are non empty sets, and F gives an interpretation for the non logical constants of L. F obeys the following conditions:

1. $F(c) \in U^I$
2. $F(K)(i) \subseteq U^I$
3. $F(P^n)(i) \subseteq (U^I)^n$
4. (MP1) F(c) is a constant function.
5. (MP2) If $f \in F(K)(i)$ f is a constant function.
6. (MP3) If $\langle f_1,\ldots,f_n\rangle \in F(P)(i)$ and $g_1(i) = f_1(i)$ and ... and $g_n(i)=f_n(i)$ then $\langle g_1,\ldots,g_n\rangle \in F(P)(i)$.

Assignments are now functions from the variables into U^I. t^g is as before. Satisfaction can now be defined as follows:

1. $M \models P^n t_1,\ldots,t_n\ [g,i]$ $\iff$ $\langle t_1{}^g,\ldots,t_n{}^g\rangle \in F(P)(i)$
2. $M \models t_1 = t_2\ [g,i]$ $\iff$ $t_1{}^g = t_2{}^g$
3. $M \models Kx\ [g,i]$ $\iff$ $g(x) \in F(K,i)$
4. $M \models \neg \phi\ [g,i]$ $\iff$ $M \not\models \phi\ [g,i]$

5. $M \models N\,\phi\ [g,i]$	$\Leftrightarrow\ \forall j \in I\ M \models \phi\ [g,j]$
6. $M \models \phi\ \&\ \psi[g,i]$	$\Leftrightarrow\ M \models \phi\ [g,i]$ and $M \models \psi\ [g,i]$
7. $M \models \phi \rightarrow \psi\ [g,i]$	$\Leftrightarrow\ M \not\models \phi\ [g,i]$ or $M \models \psi\ [g,i]$
8. $M \models \forall x\ \phi\ [g,i]$	$\Leftrightarrow\ \forall g' \sim_x g\ M \models \phi\ [g',i]$
9. $M \models \exists\, x\ \phi\ [g,i]$	$\Leftrightarrow\ \exists\, g' \sim_x g\ M \models \phi\ [g',i]$

6.3. Turning Montague Models into Gupta Models

This is not very hard, if we use the six conditions above. We can define a Gupta model GM by the following definition.

$U'(i) = U$ for all $i \in I$

$I' = I$

F' is exactly as F except for the interpretation of the predicate letters:

$$F'(P^n,i) = \{\langle f_1(i),...,f_n(i)\rangle : \exists \langle f_1,...,f_n\rangle \in F(P^n)(i)\ \}$$

GM is clearly a Gupta model. Condition (5) implies that the common noun interpretations are separated.

Moreover, on GM the same sentences are true as on M. Since all quantification is restricted to common nouns, we have only to consider those assignments, on a Montague model that assign constant functions to every variable. For those assignments it holds (under condition (4)) that:

$$\text{for all i, } t_1^g = t_2^g \Leftrightarrow t_1^g(i) = t_2^g(i)$$

and thereby that:

$$M \models t_1 = t_2\ [g,i] \Leftrightarrow GM \models t_1 = t_2\ [g,i]$$

By condition (6) it holds that

$$\langle t_1^g,...,t_n^g\rangle \in F(P)(i) \Leftrightarrow \langle t_1^g(i),...,t_n^g(i)\rangle \in F(P')(i)$$

Thereby:

$$M \models P(t_1,...,t_n)\ [g,i] \Leftrightarrow GM \models P(t_1,...,t_n)\ [g,i]$$

Since the other clauses are formally the same, it follows that for all M, ϕ, $i \in I$ and g assigning only constant functions:

$$M \models \phi\ [g,i] \Leftrightarrow GM \models \phi\ [g,i]$$

from which it follows directly (using condition (5)) that for closed formulae:

$$M \models \phi\ [i] \Leftrightarrow GM \models \phi\ [i]$$

6.4. From Gupta to Montague

It is not as easy to turn a Gupta model into a Montague model with the same theory. In fact, this is not possible in general, since Montague models do not allow for contingent identities [16]. A Gupta model on which a contingent identity is true can therefore not be transformed into a Montague model with the same theory. But these models can be excluded by demanding that the Gupta models we consider satisfy the extra condition of absolute identity [17].

Definition

Let G be some Gupta model. *Ind* is the set of those individual concepts f in S such that f is either in the extension of common noun at some index, or the intension of a proper name.

Definition

A Gupta model has *absolute identity* iff its set Ind is separated.

Note that on a Gupta model with absolute identity

$$x=y \rightarrow N\ x=y$$

is always true, if x and y have values from Ind.

The construction of a Montague model MG = <I',U',F'> from a Gupta model G = <I, U, F> is not just a matter of adjusting the types: we must also reconstruct the set of objects from the individual concepts in the Gupta model. Intuitively, an object in the domain of the Montague model is a sound individual concept in the Gupta model.; i.e. an individual concept that is provided with a criterion of identity. These are precisely the intensions of the proper names and the elements of common noun extensions, i.e. the set Ind defined above.

Let MG = <I, Ind, F'>

where F' is defined by the following conditions:

1. $F'(c) = \{ \langle i,F(c)\rangle : i \in I \}$
2. $F'(K)(i) = \{\{\langle j,f\rangle : j \in I\} : f \in F(K,i)\}$
3. $F'(P^n)(i) = \{\langle f_1,...,f_n\rangle \in (Ind^I)^n: \ \langle f_1(i)(i),...,f_n(i)(i)\rangle \in F(P^n,i)\}$

It follows by inspection of the definition that MG meets condition (1)-(6) on Montague models.

We must now check that MG has the same L-theory as G.

Since L has only restricted quantification we can, without loss of generality confine our attention to those assignments that assign members of Ind to the variables. An assignment g of this kind can be transformed into an assignment g^* that assigns to every variable x the constant function from I to g(x). We can now show that for assignments g of this kind:

$$G \models \phi\ [g,i] \Leftrightarrow MG \models \phi\ [g^*,i]$$

Proof

Again it is sufficient to prove the equivalence for atomic formulae.

A.	$G \models t_1 = t_2\ [g,i]$	<=>	(absolute identity)
	$G \models N\ t_1 = t_2\ [g,i]$	<=>	(satisfaction)
	$t_1^g = t_2^g$	<=>	(def. g^*)

$t_1^{g^*} = t_2^{g^*}$ $\Leftrightarrow$ (satisfaction)
$MG \models t_1 = t_2\ [g^*, i]$

B. $G \models Pt_1, \ldots, t_n\ [g,i]$ $\Leftrightarrow$ (satisfaction)
$\langle t_1^g, \ldots, t_n^g \rangle \in F(P)(i)$ $\Leftrightarrow$ (definition F',2)
$\langle t_1^{g^*}, \ldots, t_n^{g^*} \rangle \in F'(P)(i)$ $\Leftrightarrow$ (satisfaction)
$MG \models Pt_1, \ldots, t_n\ [g,i]$

Like before we can conclude from restricted quantification that for closed formulae

$$G \models \phi\ [i] \Leftrightarrow MG \models \phi\ [i]$$

and thereby that G and MG have the same L-theory.

6.4. Remark

So we have seen that Gupta's and Montague's formalization of IS is essentially the same, though their treatment of identity is different. Gupta intended to give a formalization of ISR. The comparison of the system establishes that in Montague's system a formalization of IS is reached. We prefer this version on philosophical grounds since it combines IS with absolute identity.

Another question is if Gupta's approach has any technical advantage over Montague's, e.g in characterising the semantics of common nouns. At first sight this may seem to be the case: Montague has to distinguish two classes of common nouns: normal ones and functional ones. It may be thought that Gupta deals with both by separation. But this cannot be true, since, intuitively, functional common nouns are not separated. Two temperatures, e.g., say the temperature in your room and in mine, may be the same at this moment, but that does not make them necessarily the same. So functional nouns are a problem in Gupta's system since he cannot account for the fact that they are often used like other common nouns in reference and quantification. Like with proper names, their referential function must be dealt with by an ad hoc stipulation that bears no resemblance to the standard case. In Montague's approach on the other hand the referential properties can be handled in the same way in all three cases. So on the whole it seems that Montague's approach to IS is preferable.

Footnotes

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1. For example,Strawson 1959, Geach 1962, Dummett 1973 and Wiggins 1980.

2. Also mass nouns can be included in the same class, since there is a criterion governing the use of *the same gold* for the mass noun *gold* and other mass nouns. However they do not meet Strawson's requirements, since they do not supply a method of counting the particulars to which they apply. Such particulars admit arbitrary divisions: all parts of some gold are gold again. With *sortal concepts* we shall mean also mass nouns to get a better correspondence with common nouns.

3. Throughout we use N for the necessity operator, and P for the possibility operator.

4. It would be natural but misleading to call these objects "the same K"; natural because they are (relatively) identical, misleading because they need not be Ks in the other world. A counterpart of a shoemaker may have a different profession. Gupta assumes however that there is always a more general sortal K' that is shared between the object and its counterparts.

5. The main ideas here are anticipated by Kaplan 1964 and Hintikka 1969. Kaplan considers a subset of the class of individual concepts which he calls essences or transworld heirlines, to connect individuals with their counterparts in other worlds. Hintikka, similarly, distinguishes individuating functions among the individual concepts.

6. See e.g. Quine 1964, Perry 1970, Wiggins 1980 chapters 1 and 2, Dummett 1973chapter 16 and Dummett 1981chapter 11, though these do not abandon ISR entirely.

7. Of course it is possible that a *statue* particular and a *lump of clay* particular coincide, i.e. occupy the the same region of space at some time. But coincidence does not entail identity. Only coincidence of continuants of the same kind entails identity .(Cf. the first observation on pointing and individuating a continuant in favour of thesis IS in section 2).

8. Gupta suggests a similar extension of his system.Gupta 1980:84ff.

9. The common nouns fall into two groups: the normal ones such as *man* or *unicorn*, that can be seen as predicates over rigid objects, and the functional nouns such as *price*, *temperature* and others that apply to functional entities like the function that assigns to every moment of time the temperature of my room at that moment in degrees Celsius. For an extensive study of the use of this distinction from a linguistic point of view, see Loebner 1979.

10. For comprehensive treatments of the technical implications see Friedman 1979 and Janssen 1983. The MPs allow for the introduction of object variables in certain cases. This is a complex matter: in PTQ this leads to a mistaken lemma:

$$\delta(x) \longleftrightarrow \delta_*(ext(x))$$

for common nouns. In the otherwise excellent Link 1979 the treatment is paradoxical. He proposes to apply MP3 and MP2 simultaneously to normal common nouns. But this does not work, since the extensions of common nouns become necessarily empty as soon as one assumes that there are at least two objects and two possible worlds. Under this last assumption, it cannot be true for any individual concept x that

$$\forall y\ (ext(y) = ext(x) \rightarrow x = y)$$

But this holds for x such that δ(x) and δ obeys both MP2 and MP3:

(1)	$\delta(x)$	
(2)	$\exists u\ (x = {}^\wedge u)$	MP2
(3)	$ext(x) = ext(y)$	assumption
(4)	$\delta(y)$	MP3, 3, 1
(5)	$\exists u\ (y = {}^\wedge u)$	MP2, 4
(6)	$x = y$	2, 3, 5

11. Both formulations are a way of stating that the extension of an individual concept in the extension of normal common noun must be constant.

12. Recall that the meaning of a proper name is the concept of the set of properties of the intension of an individual constant. The kernel is just the constant.

13. It is possible to be confused by the conception of individuals in the first quotation. Individuals are there conceived as strings of Homaams. The interpretation of equality between individuals (at an

index i) cannot be that the individuals denote the same Homaam at that index, since this would conflate identity and incidence. Rather, equality should be interpreted as denoting the same "string of Homaams" at that index. This would allow, as Scott wants, for individual terms to denote different individuals at different indices (as in 'the president').

14. As it turns out it is possible to have instances of unrestricted quantification in PTQ, that are obtained by misusing the rule that substitutes terms for pronouns in common nouns. This is in our opinion a further reason to regard this rule with suspicion. For our purposes we assume that PTQ does not contain it.

15. Gupta 1980:93 argues against these socalled Fregean analyses of natural language quantification, that are like our translation in L. The advantage he claims for his way of proceeding (contingent identities) is however fully retained in L under its Gupta interpretation.

16. Formulas of the form:

$$\forall x(Ax \rightarrow \forall y(By \rightarrow (x=y \rightarrow Nx=y)))$$

are always true on all Montague models, but not on all Gupta models.

17. There are many ways in which absolute identity may be defined. One alternative is to say that there is a common noun ("Ens") such that for all common nouns K

$$\forall x\ (K\ x \rightarrow Ens\ x)$$

and for all proper names c

$$\exists x\ (Ens\ x\ \&\ N\ c=x)$$

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ALGEBRAIC SEMANTICS

OF

EVENT STRUCTURES

Godehard Link
University of Munich

Abstract

As a further application of the author's project of *Algebraic Semantics* a natural language semantics is proposed which is based on individuals and events as basic entities. Like the set A of individuals, which carries the lattice structure of pluralities that was introduced in earlier work, the set E of events is equipped with a *lattice structure*; it is further characterized by a set of *roles* and spatio-temporal *trace functions* on E. An Austinian truth scheme combines events and types of event, which are also taken as basic. Quantification and negation are treated within this framework, which also comprises a context theory.

I. Introduction: The Project of Algebraic Semantics.

A semantic theory is, like other theories, a means of representing a certain domain of phenomena in such a way as to bring out and characterize the network of structural relationships that govern their behavior. There are two prominent ways to go about such a representation: the first is that of giving a set of *axioms* describing those relationships, e.g. Peano's axioms for the natural numbers; the trouble is that in general the axiom system is not able to exclude unintended models (e.g. non-standard models). The other way directly provides a concrete *model* for the phenomena to be represented. A typical example here is von Neumann's set-theoretic representation of the natural numbers where the '<' relation is modeled by the membership relation. There are several problems with this approach, too. The objects that model the phenomena must not be mistaken for the phenomena themselves; and even if the model is adequate it imports a number of *artefacts* of the representation that have little to do with the phenomena described: we have, for instance, the spurious fact $2 \in 5$ in von Neumann's model of the natural numbers.

In model-theoretic semantics the usual picture is that as modeling tools at our disposal we have set theory with urelements (the intended domain of individuals). All the structure to be discribed is then modeled by suitable set-theoretic constructs over those urelements. Even Montague, when he emphatically proclaimed the new philosophical age of intensional logic (Montague 1974: 154f.), didn't really depart from this methodological track; events, for instance, he construed as intension functions of moments of time, thus merely extending the urelements by adding times and worlds. The structure of events, then, is to be found in those set-theoretic functions. In spite of its formal beauty, the inherent weakness of this approach was soon uncovered: the vast variety of structures of "real world" objects couldn't be captured by the uniform shape of functions from possible worlds to individuals.

To get at what I call the *Project of Algebraic Semantics*, consider plural individuals as a very simple example of objects that have to be represented in natural language semantics. In my own work on plurals (Link 1983; Link 1986 and references therein) I did not give a set-theoretic model for those individuals; rather, I extended the domain of urelements so as to comprise usual individuals along with plural objects. The structure otherwise inherent in a set-theoretic model is here expressed in purely *algebraic* relations among the urelements. As a result, the familiar domain of individuals in Tarskian semantics, which is simply a non-void set of objects, is replaced by a *relational system* in the sense of Universal Algebra: in addition to the basic set of individuals, such a system may contain operations on and relations between the elements of this set. In the theory of plurals, for instance, the relational system is basically a semilattice structure.

Algebraic semantics, then, stays away from extensive set-theoretic modeling in favor of the axiomatic approach. Writing axioms for the objects to be represented comes down to a characterization of these objects in algebraic terms. The purpose of the present paper is to extend this approach to the theory of events.

The admission of a category of events to the domain of discourse is presumably not something these days that has to be particularly argued for. So let me merely recall some of the advantages of having events at our disposal in a semantic theory. Events can be named, counted, quantified over, and anaphorically referred to. The literature on verbal aspect even suggests that not only should events be counted among the objects of a natural language ontology, but semantic theory should be *based on events*. A familiar argument for that decision is the fact that the aktionsart of a sentence is not fully determined by the denotation of its verb phrase: while *arrive* is an achievement verb, which is incompatible with a durative adverbial phrase like *for three hours*, a plural subject transforms the achievement into a complex activity, witness the sentence *buses have been arriving at the airport for three hours*. What expresses a certain type of event, then, is nothing less than whole sentences.

The idea of a semantics that is based on events, however, requires a rethinking of the familiar model-theoretic framework. Should everything under the sun be construed as an event? Authors like Richard M. Martin (1978) seem to think so. His theory, however, is developed in a reductionist spirit deriving from modern nominalism. This is not the avenue that should be followed here I think. The elaborate system of ways in which language is able to refer to the familiar individuals strongly suggests that these individuals should be kept in our domain of discourse. Rather, "event-based" is to be understood as an alternative to "property-based": individuals are not primarily thought of as having properties or entering relations, but *playing roles in certain events*. Thus, an event-based semantics as it is understood here describes the interplay between individuals and the events that they are part of.[1] Recent work in linguistics has shown that within such a framework important generalizations can be captured that elude formulation in a more traditional setting (see, e.g. Krifka 1986, 1987). As a case in point, the well-known dichotomy between cumulative and discrete reference in the nominal domain finds its close parallel in the distinction between cumulative and "quantized" events. In fact, homomorphic relations can be established between individuals and events that show how the "referential type" (*die Referenzweise* in Krifka's wording) is transferred from one domain to the other.

An immediate consequence of a set-up along these lines is the need of a reformulation of the elementary rule of truth. What is now the condition under which, say, the sentence *John is running* is true? The work in situation theory (Barwise and Perry 1983; Barwise and Etchemendy 1986) has reminded us of an important truth scheme introduced by Austin (1961) that can provide a suitable answer to this question. Austin says that a declarative sentence S, when used assertively, contributes two things: the descriptive conventions of language yield a certain *type of event* θ that is expressed by S, whereas the demonstrative conventions refer to an actual, *"historic" event e*. The rule of truth, then, is simply that *e is of type* θ. Thus, the sentence *John is running* describes that type of event θ which is a running and has John as agent; this is a schematic event or event type since, for instance, the time of running is not specified. When a speaker truthfully utters that sentence he refers to an actual happening, one in which John is running, and asserts that this happening is of type θ, i.e. can be classified as an instance of a running of John.

If we adopt the Austinian scheme, how are we then to model types of events? Parsons (1980) and Krifka (1986,1987) choose sets of actual events, which looks like the natural option. Notorious problems with the so-called imperfective paradox, however, have convinced me that we have to go more intensional here. Following the spirit of Barwise and Etchemendy (1986) I therefore further extend the domain of urelements by adding event types apart from events. Truth is then to be explicated in terms of an inductively defined relation between events and event types. Here is a plausibility argument in favor of admitting event types as further objects in our ontology: sequences of event types are what I like to call *scenarios* ; in a world where the options of actions are tested by computer simulation it should be obvious how "real" those scenarios are: they figure prominently in economic as well as political decisions.

There are a number of problems that any theory of events has to deal with; let me mention what seem to me the most important ones: (i) individuation, (ii) negation, (iii) quantification, (iv) minimal parts, (v) the imperfective paradox.

With respect to (i), some questions at least can be answered within the algebraic approach. Consider, for instance, the event of John and Bill hitting each other; is that one event or two? It looks like one single happening, and yet, there seem to be two different acts of hitting involved, with the same participants, but in reciprocal roles. Now the lattice structure on the set of events that will be introduced below allows us to say that the event is *both* one and two: it is the unique sum event consisting of those two hitting events. Two seemingly conflicting intuitions about individuation can be reconciled this way. It is assumed here, of course, that we have to start with some class of "simple" events to which we have easy access. Basically, these are the simple facts of the form *John hits Bill* . Such an event has defined roles and roughly corresponds to what John Perry calls an *aspect* (Perry 1986). I shall adopt his term together with the term *chunk* he contrasts it with, but give them a technical meaning in the present framework; while a chunk is going to be *any* sum of events in the lattice, an aspect is either a simple fact (an atomic event) like *Bill left* or a sum of atomic events that are of the *same type*, like *every student left.*

Negation poses another conceptual problem for event theory. When events replace properties in our ontology then it is hard to say what kind of event a negative sentence like *John didn't come* is about: nothing happened, and in particular, there was no role for John to play. The first solution that comes to mind is to treat negation as *denial* : then the type of event that is expressed by *John didn't come* applies to all events that do not overlap with any event of type *John came.* The problem with this solution is that it presupposes the possibility of percolating every negation, regardless how deeply embedded, up to the highest sentence level. But this trick is doomed to fail: consider the sentence *every student didn't work for three hours* ; this is simply not the same as *not every student worked for three hours* . Thus, the existence of durative adverbials blocks the denial interpretation of negative sentences. In order to conceptually avail ourselves of a recursive negation I propose to consider *John didn't come* as expressing a negative type of *state* , the state characterized by John's not coming. Linguistic evidence supports this move: while an achievement verb like *come* cannot be combined with a durative adverbial phrase like *for three hours* , the negative sentence *John didn't come for three hours* is fine. Thus it is only when conceived in a narrow sense (as happenings, say) that events are not closed under negation. In what follows events are taken to comprise telic and atelic processes as well as states; the latter are needed anyway for generally representing all non-dynamic states of affairs.[2]

Next I like to take up the *minimal parts problem*, which is familiar from the study of mass terms (see Bach 1986); it reappears in the present context of event structures. Consider the event of Mozart's death, referred to by the sentence *Mozart died on the 5th of December, 1791*. In the formal treatment this event is going to be represented as an atomic element e in the lattice of events, since *die* is an achievement verb denoting a durationless change; no non-zero event can be a proper part of e. There is, however, a level of description on which Mozart's death is composed of a more or less complex series of events, e.g. the physical processes involved in his dying. The formal problem here is how those intuitive subevents are to be located in the lattice structure of events with respect to the (already atomic) event e. Or consider two other, less macabre examples.

(1) a. Immediately after (landing / his return from the summit meeting) the president conferred with his advisers / ?opened his seat belt.

b. Immediately after touch-down the president opened his seat belt / ?prepared a speech.

(2) Soon the polarity of the earth's magnetic field will be reversed (i.e. in 2000 years).

The point here is this. Conjunctions like *immediately after* should connect two atomic events where there cannot be a third one inbetween. But the president certainly must have opened his seat belt before conferring with his advisers (who are not on the plane, say). In the second example, the pace of the kind of processes that are on the same level as the reversal of the earth's magnetic field must be such that a time lapse of 2000 years can be called "soon".

Observations like these suggest that a single lattice E cannot represent the multi-layered structure of events in a realistic way. Since the model presented below is already quite complex I shall only indicate here how it could be extended in such a way as to resolve the minimal parts problem. A whole system of lattices $(E_i)_{i \in J}$ replacing E can be introduced, which is indexed by a partially ordered set J. Each element of J represents a certain *granularity* of the events in the corresponding lattice: the events in E_i are more fine-grained than those in E_j for $i \leq j$. A family of mappings between the E_i is added to model the fact that the E_i are but different conceptualizations of the same realm of phenomena. Formally, we have an *inverse system* in the following sense: for all $i, j \in J$ with $i \leq j$ there is a homomorphism h_{ij} from E_j into E_i such that (i) for all $i \in J$ h_{ii} is the identity map on E_i, and (ii) for all $i,j,k \in J$ with $i \leq j \leq k$, $h_{ik} = h_{ij} \circ h_{jk}$. Thus, a certain event can be atomic in a coarser domain and still be the image under a h_{ij} of a complex sum of events in a more fine-grained E_j.

The granularity of events has to be treated as a discourse parameter. A piece of discourse might evolve at a certain granularity which can be lowered and raised by appropriate linguistic means. Familiar narrative structures with their characteristic changes of level can be captured this way.

I would like to conclude this introduction with some remarks on the imperfective paradox. How can a sentence like *John is building a house* be represented in a way which does not presuppose the existence of a house that John built? Using the notion of granularity the following suggestion could be made: on a more fine-grained level the event type of building a house really consists of a whole scenario $\langle \theta_1, \ldots ,\theta_n \rangle$ of subevent-types θ_i such that θ_i has to temporally precede θ_j for $i < j$ $(1 \leq i,j \leq n)$. Then the event that John is building a house simply means that it can be matched with an initial segment $\langle \theta_1, \ldots ,\theta_k \rangle$ of the above scenario with $k < n$, which could mean, for instance, that the house is only half-way completed. Since a scenario as a sequence of event types is an intensional entity that condition would not imply the existence of a house, as desired. But this suggestion has a serious drawback:[3] it hinges upon the assumption that every accomplishment type of event has some kind of standard "definition" which can be expressed by a scenario of the above kind. Now consider the sentence *Mary made John a millionaire*; there is really no standard way of making somebody a millionaire: the only thing that counts is final success! I shall not pursue the issue further here but leave it with the following rather weak suggestion due to Jon Barwise, which can in a similar form be also found in Parsons (1980). There is the clear intuition that if John has built a house there was a time when he had the property of building a house. This connection could be formulated as a *constraint* on types of event. The converse, however, does not hold: if John has the *property of building a house*, there is no state in which John has built a house.

II. The Model Structure.

I now proceed to present in turn the various elements of the event-based semantics announced above. In what follows I shall assume a basic model structure of the form $\mathfrak{I} = \langle A,E,T,H,\mathcal{E},R,\pi,\sigma,\tau \rangle$ (the "aether model"). Here, A is the set of (ordinary) *individuals a,b, ...* of $\mathfrak{I}$ with parametric variables **a**,**b**, ... ; E is the set of *events e,e', ...* of $\mathfrak{I}$ with parametric variables **e**,**e'**,...; T is the set of *time stretches* or simply *times t,t', ...* of $\mathfrak{I}$ with parametric variables **t**,**t'**, ... ; H is the set of *regions of space h,h', ...* of $\mathfrak{I}$ with parametric variables **h**,**h'**, ... ; $\mathcal{E}$ is the set of *types of events* θ,θ', ... of $\mathfrak{I}$; R is a finite set of *roles* [4] $\rho_i : E \dashrightarrow A$ (e.g. agent, patient, etc.), which are partial functions from E into A ;[5] π is the basic relation *"is of type"* of $\mathfrak{I}$ between certain events and event types; $\sigma : E \dashrightarrow H$ is the *spatial trace function* and $\tau : E \dashrightarrow T$ the *temporal trace function* of $\mathfrak{I}$, with $Dm(\tau) \supseteq Dm(\sigma)$.[6]

These elements of the model structure are further specified in the following way. The sets $X := A, E, T, H$ are complete atomic lattices, with lattice operations $\vee$, $\wedge$, the infinite join $\bigsqcup$, and the intrinsic ordering relation $\leq$; the set of atoms in X is denoted by X^{o}. The lattice structure on A is the plural structure that was introduced in Link (1983). The extension of this structure to events was proposed by Bach (1986), Hinrichs (1985) and Krifka (1986); unlike in Hinrich's work, no stages are considered here. The trace functions σ and τ are complete homomorphisms, i.e. they are compatible with the formation of arbitrary joins and meets.

There is a 2-place relation S defined on the set E^{o} of atomic events: $e\,S\,e'$ means "e specifies e'". An example is *(John reads 'Gravity's Rainbow') specifies (John reads).* S is a partial order such that if e_1, e_2 specify e they are both specified by a common e'. The idea here is that it is not presupposed that an event is always and inherently specified in every respect; but if *John reads 'Gravity's Rainbow'* specifies a particular event of John's reading, and *John reads at midnight* specifies the same event, then there is an event, e.g. *John reads 'Gravity's Rainbow' at midnight,* specifying both *John reads 'Gravity's Rainbow'* and *John reads at midnight* .

Furthermore, it is natural to assume a linear order $\leq_0$ on the set T^{o} of basic times, with its strict version $<_0$. This induces a strict order $<$ on T :

(Def) $t < t' \;:\Leftrightarrow\; \forall s,s' \;[s,s' \in T^{o} \;\&\; s \leq t \;\&\; s' \leq t' \;\Rightarrow\; s <_0 s'\,]$

That relation in turn gives rise to the *precedence relation* « between events:

(Def) $e \ll e' \;:\Leftrightarrow\; \tau(e) < \tau(e')$ (" e temporally precedes e' ").

Temporal overlap between events is also defined in terms of the temporal trace function.

(Def) $e \circ e' \;:\Leftrightarrow\; \tau(e) \wedge \tau(e') \neq \mathbf{0}$.

A similar relation can be defined for spatial overlap. Note that we have $e \wedge e' \neq \mathbf{0} \Rightarrow e \circ e'$, but not the other way around. Finally, I assume the existence of *additive measure functions* $|\cdot|_\alpha : T \to \mathbf{R}$ whose axioms I shall not stop to specify (α stands for **min** [minutes], **h** [hours], **d** [days], **a** [years], etc.; **R** is the set of real numbers).

The roles ρ_i are necessarily partial function since obviously, not every event has a patient, for instance. But there is another reason for partiality. A sum event or chunk which is composed of heterogeneous aspects with lots of patients also has no defined patient role since uniqueness fails. If a sum event, however, consists of atomic events which have all a certain role defined, and, in addition, this role is filled by the same object, then the role is also defined for the sum event, with the same value. That is the content of the following axiom.

(Ax) Let $\rho_i \in R, e \in E, a \in A$; then $e \in Dm(\rho_i)$ & $\rho_i(e) = a$ iff $\forall e' \, [e' \in E^\circ \,\&\, e' \leq e \Rightarrow e' \in Dm(\rho_i) \,\&\, \rho_i(e') = a\,]$.

For further axioms that specify the roles I refer to Krifka (1986,1987). The axioms are needed there to determine the referential type of an event as a function of the referential type of objects playing roles in that event. With their help it can be proved, for instance, that the cumulative reference of *wine* leads to the cumulative reference of *drinking wine*, whereas the quantized reference of *a glass of wine* makes *drinking a glass of wine* quantized, too.[7]

We will need to have a name for the set of all objects playing a role in an event. It will be called a *cast*. Let $r(e)$ be the set of all roles that are defined for $e \in E$. Then the *cast of e*, *CAST* (e), is defined as follows.

(Def) $CAST(e) := \{\rho(e) \mid \rho \in r(e)\}$ for $e \in E^\circ$;
$CAST(e) := \bigcup \{CAST(e') \mid e' \in E^\circ \,\&\, e' \leq e\}$.

I proceed to characterize the important notion of an event type; this will be done inductively.

(Def) A *type of event* $\theta \in E$ is of one of the following forms.

1. θ is an element of a given poset [8] $\langle E^\circ, \leq^\circ \rangle$ of *atomic event types* and their opposing *negatives* (denoted by $-\theta$); examples are READING, WRITING, –READING, etc.; $-(-\theta)$ is the same as θ;
2. θ is an *elementary event type*, i.e.

2.1 θ is an atomic event type; or

2.2 $\theta = [\mathbf{e}; Sp(\theta) \ \& \ \theta_1(\mathrm{e})]$, where
$Sp(\theta) := RC(\theta) \ \& \ Re(\theta)$ is the *specification of* θ, with
$RC(\theta)$ denoting the *role conditions of* θ (e.g. $\rho_i(\mathrm{e}) = \mathbf{a}$),
and
$Re(\theta)$ denoting the *restrictions of* θ (e.g. BOOK(e)); and
$TC(\theta) := \theta_1(\mathrm{e})$ is the *type condition of* θ, with θ_1
elementary;

2.3 $\theta = \Sigma(\theta_1 \mid \theta_2)$, with θ_i elementary $(i = 1,2)$;

2.4 $\theta = \theta_1^*$, with θ_1 elementary (the *dual* of θ_1) ; $(\theta^*)^*$ equals θ ;

3. θ is a *conditional (event type)* $\theta_1 \supset \theta_2$, with θ_i elementary $(i = 1,2)$;

4. $\theta = \Delta\{\theta' \mid \theta' \in \Theta\}$ or $\theta = \nabla\{\theta' \mid \theta' \in \Theta\}$, where Θ is a set of elementary event types or conditionals (Δ stands for the *conjunction*, ∇ for the *disjunction* of types).

The semantic rules for the satisfaction relation to be defined below will make it clear why the event types are categorized just the way they are. Basically, the relation of an event being of type θ will only be defined for elementary θ, while truth is defined for all event types. Conditional event types (which formalize donkey sentences, for instance, or more generally, constraints) are not considered as elementary, since otherwise we would have to be able to say what it means for an event to be of type $\theta_1 \supset \theta_2$, or, worse, of type $[\theta_1 \supset \theta_2]^*$. Also, an event cannot be of type θ, where θ is a disjunction of types, $\nabla\{\theta_1,\theta_2\}$. Thus, rather than following the typical recursion on the usual logical symbols, the structure of event types is closely modeled after natural language. Elementary event types of form 2.2 correspond to simple (positive) predication in the highest node involving only singular NPs (like names or indefinite NPs), whereas sum event types of form 2.3 model (positive) sentences with general NPs, like *every student reads a book* . Negation is represented by the dual star, '*'.

The atomic event types under 1 are the ones which all the others are built up from. They come in positive and in negative form; this reflects our above decision to treat negation recursively. While, say, ARRIVING is an achievement event type, –ARRIVING is still an admissible event type, though not an achievement anymore. An event being of a negative (atomic) type, should not be located in space (it seems meaningless to ask in which region of space John didn't arrive at Munich airport), so the spacial trace function σ is not defined for it. That distinguishes such an event from an activity like RUNNING; together with the observation that negative types are compatible with durative adverbials this shows that we were right in regarding those types as states. - The partial order $\leq^o$ on E^o, finally, is meant to represent existing *constraints* on the atomic event types, e.g. KISSING $\leq^o$ TOUCHING .

There is one piece left in the model structure that has to be characterized by additional axioms. The relation "is of type", π, is defined on pairs of *atomic* events and *atomic* event types only. Furthermore, call two atomic events e,e' *role-trace-identical* (in symbols $e \approx_{rt} e'$) iff $r(e) = r(e')$, $\rho(e) = \rho(e')$ for all $\rho \in r(e)$, and for $\xi = \sigma, \tau$, $e \in Dm(\xi) \Leftrightarrow e' \in Dm(\xi)$ and $\xi(e) = \xi(e')$ if the traces are defined. Then π has to be coherent in the following sense.

(Def) A relation π in $E^o \times E^o$ is *coherent* iff

1. $\forall e \in E^o\ \exists!\ \theta \in E^o : \langle \theta, e \rangle \in \pi$;
2. $\langle \theta, e \rangle \in \pi \ \Rightarrow\ \langle -\theta, e' \rangle \notin \pi$ for role-trace-identical e,e';
3. $e\ S\ e' \ \Rightarrow\ [\langle \theta, e \rangle \in \pi \ \Leftrightarrow\ \langle \theta, e' \rangle \in \pi]$.
4. $\theta \leq^o \theta' \ \Rightarrow\ [\langle \theta, e \rangle \in \pi \ \Rightarrow\ \exists e' [e' \approx_{rt} e\ \&\ \langle \theta', e' \rangle \in \pi]]$.

Since π is coherent, every atomic event is of exactly one atomic event type; in other words, every basic fact must be of a certain type, and this type is uniquely determined. Secondly, the same objects cannot play roles in trace-identical events of opposing event types. Also, if event e specifies event e', e and e' have to be of the same type. The fourth condition means, for instance, that if an event is a kissing there has to be a role-trace-identical touching.

Two final definitions. An event $e \in E$ is an *aspect (of the world)* iff e is a sum of atomic events of the same (atomic) event type. An event $e_0 \in E$ is called a *(world) chunk* if it is $\leq^o$-closed, i.e. if $e \leq e_0$ for an atomic event e, $\langle \theta, e \rangle \in \pi$, and $\theta \leq^o \theta'$, then $e' \leq e_0$ for any role-trace-identical e' with $\langle \theta', e' \rangle \in \pi$.

III. Translation and Truth.

In the Austinian picture the descriptive conventions of language yield an event type $\theta = || S ||$ for every natural language sentence S. This event type is what is usually called the logical form of S. There have to be rules, then, which produce $|| S ||$ from a given S. I am not going to specify those rules here. Let us simply assume that they can be specified, and that they are given in such a way as to yield event types where indefinite NPs are represented in parametrized form along the lines of Kamp (1981) and Heim (1982). Also, instead of building up trees or DRS's to encode dependence of parameters, I assume an indexing of the parameters according to some given hierarchy of *dependence levels* (for this idea see, e.g., Fine 1985). If *PAR* is the set of parameters a,b, ..., t,t', ... , let $FR(\theta)$ be the set of "free" parameters, i.e. either of dependence level 0 or in case θ is a constituent of a larger type, of the lowest level not occurring outside of θ.[9] Then the notion of an anchor for an event type θ is defined in the following way.

(Def) Let e_0 be a chunk and θ an event type y.f is an *anchor* for θ and e_0 ($A[f,\theta,e_0]$ for short) iff f is a partial function from *PAR* into $CAST(e_0)$ such that $Dm(f) \supseteq FR(\theta)$.

I need a few abbreviations to prepare the central definition of satisfaction.

(Def) Let $e \leq e_0$; then $RC(\theta) \ |{>}_f \ e$ iff $A[f,\theta,e_0]$ and the role conditions of θ are fulfilled for e with respect to f, i.e. we have, for instance, $\rho_i(e) = f(\mathrm{a})$ for $\rho_i(\mathrm{e}) = \mathrm{a}$ in $RC(\theta)$.

(Def) $e_0, f \models Re(\theta)$ iff e_0 and f realize all restrictions of θ (see below)[10]

(Def) $Sp(\theta)[e_0, f, e] \ :\Leftrightarrow \ RC(\theta) \ |{>}_f \ e$ and $e_0, f \models Re(\theta)$

(Def) Let e_0 be a chunk, e an event with $e \leq e_0$, θ an elementary event type and f a partial function from *PAR* into $CAST(e_0)$. Then e_0, f *satisfy the relation "e is of type θ"* (in symbols $e_0, f \models \theta(e)$) according to the following recursive clauses:

1. $\theta = \theta_0$ atomic; then $e_0, f \models \theta(e) \ \Leftrightarrow \ \langle \theta, e \rangle \in \pi$;
2. $\theta = [\mathrm{e}; Sp(\theta) \ \& \ \theta_1(\mathrm{e})]$ with elementary θ_1; then
   $e_0, f \models \theta(e) \ \Leftrightarrow \ Sp(\theta)[e_0, f, e] \ \& \ e_0, f \models \theta_1(e)$
3. $\theta = \Sigma(\theta_1 \mid \theta_2)$, with θ_i elementary $(i = 1,2)$; then
   $e_0, f \models \theta(e) \ \Leftrightarrow \ e = \bigsqcup\{e_g \mid g \geq f \ \& \ e_0, g \models \theta_1\}$
   such that
   $\forall g \geq f \ [e_0, g \models \theta_1 \ \Rightarrow \ \exists g' \geq g : e_0, g' \models \theta_2(e_g)]$
4. θ atomic; then $e_0, f \models \theta^*(e) \ \Leftrightarrow \ e_0, f \models -\theta(e)$;
5. $\theta = [\mathrm{e}; Sp(\theta) \ \& \ \theta_1(\mathrm{e})]$ with elementary θ_1; then
   $e_0, f \models \theta^*(e) \Leftrightarrow e = \bigsqcup\{e_g \mid g \geq f \ \& \ Sp(\theta)[e_0, g, e_g]\}$ s.t.
   $\forall g \geq f \ [Sp(\theta)[e_0, g, e_g] \ \Rightarrow \ \exists g' \geq g : e_0, g' \models \theta_1^*(e_g)]$;
6. $\theta = \Sigma(\theta_1 \mid \theta_2)$, with θ_i elementary $(i = 1,2)$; then
   $e_0, f \models \theta^*(e) \Leftrightarrow \exists g \geq f \ [e_0, g \models \theta_1 \ \& \ e_0, g \models \theta_2^*(e_g)]$.

(Def) Let e_0 be a chunk, θ an event type, and f a partial function from *PAR* into *CAST* (e_0). Then e_0, f *realize* θ (in symbols $e_0, f \models \theta$) iff the following conditions hold:

1. θ elementary; then $e_0, f \models \theta \Leftrightarrow A\,[f, \theta, e_0]\ \&\ \exists\, e \le e_0 : e_0, f \models \theta(e)$;
2. $\theta = \theta_1 \supset \theta_2$; then $e_0, f \models \theta \Leftrightarrow$
   $\forall$ chunks $e \ge e_0\ \forall\, g \ge f\ [e, g \models \theta_1 \Rightarrow \exists\, g' \ge g : e, g \models \theta_2]$;
3. $\theta = \Delta\{\theta' \mid \theta' \in \Theta\}$; then $e_0, f \models \theta \Leftrightarrow e_0, f \models \theta'$ for all $\theta' \in \Theta$;
4. $\theta = \nabla\{\theta' \mid \theta' \in \Theta\}$; then $e_0, f \models \theta \Leftrightarrow e_0, f \models \theta'$ for some $\theta' \in \Theta$.

(Def) Let θ be an event type, e_0 be a chunk, and let $Prsp(\theta)$ be the conjunction of the types that describe the presuppositions of θ. Then

$$e_0 \textit{ admits } \theta \quad :\Leftrightarrow \quad \exists f_0 [\, e_0, f_0 \models Prsp(\theta)\,] .$$

(Def) Let e_0 be a chunk and θ an event type. Then θ *is true in* e_0 iff the following conditions hold:

1. θ elementary or a conditional; then θ is true in $e_0 \Leftrightarrow$
   e_0 *admits* $\theta\ \&\ \forall f_0 [\, e_0, f_0 \models Prsp(\theta) \Rightarrow \exists f \ge f_0 : e_0, f \models \theta\,]$;
2. $\theta = \Delta\{\theta' \mid \theta' \in \Theta\}$, where Θ is a set of elementary event types or conditionals; then
   θ is true in $e_0 \Leftrightarrow \forall\, \theta' \in \Theta : \theta'$ is true in e_0;
   $\theta = \nabla\{\theta' \mid \theta' \in \Theta\}$, with Θ as above; then
   θ is true in $e_0 \Leftrightarrow \exists\, \theta' \in \Theta : \theta'$ is true in e_0 .

Remark. Truth is defined only locally. The chunks can therefore be made to play the role of the *context* in presupposition theory, garanteeing the uniqueness of names and definite descriptions as well as the proper reference for context parameters like *I* and *now*. In fact, it can be seen from the definitions that truth is made dependent here on the condition that the context admits the event type, i.e. realizes all its presuppositions (Heim 1983, Link 1987). It follows that we do not have, in general, persistence of truth on chunks; i.e. if θ is true in e_0 and $e \ge e_0$, θ might cease to be true in e. There might be only one John around in chunk e_0, but a second John might enter the scene when we extend e_0 to e so that the uniqueness presupposition, and thereby truth, fails in e.

IV. Examples

Rather than giving an explicit set of rules I shall illustrate the idea behind the mechanism of assigning dependence levels to the parameters in an event type by means of some characteristic examples. Basically, general NPs in the sense of Barwise (1985) (viz. *every student* , *no student*) give rise to pushing the current dependence one level up (example (2)), whereas with indefinite NPs the given level remains unaltered (example (1)). Proper names and definite descriptions always stay on level 0, which reflects their scopelessness (example (5)). In case an indefinite NP is intended to have scope over an incoming general NP it may stay on the current level (example (11ii)).

It is convenient to provide a natural language sentence with the relevant dependence information before it is assigned its event type, as can be seen from the following examples.

(1) John reads a book.
(^{0}[John], ^{0}[reads a book]) = ^{0}[John reads a book]

(2) Every student reads a book.
(^{1}[every student], ^{0}[reads a book]) = ^{1}[every student reads a book]

(3) John read every book.
(^{0}[John], ^{1}[read every book]) = ^{1}[^{0}[John] read every book]

(4) Not every student read a book.
(^{1}[not every student], ^{0}[read a book]) =
^{1}[not every student read a book]

(5) No student wrote a letter to the dean.
(^{1}[no student], ^{0}[wrote a letter to ^{0}[the dean]]) =
^{1}[no student wrote a letter to ^{0}[the dean]]

(6) No student read every book.
(^{1}[no student],^{1}[read every book]) = ^{1}[no student ^{2}[read every book]]

(7) Every student read no book for three hours.
(^{1}[every student], ^{0}[^{1}[read no book] for three hours]) =
^{1}[every student ^{2}[read no book] for three hours]

(8) No student listened to a tape for three hours.
(^{1}[no student], ^{0}[^{0}[listened to a tape] for three hours]) =
(^{1}[no student], ^{0}[listened to a tape for three hours]) =
^{1}[no student listened to a tape for three hours]

(9) No student wrote more than three papers.
(^{1}[no student], ^{0}[wrote more than three papers]) =
^{1}[no student wrote more than three papers]

(10) Every German with a car polishes it.
(^{1}[every German with a car], ^{0}[polishes it]) =
^{1}[every German with a car polishes it]

(11) Every country has a government spokesman telling all journalists a lie (viz. that the country's nuclear power plants are the safest in the world).

(i) (^{1}[every country], ^{0}[has a g.sp.^{1}[telling all journalists a lie]]) = ^{1}[every country has a g. sp. ^{2}[telling all journalists a lie]]

(ii) (^{1}[every country],^{0}[has a g.sp.^{1}[telling all journalists] a lie]) = ^{1}[every country has a g. sp. ^{2}[telling all journalists] a lie]

The next step is the assignment of event types to the indexed sentences. To demon- strate it, some typical examples from the above list will be selected. The dependence level is copied to every parameter that is introduced inside its scope (indicated by the brackets) and has not yet received a level. Sentence (1) is given an elementary event type of the form θ = [e ; Sp (θ) & θ_1(e)], where θ_1 is the atomic event type READING, the role conditions RC (θ) are ρ_1(e) = $\mathbf{a}^0$ & ρ_2(e) = $\mathbf{b}^0$ & τ (e) = $\mathbf{t}^0$, and the restrictions are JOHN(**a**) & BOOK(**b**) & **t** $\geq$ $\mathbf{t}_0$ ($\mathbf{t}_0$ is to represent the context parameter *now*). The quantifier *every* gives rise to a sum event type of the form $\theta = \Sigma\,(\theta_1 \mid \theta_2)$; whereas in principle both θ_1 and θ_2 are to be regular event types, the type θ_1 is written below in the familiar function-argument form since in all sample cases here it happens to be a state type (e.g. STUDENT(a)). Proper names and definite descriptions are treated as restrictions; as was noted above, the uniqueness condition has to be part of the context (chunk) in which the event type is interpreted. Example (9) contains the plural phrase *more than three papers*, whose parameter may be anchored to a sum individual containing more than three atoms. The star in front of the noun PAPER in (9'), which is borrowed from the plural logic in Link (1983), expresses the transition from individual papers to arbitrary sums of papers; these are then restricted by the numeral '>3'. Finally, the space parameter is omitted from all event types since I don't have anything specific to say about the function σ at this point; but see ter Meulen's (1987) on the topic of locating events.

(1') S = ^{0}[**John reads a book**] ; $\quad\quad \|S\|$ =
[e; ρ_1(e) = $\mathbf{a}^0$ & JOHN(a) & ρ_2(e) = $\mathbf{b}^0$ & BOOK(**b**) & τ (e) = $\mathbf{t}^0$ & **t** $\geq$ $\mathbf{t}_0$ & READING(e)]

(2') S = ^{1}[**every student reads a book**] ; $\quad\quad \|S\|$ =
Σ (STUDENT($\mathbf{a}^1$) | $\|^1$[a reads a book] $\|$) =
Σ (STUDENT($\mathbf{a}^1$) | [e ;ρ_1(e) = $\mathbf{a}^1$ & ρ_2(e) = $\mathbf{b}^1$ & BOOK(**b**) & τ (e) = $\mathbf{t}^1$ & **t** $\geq$ $\mathbf{t}_0$ & READING(e)])

(3') $S \;=\; {}^1[\,{}^0[\textbf{John}]\ \textbf{reads every book}\,]\,;\qquad \|S\| \;=$
$[\,e\,;\rho_1(e) = a^0\ \&\ \text{JOHN}(a)\ \&\ \|\,{}^1[\text{ a reads every book }]\,\|\,(e)\,] \;=$
$[\,e\,;\rho_1(e) = a^0\ \&\ \text{JOHN}(a)\ \&\ \Sigma\,(\,\text{BOOK}(b^1)\ \mid [\,e'\,;\rho_2(e') = b\ \&$
$\tau(e') = t^1\ \&\ t < t_0\ \&\ \text{READING}(e')]\,)\,(e)]$

(5') $S \;=\; {}^1[\ \textbf{no student wrote a letter to}\ {}^0[\textbf{the dean}]\ ]\,;\quad \|S\| \;=$
$[\,e\,;\rho_1(e) = a^1\ \&\ \text{STUDENT}(a)\ \&\ \rho_2(e) = b^1\ \&\ \text{LETTER}(b)\ \&\ \tau(e) = t^1$
$\&\ t < t_0\ \&\ \rho_3(e) = c^0\ \&\ \text{THE DEAN}(c)\ \&\ \text{WRITING}(e)\,]^*$

(6') $S \;=\; {}^1[\ \textbf{no student}\ {}^2[\ \textbf{read every book}\ ]\ ]\,;\qquad \|S\| \;=$
$[\,e\,;\rho_1(e) = a^1\ \&\ \text{STUDENT}(a)\ \&\ \Sigma\,(\,\text{BOOK}(b^2)\ \mid [\,e'\,;\rho_2(e') = b\ \&$
$\tau(e') = t^2\ \&\ t < t_0\ \&\ \text{READING}(e')])(e)]^*$

(7') $S = {}^1[\textbf{every student}\ {}^2[\ \textbf{read no book}\ ]\ \textbf{for three hours}\ ]\,;\ \|S\| =$
$\Sigma\,(\,\text{STUDENT}(a^1)\ \mid\ \|{}^1[\ a\ {}^2[\text{ read no book }]\text{ for three hours }]\,\|\,) \;=$
$\Sigma\,(\,\text{STUDENT}(a^1)\ \mid\ [\,e\,;\rho_1(e) = a\ \&\ \tau(e) = t^1\ \&\ \mid t\mid_h \geq 3\ \&\ t < t_0$
$\&\ \|\,{}^2[\text{ read no book }]\,\|\,(e)]\,) \;=$
$\Sigma\,(\,\text{STUDENT}(a^1)\ \mid\ [\,e\,;\rho_1(e) = a\ \&\ \tau(e) = t^1\ \&\ \mid t\mid_h \geq 3\ \&\ t < t_0$
$\&\ [\,e'\,;\rho_2(e') = b^2\ \&\ \text{BOOK}(b)\ \&\ \text{READING}(e')]^*\,(e)\,]\,)$

(9') $S \;=\; {}^1[\ \textbf{no student wrote more than three papers}\ ]\,;\ \|S\| \;=$
$[\,e\,;\rho_1(e) = a^1\ \&\ \text{STUDENT}(a)\ \&\rho_2(e) = b^1\ \&\ [(>3)^*\text{PAPER}](b)\ \&$
$\tau(e) = t^1\ \&\ t < t_0\ \&\ \text{WRITING}(e)\,]^*$

(10') $S \;=\; {}^1[\ \textbf{every German with a car polishes it}\ ]\,;\qquad \|S\| \;=$
$\Sigma\,(\,\text{GERMAN}(a^1)\ \&\ \text{CAR}(b^1)\ \&\ \text{WITH}(a,b)\mid [\,e\,;\rho_1(e) = a\ \&\ \rho_2(e) = b$
$\&\ \text{POLISHING}(e)\,]\,)$

I shall give now two examples for the *semantic evaluation* of event types. Let us consider first example (3'); let θ be the event type $\|\ {}^1[\ {}^0[\text{John}]$ read every book $]\ \|$ and e_0 a chunk. Then we have

(12) θ true in $e_0 \Leftrightarrow e_0$ admits $\theta\ \&\ \forall f_0[e_0,f_0 \models Prsp\,(\theta) \Rightarrow \exists f \geq f_0{:}e_0,f \models \theta]$;
$e_0,f\ \models \theta\ \Leftrightarrow A\,[f,\theta,e_0]\ \&\ \exists\, e \leq e_0{:}\ e_0,f\ \models \theta\,(e)\,;$
$e_0,f\ \models \theta\,(e)\ \Leftrightarrow\ \rho_1(e) = f(a^0)\ \&\ \text{JOHN}(f(a)) \leq e_0\ \&$
$e_0,f\ \models \Sigma(\text{BOOK}(b^1)\mid [\,e';\rho_2(e') = b\ \&\tau(e') = t^1\ \&\ t < t_0\ \&$
$\text{READING}(e')])(e)$;
$e_0,f\ \models \Sigma(\text{BOOK}(b^1)\mid [e';\rho_2(e') = b\ \&\tau(e') = t^1\ \&\ t < t_0\ \&$
$\text{READING}(e')])(e)$
$\Leftrightarrow e \;= \bigsqcup\{\,e_g\ \mid g \geq f\ \&\ e_0,g\ \models \text{BOOK}(b^1)\,\}$ such that
$\forall g \ngeq f\ [e_0,g\ \models \text{BOOK}(b^1) \Rightarrow \exists\, g' \geq g : e_0,g' \models \theta_1(e_g)]$, where
$\theta_1 = [\,e';\rho_2(e') = b\ \&\tau(e') = t^1\ \&\ t < t_0\ \&\ \text{READING}(e')\,]$;

$$e_o,g' \models \theta_1(e_g) \quad \Leftrightarrow \rho_2(e_g) = g'(\mathrm{b}) \;\&\; \tau(e_g) = g'(\mathrm{t}) \;\&\; g'(\mathrm{t}) < f_o(\mathrm{t}_0) \;\&\; \text{READING}(e_g).$$

Next let θ be the event type $\|\, ^1[$ every student $^2[$ read no book] for three hours] $\|$. This is example (7'), which contains a negation. Then we get the following truth conditions:

(13) θ true in $e_o \Leftrightarrow e_o$ admits θ $\&\ \forall f_o\, [e_o, f_o \models Prsp(\theta) \Rightarrow \exists f \geq f_o : e_o,f \models \theta]$;

$e_o,f \models \theta \quad \Leftrightarrow A\,[f,\theta,e_o] \;\&\; \exists\, e \leq e_o : e_o,f \models \theta(e)$;

$e_o,f \models \theta(e) \quad \Leftrightarrow e = \bigsqcup\{ e_g \mid g \geq f \;\&\; e_o,g \models \text{STUDENT}(\mathrm{a}^1) \}$ s. t.

$\forall g \geq f\, [e_o,g \models \text{STUDENT}(\mathrm{a}^1) \Rightarrow \exists\, g' \geq g : e_o,g' \models \theta_1(e_g)\,]$,

where $\theta_1 = \|^1[$ a $^2[$ read no book] for three hours] $\|$;

$e_o,g' \models \theta_1(e_g) \Leftrightarrow \rho_1(e_g) = g'(\mathrm{a}) = g(\mathrm{a}) \;\&\; \tau(e_g) = g'(\mathrm{t})$

$\&\; |\, g'(\mathrm{t})|_{\mathrm{h}} \geq 3 \;\&\; g'(\mathrm{t}) < f_o(\mathrm{t}_0) \;\&\; e_o,g' \models \theta_2^*(e_g)$, where

$\theta_2 = [\, \mathrm{e}' ; \rho_2(\mathrm{e}') = \mathrm{b}^2 \;\&\; \text{BOOK}(\mathrm{b}) \;\&\; \text{READING}(\mathrm{e}')]$;

$e_o,g \models \theta_2^*(e_g) \Leftrightarrow e = \bigsqcup\{ e_{gg} \mid g \geq g \;\&\; Sp\,(\theta_2)[e_o,g,e_{gg}\,]\}$ s. t.

$\forall g'' \geq g\,[Sp\,(\theta_2)[e_o,g'',e_{gg}\,] \Rightarrow \exists g_1 \geq g'' : e_o,g_1 \models \neg\text{READING}(e_{gg''})]$,

and $Sp\,(\theta_2)[e_o,g'',e_{gg''}] \Leftrightarrow \rho_2(e_{gg''}) = g''(\mathrm{b}^2)$ &

$e_o,g'' \models \text{BOOK}(g''(\mathrm{b}))$.

Notes

1) Obviously, events have to be conceived broadly enough so as to cover states like *John is intelligent*; see below.

2) In Situation semantics, the very existence of simple facts with a negative polarity (viz. <<COME,JOHN; no>>) shows that a similar decision regarding negative events has been tacitly made.

3) This objection, together with the example, is due to Barbara Partee.

4) Jon Barwise pointed out to me that these roles can be viewed as uniformities across the roles used in situation semantics. He also argued for preferring the latter notion to the one introduced here, basically on the grounds that the specific character of the roles is quite ideosyncratic of the relation at hand. Granted this, there still remain im- portant uniformities that justify the more general use of the notion; see, e.g., the axioms which (partly) characterize *effected* and *affected patient objects* in Krifka (1986,1987).

5) Here and in what follows, '-->' is to indicate a partial function.

6) This qualification is to reflect the fact that whenever an event has a spatial trace, i.e. a region of space where it occurs, it also has a temporal trace; on the other hand, stative events like that of John loving Mary, while certainly equipped with a temporal trace, do not seem to be located in space. Finally, also τ is considered to be a partial function since there are facts (e.g. those of mathematics) that are neither in space nor in time.

7) A comment is in order on the relation between the lattice structure for events in Krifka (1986) and the one intended and described here. Let w and w' be two disjoint portions of wine making up the contents of a glass of wine, and consider the events e of John's drinking w, e' of John's drinking w', and e^* of John's drinking the sum $w \vee w'$ of the portions w and w' (objects like portions of wine are supposed to form a semi-lattice, which is not at issue here). Now Krifka seems to think that the sum event $e \vee e'$ equals e^*, but according to the present framework e^* is just another single atomic event, whereas $e \vee e'$ is the a sum of two atoms which cannot itself be an atom again. Is there a redundancy here? I think not; the sum $e \vee e'$ models the collection of *two* acts of drinking, whereas e^* is just one, albeit protracted, act of drinking. The question cannot be whether $e \vee e'$ and e^* "really" are identical happenings - it all rather depends on our capacity to pick out different aspects of the processes around us: so in one case we might say "John drank twice", referring to the sum event $e \vee e'$, and in another "John drank the whole glass", stressing that he consumed the sum portion $w \vee w'$. The connection between the two events can be expressed in terms of the patient role function (call it ρ_2): $\rho_2(e^*) = w \vee w' = \rho_2(e) \vee \rho_2(e')$. By the same token, two consecutive (atomic) runnings e,e' might either be viewed as another atomic running e^*, where $\tau(e^*) = \tau(e) \vee \tau(e')$, or as the sum $e \vee e'$ of the two atomic runnings. It follows from this observation that (i) the sense in which activities like *running* or *drinking wine* are cumulative is *not* represented by the lattice structure on events that is assumed here, and (ii) the homomorphic property of ρ_2 and τ does not express the "referential transfer" between the activities and the domain of affected objects towards which those activities are directed; thus the structure on E is different from Krifka's event lattice. However, *within* the set E^o of atoms of E a whole array of other lattice structures may be defined (one for each atomic activity) which does capture the aspectual phenomenon of referential transfer that Krifka is concerned with. Now although an explicit account of the aspectual classes and their interrelations is a natural desideratum for any theory of events, it will not be given here, but has to be deferred to another occasion.

8) Poset = partially ordered set.

9) For an indication of how the algorithm for assigning dependence levels works, see the examples below.

10) The air of circularity in using this relation in the clauses of the satisfaction relation is spurious since $Re\ (\theta)$ is shorter than θ and "realize" could always be replaced by its definiens.

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Incomplete Events

Alice ter Meulen

Department of Linguistics

University of Washington
Seattle, WA 98195, USA

Abstract
A modeltheoretic analysis of English progressives in a lattice-theoretic dynamic interpretation is proposed, differing in major respects from possible world semantics. A type-theory with a universal entailment-relation serves to construct perspectives on structured domains, which are subsequently applied to temporal anaphora with progressives, offering also a new solution to the 'imperfective paradox'.

In this paper I propose a modeltheoretic analysis of the English progressive based on semi-lattices representing structured domains for events in a direct and dynamic interpretation. To assess the major differences between this lattice-theoretic approach and the interpretations of progressives in terms of possible world semantics I will first review some points of criticism of such modal interpretations. The main body of the paper presents the formal type-theory and the construction of structured domains and defines the central notion of a perspective on events. These lattice-theoretic tools are subsequently applied to temporal anaphora with progressives, and I conclude with outlining a new solution to the 'imperfective paradox'.

1. The modal interpretation of progressives

In Montague Grammar with indirect interpretation and other translational semantics progressive sentences have commonly been analyzed with a Priorean progressive operator of category $< t, t >$ interpreted as quantifying over accessible or 'inertia' future worlds[1]. Despite the formal similarity of such a progressive operator to the common tense operators, there are important semantic discrepancies between the progressive and tense-inflection. First of all, tenses serve to locate events, interpreting inflected clauses, with respect to the point of speech or other contextually determined temporal reference points. The progressive, however, does not have such deictic or anaphoric force, but rather carries aspectual information about the internal structure of the event, indicating that the event is incompleted. The internal structure of an event partly determines its temporal location relative to other events, as we will see below. Furthermore, the tense operators exhibit the familiar scope ambiguities of NPs as any intensional operator does, whereas a progressive operator does not seem to introduce any new ambiguities in addition to these. Looking at it syntactically, tenses are iterative both in the natural language (e.g. 'it was the case that S') and as operators in the formal language, but the progressive is not iterative in natural languages. Although a formal language will always contain infinitely many fomulas which never serve as translations of natural language sentences, this difference in iterability of the tenses and the progressive in natural languages does cast further doubt onto the reasons for analyzing progressives on a par with tenses by an operator quantifying over possible worlds.
In reporting an event as ongoing by using a progressive, we may make definite reference to something which is yet only partly completed and predicate some property of its completion. The semantic representation of such referential expressions needs a systematic way to relate an object to its temporal parts or stages, allowing for a case where a temporal part of an incomplete object does not necessarily end up as part of its completion. For such a part-whole relation the modal analysis of progressives would require backtracking from the world containing the completed event to a prior world where the event was still going on in order to interpret, for instance, the sentence

(1) Later Mary may mail the letter she is writing

The internal argument in (1) makes definite reference to a letter which is now only partly realized, and to its completion a further modal property is predicated. The interpretation of (1) in a possible worlds semantics would require tracking back from the completed realization of the letter to what exists of it now. Hence (1) would require an inverse of the 'inertia-world'-function to backtrack from a world **w'** with the completed letter to the current world **w** with the incomplete letter with respect to which **w'** is an inertia world. But, given the asymmetric temporal ordering, the inertia world **w'** in which we end up when the letter is completed may well have many possible past histories leading up to it, hence such backtracking cannot be captured in an intermediate formal language as an operator interpreted by a straightforward inverse function.[2]

Even if the translation to a formal language is dispensed with, there remain arguments against a modal interpretation of progressives reducing ongoing events to quantification over states or static reference-points.
The meaning assigned by Dowty 1979 to the progressive operator is that an event so described must be completed in all its inertia worlds. A semantic analysis requiring completion of the event in <u>all</u> accessible future worlds I call here **the strong modal interpretation**. The notion of an inertia world which resembles our world in all respects, except that the ongoing event is there completed, faces known foundational difficulties. To make the similarity-ordering on worlds precise single atomic facts must be weighed to measure how far they get us from the actual world and how unsimilar worlds containing them are from our world. E.g. adding the atomic fact that the law of gravitation does not hold must get to distant worlds, but adding another contingent atomic fact that Jim is walking remains close to ours in a world very similar to our own. But assignments of relative weight to atomic facts are not independent of each other. In a world without the law of gravity, for instance, a host of other atomic facts must be adjusted accordingly. To characterize precisely such semantic dependencies between atomic facts requires a non-trivial foundational modification of any possible world semantics. [3]
But besides these fundamental problems, the strong modal interpretation is known to be too strong on empirical grounds, as has been pointed out a.o. in Hinrichs 1983. On this interpretation, contrary to our intuitions, (2) entails (3)

(2) John was crossing the street, when a car hit him
(3) John must have crossed the street

This entailment would not be valid on a **weak modal interpretation**, advocated by Hinrichs 1983 and Cooper 1985 requiring that the ongoing crossing event is completed in <u>at least one</u> accessible future. [4]
One of the motivating arguments underlying the strong modal interpretation was, I believe, originally due to Rich Thomason.[5] Consider the following sentences

(4) The coin is coming up heads
(5) The coin is coming up tails

It has been claimed that (4) and (5) cannot be simultaneously true as long as the coin is in the air. In general, two progressive sentences cannot be simultaneously true when their simple past forms are incompatible. The

strong interpretation avoids the possibility of (4) and (5) being simultaneously true by requiring completion of the ongoing event at all accessible future worlds or situations. Accordingly neither (4) nor (5) is true as long as the coin is up in the air.
But this Montegovian account seems to run directly into difficulties. Despite our contrary intuitions, the disjunction of (4) and (5) must then be false (or at least not true) and classical bivalence will make the negations of (1) and (2) simultaneously true. Even if bivalence would not be valid and partial functions were admitted, the strong modal interpretation still has (6) entail (7), since it cannot maintain both the head and the tail outcome as options when the coin is in the air prior to its actually landing heads.

(6) The coin came up heads
(7) The coin must have come up heads

If we then try to save the modal interpretation of progressives by reverting to a weak interpretation, requiring only that at least one accessible future world or partial situation contains the completed event, there are still other problems. Contrasting the progressives in (4) and (5) to the modal + statives in (8) and (9),

(8) The coin may come up heads
(9) The coin may come up tails

I claim that (8) and (9) are both simultaneously true as long as the coin is in the air, but that (4) and (5) or their negations can only mean that the speaker has certain expectations concerning the outcome of the toss. Hence (4) and (5) express something about the speaker's attitude towards the tossing-event, but not about the event itself and one can use such progressives to convey the information that the coin is biased.
These considerations support the conclusion that progressives should not be analyzed as modals + statives at all, neither strong nor weak. The semantic interpretation should however retain the sound intuition that if an ongoing event is completed, the temporal stages towards its completion are its temporal parts. Hence I propose to represent incomplete events as parts of completed ones by a partial order on events in a domain structured as semi-lattice based on realizations of typed indeterminates.

2. Structured domains for events

The objectives of the structured domains I propose are the following:
1) to represent growth of partial information about temporal relations between events
2) to represent different aspectual properties of events by differences in the their internal structure of their semantic representation
3) to account for the anaphoric potential of events by the logical properties of their representation
4) to explain in purely modeltheoretic terms the 'imperfective paradox' and other tensed inferences.

Pursuing these objectives I start with the following modeltheoretic assumptions:

1) structure of semantic base should be as universal as possible, i.e. minimum of primitives and weakly structured

2) admit locally stronger structure in domains constructed by dynamic interpretation of linguistic input

3) semantic types are procedures to construct semantic objects

The structured domains resemble structures of situations as defined in Barwise and Perry 1983 in certain respects, but far less set-theoretic structure is built into the semantic objects here and I try to avoid imposing constraints as external conditions onto domains. The most important difference is perhaps that in these structured domains events are not sets of static atomic facts, but they may have other events as temporal parts. I.e. an event may be a stage within another event in a perspective on structured domains and an event is not semantically equivalent to the sum of its temporal parts.

2.1. Typing indeterminates and realizing types

The set **TYPE** of indeterminate-types is defined by

Basic types:

(i) type of relation-indeterminates, **REL** = $\{R^1_1, R^1_2, ..., R^2_1, R^2_2, ...\}$

The superscript indicates the number of argument-places needed to satisfy the relation. The subscript is used only to discriminate between indeterminates, and will not be used for coindexing.

(ii) type of argument-indeterminates, **ARG** = $\{A_1, A_2, ...\}$

The intention is that individuals and groups or collectives can equally realize arguments of relations, but they will differ in their semantic properties and hence in logical behavior.

(iii) type of polarity-indeterminates, **POL** = $\{ pol_1, pol_2 \}$

These are included for sake of completeness. I presume the two values 1 and 0 are the only possible realizations of polarity-indeterminates.

These basic types are used to define complex types, and specifying their type-structure determines how they are constructed from the basic types and how consequently their values are to be composed as internally structured.

Complex types

(i) type of event-indeterminates, **EVENT** = $\{ E_1, E_2, ... \}$

type (**EVENT**) = type (<< **REL**, **ARG** ^{n} > **POL** >)

the superscript ^{n} means n indeterminates of that type occur in the complex type. [6]

(ii) type of role-indeterminates, **ROLE** = $\{ O_1, O_2, ... \}$

type(**ROLE**) = type(< **ARG**, **EVENT** >)

$\mathbf{T}, \mathbf{T_1}, \mathbf{T_n}$ etc. are used as symbols for any arbitrary type in **TYPE**

x, y, z are used as symbols for indeterminates of an arbitrary type

A complex type for spatio-temporal locations of events is not included here, but I envisage incorporating locations as defined along the lines of my contribution to the previous Amsterdam Colloquium (ter Meulen, 1987).

Types should be thought of as methods to construct semantic objects, which are values obtained by executing semantic operations or procedures as specified by the type-structure. But different constructions may produce the same object, so it must be made precise how two distinguished typed indeterminates may be used to construct objects that are nevertheless indistinguishable, i.e. type-equivalent, a notion to be defined below.
The **TYPE** definition specifies the formal system in which meanings and informative content are represented. The realization-relation between types and semantic objects is defined by a homomorphism f :**TYPE** |---> **OBJ**, where **OBJ** is a set of semantic objects as specified by the following definition which simultaneously determines the type of a semantic object since f is a type-preserving mapping.

A semantic object <u>o realizes a type T in an event e</u> if there is a homomorphism f :TYPE |---> **OBJ** such that
(i) if **T** is basic, x in **REL** ∪ **ARG** ∪ **POL**, $f(x) = \mathbf{o}$
(ii) if **T** = **EVENT**, x in **EVENT**, $f(x) = \langle f(R^n), f(A_1), \ldots, f(A_n), f(pol_1) \rangle = \mathbf{o}$
This means that f assigns an object in the event **e** to all the relation-, polarity- and argument-indeterminates within a event-indeterminate , but that **e** may contain more that just those assigned objects, i.e. **e** may contain other events, but if it does not, it is indistinguishable from **o**
(iii) if **T** = **ROLE**, $x = \langle A_n, E_n \rangle$ in **ROLE**, $f(x) = f(A_n) = \mathbf{o}$ and $f(E_n)$ is part of **e**

A semantic object <u>o is of type T in some event e</u> iff. for some f : **TYPE** |---> **OBJ** and some indeterminate x of T, $f(x) = \mathbf{o}$ and **o** is part of **e**.
Defining this realization-relation relative to an event **e** itself allows quantification and temporal ordering over such realization-events, which is needed for instance for the interpretation of temporal frequency adverbials.

2.2. Type-equivalence and ordering types

If typed indeterminates are methods of constructing semantic objects, we should define what it means for such methods to be equivalent. Types should be equivalent when the procedures never construct different objects in an event. In other words, for $\mathbf{T_1}$ to be equivalent to $\mathbf{T_2}$ all objects that realize an arbitrary indeterminate of a type $\mathbf{T_1}$ should also realize an indeterminate of type $\mathbf{T_2}$ and vice versa. The following definition 1 captures this very strong notion of type-equivalence.

<u>Definition 1. Type-equivalence</u>
A type $\mathbf{T_1}$ is equivalent to a type $\mathbf{T_2}$, written $\mathbf{T_1} \Leftrightarrow \mathbf{T_2} =_{def}$
in every **e** for all x in $\mathbf{T_1}$ if $f(x)$ is of type $\mathbf{T_1}$ in **e** then $f(x)$ is of type $\mathbf{T_2}$ in **e**, and for all y in $\mathbf{T_2}$ if $f(y)$ is of type $\mathbf{T_2}$ in **e** then $f(y)$ is of type $\mathbf{T_1}$ in **e**.

Distinct types are, for instance, equivalent when they differ only in the order of application of an associative operation. Related to type-equivalence is the derived partial ordering of types representing modeltheoretically that an object may be of two distinct types if the types are structurally related. The definition is just half of the type-equivalence.

Definition 2. Type-entailment
Type $\mathbf{T_1}$ entails type $\mathbf{T_2}$, written $\mathbf{T_1} \leq \mathbf{T_2} =_{def}$
if in every **e** for all x in $\mathbf{T_1}$ if $f(x)$ is of type $\mathbf{T_1}$ in **e** then $f(x)$ is of type $\mathbf{T_2}$ in **e**.

Type-entailment guarantees for instance the validity of the entailment from

(10) John is reading a book

to

(11) John is reading

because of the structural relation between the event-type $\mathbf{T_1}$ = << ***read***, *x*, *y* >, 1> and $\mathbf{T_2}$ = << ***read***, *x* >, 1>, i.e. $\mathbf{T_1} \leq \mathbf{T_2}$. Entailments based on hyponymy or lexical relations between non-logical expressions can also be analyzed as type-entailments.
Based on this partial order of types the derived order on any x, y in **TYPE** is $x \leq y$ iff. type (x) $\leq$ type (y).

These are all the basic modeltheoretic concepts required to define internally structured events and the central notion of a perspective on a structured domain.

2.3 Structured domains and perspectives.

For my purposes I am only interested in semantic objects that realize types in events, and not in the entire set of possible semantic objects. Any class of semantic objects that are type-realizations constitute a domain D

D = {**o** in **OBJ** | there is an x and f such that $f(x)$ = **o**}.

Objects in a domain are ordered through the partial order of their indeterminates:
for any **d**, **d'** in D $\mathbf{d} \leq \mathbf{d'}$ iff. for some f and $x \leq x''$ $f(x)$=**d** and $f(x'')$= **d'**

A structured domain is the meet-semi-lattice based on a domain of objects with an idempotent, commutative and associative meet-operation $\wedge$ (sum or collective object) on the objects by the standard lattice correspondence $x \leq y$ iff. $x \wedge y = x$.

Definition 3. Structured domain
A structured domain $\mathbf{D}$ = < D, $\leq$, $\wedge$ > is a completed meet-semi-lattice based on the domain D of semantic objects.

On any structured domain the partial order defines an equivalence class of semantic objects with the 'same internal structure', i.e. objects which cannot be distinguished from one another by the available types. The intuitive idea is that in a structured domain you cannot tell objects apart unless the domain contains a typed object which tells them apart. This subjective perception of objects is formalized as a 'perspective' on a structured domain. Perspectives determine what is considered to be the same object in a structured domain, and the more types become available the more objects are discriminated in that domain. Hence perspectives allow continuous refinements of the 'representational grain'.

Definition 4. Perspective on a structured domain
A perspective **P** on a structured domain ***D*** is an equivalence relation **d** ~ **d'** defined by equivalence-classes **[d]** = { **d'**| **d** ≤ **d'** and **d'**≤ **d**}.

Type-equivalence makes objects of equivalent types equivalent in any perspective, i.e. if type (**d**) <=> type (**d'**) then in every **P** **d** ~ **d'**. The reverse does not hold, because type-equivalence is independent of perspectives and hence stronger than equivalence of semantic objects within a perspective. The equivalence classes may be relative to types, i.e. the objects in each class are of the same type, and one perspective consists of various equivalence classes of typed objects.
The class of perspectives is again partially ordered which determines precisely in what sense a perspective $\mathbf{P_1}$ may be a refinement of another perspective $\mathbf{P_2}$. If you refine the perspective on an object you first considered to be a unity, it may get divided into distinct objects.

Definition 5. PO-set of perspectives
$\mathbf{P_1} \leq \mathbf{P_2}$ iff. for all **d, d'** in D_1 such that in $\mathbf{P_1}$**d** ~ **d'**then if **d, d'** in D_2, in $\mathbf{P_2}$ **d** ~**d'**

This partial order of perspectives itself constitutes another meet-semi-lattice, respected by homomorphisms upon extending the domain.
By processing new linguistic input, new semantic objects realizing newly available types are introduced into the structured domain, while preserving the substructure of the old typed objects. In two respects this dynamic interpretation introduces more information : it provides 1) a more detailed description of what happened during the events already represented in the domain, or 2) a description of events which extend the structured domain with new objects which are not temporal parts of the old objects. Perspective refinement is used for the first kind of growth of information, but it also serves the characterization of incomplete and divisible events, to which I turn now.

2.4. Incomplete events and divisibility

Within a perspective an event may be perceived as ongoing and not (yet) completed, and two perspectives on the same structured domain may differ in what are considered to be ongoing events. The intuitive idea is quite simple: an event is in progress in a given perspective if in a perspective-refinement new stages of the event are introduced. In other words, only to completed events no further stages are ever added. Hence we don't require that ongoing events ever come to completion, but if they do, the stages of it introduced into the structured domain while it was still going on are temporal parts of the completed event.
In a given perspective an equivalence class of events that realize the same event-indeterminate represents an internally structured event. Notationally, an internally structured event is written **[e]** as opposed to **e** which is a realization of an event-indeterminate., i.e. $\mathbf{[\ e\ ]^{P}}$ = { **e'** | for some E_n in

EVENT f (E_n) = **e'** and in **P e ~ e'** }. The internal structure of an event is constituted by its stages which are the events realizing the same event-indeterminate. If two occurrences of the same kind of event are distinguished, then the perspective must be able to tell them apart by containing an object which is a temporal part of the one and not of the other occurrence.
An ongoing incomplete event is accordingly defined by

Definition 6. Incomplete event
$[e]^P$ is incomplete iff. there is a perspective $P_1 < P$ such that $[e]^P \subset [e]^{P1}$

An event is said to be completed in a perspective when it is not incomplete, so no perspective refinement will subsequently add new stages to a completed event. The progressive will be interpreted by incomplete events, and the locating tenses that do not convey aspectual information concerning the internal structure of events by completed events. The interpretation of the locating tense-morphemes will impose requirements on the relation between the current time of speech and the location of the events. The interpretation of the progressive morphology will require that given a realization-morphism f, a structured domain and a perspective, f is extended in a refinement of perspective on the possible new indeterminates. These conditions can be formalized as constraints on the dynamic interpretation process itself, but I leave them here in this semi-formal formulation.

Perspective refinements are designed to do one other important semantic job; namely to formalize the so called homogenous reference or cumulative reference of activities, events that may contain as temporal parts events of the same type. E.g. walking or reading events can be so divided, finishing or knocking events not (resp. accomplishment and achievement). In earlier publications I have proposed ways of formalizing these Vendler-classes in a partial modeltheory, which resembled the structured domains in some respects. Important is that the modeltheory gives a unified account of the homogeneity in mass and plural NPs and in events, so that a compositional account of the semantic properties of the Vendler classes can be given.

Here I present the definition of divisibility of structured events without much further discussion, and it is straightforward to generalize the notion to divisibility of any type. A structured event is divisible in a perspective if there is finer grained perspective in which other events as temporal stages of it are distinguishable, i.e. a perspective refinement in which the event is split into two distinct structured events.

Definition 7. Divisibility of a structured event
(i) $[e]^P$ is divisible iff. for some $P_1 < P$ $[e]^P = [e']^{P1} \cup [e'']^{P1}$
and $[e']^{P1}$ is disjoint from $[e'']^{P1}$

(ii) $[e]^P$ is indivisible iff. for all $P_n < P$ if there exists $[e']^{Pn}$ and $[e'']^{Pn}$ such that $[e]^P = [e']^{P1} \cup [e'']^{P1}$ then either $[e]^P = [e']^{Pn}$ or $[e]^P = [e'']^{Pn}$

An indivisible event cannot contain structured events as proper parts, since it is meet-irreducible in any structured domain. It incorporates all its possible stages, i.e. refinements of the perspective never split it into distinct events which are its temporal parts. Indivisibility may be absolute as defined, or relative to the same type of events, i.e. the three equivalence classes contain in that case only events realizing the same event-indeterminate (T-indivisibility).

These definitions make incomplete events divisible, although a divisible event is not necessarily incomplete. Furthermore a completed event is divisible only when one or more of its argument-indeterminates is realized by a divisible object (interpretation of mass or plural argument). Realizations are like chains which are as strong as their weakest link. The divisibility of events is shown below to account for the failure of progressives and activities to shift temporal reference points forwards.

3. Progressives and temporal anaphora

One of the major reasons for introducing this type-theory, incomplete events and divisibility in perspectives on structured domains is to account modeltheoretically for the compositional nature of aspect and temporal anaphora.
In the remainder of my time I will sketch some applications of the structured domains for events to temporal anaphoric dependencies between the simple past and the progressive tense, showing why the incomplete events, like activities, are incapable of shifting the discourse reference time forward . The interpretation of (12)

(12) John entered the room. Mary was reading a book.

introduces a completed structured event constructed from the equivalence class of all events realizing for some realization-function ***f*** the event-type

(12a) << ***enter*** , < A_1 ,<<***John*** , A_1 > 1 >, <A_2 ,<< ***room*** , A_2> 1>>,1>

and we could also require that ***f*** picks up an old object realizing the room from the structured domain already established. The simple past tense is interpreted by requiring 1) that this structured event be located entirely before the current speech time and 2) that no perspective refinement adds later stages to it , i.e no extension of ***f*** will produce other realizations of the same event-type that fall within the same equivalence-class. Of course, John may enter again later, but that means that the structured domain must contain an event which separates the distinct occurrences of John entering.
The second sentence in (12) is interpreted as an incomplete event constructed from the stages which realize the type in (12b)

(12b) << ***read*** , < A_3 ,<<***Mary***, A_3 > 1 >, <A_4 , << ***book***, A_4 > 1>>, 1 >

the realization-morphism ***f*** now is extended to ***f'*** and further constrained by 1) the tense requiring that the realized part of the event is located before the speech time, and 2) by the progressive morphology requiring that the event is structured as an incomplete event. Since ***f*** already carried the constraint that it could not be extended by temporal parts of the preceding structured event of John entering, because it was completed, the only way to locate Mary's reading the book is to make John's entrance a temporal part of it, lacking any more specific information as to the actual beginning or end of Mary's reading. Further information and perspective refinements may subsequently structure Mary' reading as starting before John's entrance and continuing after it as well, possibly even continuing now, but there is no semantic requirement that structures Mary's reading in this way. This is right from an empirical point of view, since (12) may be continued by any of the sentences in (13)

(13) a. She put it down right away
b. She had just started it and had read only the first page
c. When he closed the door she did not even look up

Only completed structured events move the reference time forward and fix in the structured domain a temporal antecedent for the structured event immediately succeeding it in the temporal ordering. Incomplete events or events which are part of events of the same type (activities) are incapable of doing so, because domain extensions and perspective refinements may provide additional temporal stages of an event needed before the reference time of the completed event can be determined, indicating what all temporally precedes the 'next' event. But in the structured domains an independent notion of a reference time is not needed, since the structural properties of the events account dynamically for their anaphoric potential and hence for growth of partial information about the temporal relations that may obtain between events or their parts. Locations arise in my analysis as constructions from structured events, and the only primitive temporal notion needed is just the time of speech. If an event is incomplete, perspective refinements may add later stages to it, so we have no information yet about its last stage, if any. But if another event is to be represented by interpreting the following tensed clause, it cannot be located in such a way that it shares no object as temporal part with the incomplete event (remember that one and the same object may realize different types). Only with respect to a completed and indivisible event it is possible to define a next event which succeeds it in the temporal precedence order. This logical property of incomplete structured events accounts for the fact that progressives (incomplete events) share with activities (divisible events) the inability to shift reference time.

Even if the overt temporal locating adverbial 'after' is used, it is only possible to locate an event as succeeding another event if both are completed and indivisible. Consider the following sentences

(14) John read every poem after Mary did
(15) The men read every poem after the women did
(16) ? John read poems/poetry after Mary did
(17) ? Men/burocracy read every poem after women/faculty did
(18) * John read the poem after Mary was reading it
(19) Mary was reading the poem before John read it

Sentences (14) and (15) are perfectly fine on a 'successor'-reading, because they contain only simple tenses and all NPs are definite and count and hence each event is structured as indivisible and completed.[7] But a simple tense in (16) and (17) with respectively a bare plural or predicative mass term in subject or object-position lacks a successor-interpretation, admitting only marginally of a habitual successor-interpretation. (18) is definitely not interpretable as describing successive events, although (19) admits of an interpretation which makes John's reading a temporal part of Mary's incomplete reading. In (18) the temporal adverbial conflicts with the constraint on the anaphoric potential of progressives represented as events with an incomplete internal structure.[8] Hence there seems to be an interesting anaphoric asymmetry between the locating adverbials 'after' and its supposed inverse 'before': the ongoing event has to be described first, if it is to serve as antecedent for an event temporally located within it. The issue deserves more study than I have been able to give it so far.

The temporal anaphoric properties of progressives makes for an important semantic difference in the interpretation of the VP-ellipsis in (20) and (21).

(20) Whenever John was crossing the street, Mary did
(21) Whenever John crossed the street, Mary did

The incomplete events interpretation of (20) requires a symmetric possibly partially simultaneous relation between the two crossings in all pairs of occurrences of the two events. But the completed past events interpreting (21) are asymmetrically ordered in time in virtue of their internal structure. Only in (21) is John's crossing a temporal antecedent on which Mary's crossing depends. The simple past tense is interpreted by events which are completely realized, i.e. have no unrealized parts anymore, so an asymmetric temporal dependency relation is definable on its structure.

Another interesting progressives puzzle once given to me by Frank Veltman is the question why (22) requires a successor reading of two events of smoking a cigarette, whereas (23) admits of an interpretation in which two cigarettes are being smoked simultaneously.

(22) Jane smoked two cigarettes last night
(23) Jane was smoking two cigarettes last night

Part of the solution is realizing that (22) is equivalent to (24), but (23) is not

(24) Twice last night Jane smoked a cigarette

where world-knowledge adds that it could not have been the same cigarette at both occasions. So (23) contains only very partial information, it leaves open whether the cigarettes were smoked entirely or only partially, one after another or possible partly simultaneously. All we are entitled to infer from (23) is that within last night there are at least two realizations of the event-type (23a)

(23a) $<<\textbf{\textit{smoke}}, < A_1, <<\textbf{\textit{Jane}}, A_1 > 1>>, < A_2, <<\textbf{\textit{cigarette}}, A_2 > 1>>> 1>$

and the past progressive requires only that both realizations are located in the past and does not even provide information whether both fall into the same incomplete structured event or in two distinct incomplete structured events. Further information may provide us more structure to determine what exactly was the case. One moral to draw from this is that numerical determiners in completed events as in (22) are equivalent to sentential frequency adverbials counting occurrences of completed events, whereas this equivalence does not hold for such determiners in incomplete events, independently of the syntactic position of the argument NP. This semantic insight might support the syntactic configurational condition that both tense and aspectual morphological markers govern determiners in argument-NPs.

A related point that might be of interest here is that gerunds of the form V-*ing* in complements of perception reports have progressive force in the sense that the report is about incomplete event. Consider

(24) Jane saw Mary reading poetry

in which the reading-event is reported as ongoing and only partly perceived by Jane. In particular we cannot infer from (24) that Jane knows when Mary started or stopped or how long she read for. We do infer from (24) the naked infinitive report

(25) Jane saw Mary read poetry

but perhaps this is so only because the reported event is itself an activity, a divisible event. However, it seems at least to some of my informants that the at the same inference would also hold for the accomplishment in

(26) Jane saw Mary reading a poem

(27) Jane saw Mary read a poem

This leads me to conclude that naked infinitive perception reports seem to admit a progressive interpretation of the complement as well as the well-known completed event interpretation in which Jane must have seen the entire reading-event for (27) to be true. In future work I hope to analyze in more depth within the structured domains for events these issues arising from progressives and Vendler-classes in perception reports. Obviously the issue here is closely related to the much debated 'imperfective paradox', which turns out in the next section to be not at all paradoxical on the interpretation in structured domains.

4. A new solution to the imperfective paradox

This interpretation of the semantic differences and relations between simple past tense and past progressives in structured domains will also provide a new purely modeltheoretic solution of the 'imperfective paradox', illustrated by (28) and (29).

(28) a. John is driving a car
     b. John drove a car
(29) a. John is reading a poem
     b. John read a poem

Here, (28a) entails (28b), an activity, but (29a) does not entail (29b), an accomplishment, eventhough both sentences contain a count noun in object position. If we interpret each a. sentence by an incomplete structured event, a perspective-refinement will contain another realization of the same event-type. Since the a. sentences are in the present tense, both incomplete events must be located containing the speech-time as temporal part. Hence they are divided by the 'now' into a part preceding it, a past temporal part, and a future part preceded by 'now'. Since (28) is an activity and hence divisible, no matter how small the past part of the representation of (28a) is, it must be of the same type and hence contain a completed realization of the car. But, since (29) is an accomplishment and hence indivisible with respect to its type, no part of it can realize the same type (of John reading a poem) , although part of it will realize the subtype of John reading.

Note in conclusion that the interpretation of the a. and b. sentences are constructed from events realizing the same event-type. A completely realized event-type will always contain as a proper part the incompletely realized event-type, correspondingly the b. sentences entail the a. sentences only if they agree in tense. Furthermore, if an activity sentence would contain a divisible NP as in (30a)

(30) a. John was reading poetry

exactly the same account as for (28) is given of the reason why (30) entails the simple past counterpart

(30) b. John read poetry

If some reference point is represented in the domain with respect to which the ongoing event can be divided into a completed past and an incomplete future part, and, of course, the speech-time must always be represented in a domain, an incomplete divisible event-type will entail its completed divisible event-type which is a past temporal part of it.
These semantic facts follow in the structured domains from the partial order on event-indeterminates and type-entailment, avoiding any appeal to lexical decomposition, meaning postulates or externally imposed constraints.

5. Conclusion

First a summary of the main features of the modeltheory defined in this paper is in order.
From the indeterminates of three primitive semantic types, i.e. relation, argument- and polarity-types, types for events and roles are defined. Indeterminates are realized by a homomorphism from the types to semantic objects which consequently inherit the type of the indeterminate. The strong notions of type-entailment and type-equivalence respect the internal type-structure of the semantic objects. Perspectives on structured domains, i.e. meet-semi-lattices of objects, contain equivalences classes representing structured typed objects. Incomplete events are represented by structured events to which more stages can be added by perspective refinement, and divisible events contain events of the same type, whereas indivisible events

either contain events of other types (T-indivisibility) or they are strongly indivisible and do not contain any events as parts.
The progressive is interpreted by incomplete events, the locating tenses by completed events. Activities are represented by divisible events, accomplishments by T-indivisible events and achievements by 'atomic' strongly indivisible events. States were not included in this analysis, as my views on statives have changed considerably and I now defend an analysis which would render them as constraints on structured domains (cf. ter Meulen , 1986a). Incomplete events cannot shift the reference time, since their 'open' structure does not provide a last stage with respect to which a next event can be defined. Since incomplete events are by definition divisible (but divisible events are not necessarily incompleted), this account of the temporal anaphoric potential of progressives offers a nice generalization to cover the anaphoric potential of activities as well.

Notes

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1 See Dowty 1979.

2 Definite and indefinite NPs exhibit different semantic properties with progressives. Compare for instance (1) to (1a) - (1c)

(1a) ? Later Mary may mail a letter she is writing

(1b) ? Mary is writing the letter which she may mail later

(1c) Mary is writing a letter which she may mail later

It seems to me, but my intuitions are not too clear, that (1a) and (1b) are less acceptable than (1) and (1c). The generalization one might see here is that if the main verb is a stative modal, it prefers a definite internal argument restricted by a subordinate progressive to provide the background against which modal options are determined. But if the main verb is a progressive, an indefinite internal argument modified by a subordinate modal sets the background for modal options at the time of the main tense of the progressive, i.e. at the moment of speech for (1c). I have no explanation to offer, but merely wish to suggest that internal arguments of progressives are to be represented as incompleted objects, i.e. temporal parts of completed ones. If such an argument is a pronoun and hence definite, prior discourse or other contextual parameters may supply its antecedent determining of what completed object it is a temporal part, as in (1d).

(1d) Mary went upstairs to work on her book. She is writing it in her study.

Clarification is needed of the way in which internal arguments of progressives can be incompleted and yet be referentially dependent upon a completed object.

3 See A. Kratzer's contribution to these proceedings.

4 Cooper 1985 introduces Situation Semantics for progressives analyzing them as unlocated event-types which are located in some possible extension of the actual situation. I believe this to be a partial form of the weak modal interpretation as the atomic facts are still stative themselves and located events are simply sets of facts. Against the weak modal

interpretation the obvious empirical argument may be adduced that the interpretation of a sentence as (2')

(2') John was crossing the street, but he never reached the sidewalk.

should not be contradictory, but simply be a set of incompleted events of street-crossing by John.

[5] See Dowty 1979, p. 147 and Cooper 1985, p.21. Note that the argument would also work with 'Jane is drawing a horse' and 'Jane is drawing an unicorn'. Describing Jane, when she has only drawn the body and legs, by the latter progressive sentence conveys the information that the speaker is expecting her to add a horn in the end.

[6] Perhaps these event-indeterminates would be more appropriately called 'stage-indeterminates' as they collectively represent a structured event.

[7] Note that (14) and (15) admit two distinct interpretations in a similar way: one in which all the poems are read first respectively by Mary or by the women (collective poems), and then by John or the men; and the second interpretation orders events containing a single poem, i.e. Mary reads "Shall I compare thee to a summer's day" before John reads it and she reads "If " before he does etc. and idem for the women and the men. Possibly (15) admits of an additional interpretation, namely when the plurals are taken distributively and the ordered events contain a single poem and a single reader.

[8] Note that (18) would be acceptable if the progressive were in the perfective tense, i.e. Mary had been reading the poem. Perfective tenses require that no stage ever occurs after the moment of speech, and perfectivity as a tense should be sharply distinguished from completeness as aspectual property of an event.

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THE ETHICS OF MURDER
A Simple Solution to the "Deepest" Paradox in Deontic Logic

J.-J.Ch. Meyer

Free University Amsterdam
Department of Mathematics and Computer Science
P.O. Box 7161, 1007 MC Amsterdam

ABSTRACT

James Forrester has pointed out that there is a variant of the Good Samaritan Paradox, involving aspectual actions, which seems to be harder to cope with than the other ones. In this paper we show that in the formal system PD_eL one can adequately deal with this paradox in a straightforward manner, once the necessary formal tools have been added.

1. Introduction

During his visit to Amsterdam in May 1985 Hector-Neri Castañeda gave a talk about what he called "the deepest paradox of deontic logic", which was discovered recently by James Forrester. He argued that while the more standard version of the Good Samaritan Paradox can be resolved fairly easily, the Forrester variant of the paradox was much harder to deal with.

Castañeda's version of the Good Samaritan is the following paradoxical argument: Imagine that Arthur plans to kill Jack a week hence and that he will actually do so. At this moment, however, Jack is wounded and Arthur is morally (or legally - this makes no difference for the argument) obliged to bandage him. Now we have the following:

(0) Arthur is forbidden to kill anyone (which is assumed to be a basic moral and legal law).

(1) Arthur ought to bandage Jack whom he will kill a week hence.

(2) Arthur bandages Jack whom he will kill a week hence implies that Arthur will kill Jack a week hence.

(P) If X's doing A implies X's doing B then it is also the case that "X ought to do A implies that X ought to do B".

From (1),(2),(P) we can infer the absurdity

(3) Arthur ought to kill Jack,

which is contradictory to (0).

In Castañeda's view the solution to this paradox is that we must discriminate between propositions like "Arthur will kill Jack a week hence" and practitions (or actions, as we prefer to call them) such as the act of Arthur killing Jack. The principle (P) is only concerned with actions, so (2) cannot be used as its premiss, thus breaking down the argument. (Cf.[C1].)

However, Forrester's Paradox has the following form:

(4) Arthur is forbidden to murder someone.

(5) Still, if Arthur murders someone, he will have to do it gently.

This is an abbreviation of

(5') Still, if Arthur murders someone, he will have to murder him gently.

Together with

(6) Arthur murders someone gently implies that Arthur murders someone

and the principle (P), which *does* apply in *this* case, we obtain

(7) Arthur ought to murder someone,

again an absurd duty, conflicting with (4).

Obviously in this case Castañeda's solution of the Good Samaritan by discrimination between actions and propositions does not help, since in both (5′) and (6) we are concerned with actions, and no propositions like in the standard Good Samaritan enter the argument. Castañeda tries to solve this paradox by a refined manner of discrimination involving *aspects* cq. adverbs like "gently" in this particular case. (See [C2]).

However, I do not think this is the issue here and I have discovered that in [SA] this opinion on Castañeda's solution is shared. In [SA] a much more elegant solution is given by means of only quantifiers and scope distinctions. But we shall see in the present paper that even these are not necessary to resolve the paradox, since we can stay within propositional deontic logic when dealing with it.

I agree with Castañeda that the Forrester Paradox is somewhat trickier than other, similar paradoxes. In fact, we shall see that also in the original version of the formal deontic system PD_eL we cannot deal with it adequately. However, with a slight extension of PD_eL the paradox becomes almost trivial to cope with.

But first we shall recapitulate the system PD_eL from [M1,M2], which is a variant of *PDL* (Propositional Dynamic Logic; cf.[H]), rendered suitable to express deontic propositions.

2. The System PD_eL with Its Semantics

The language of PD_eL (Propositional Deontic Logic) consists of *actions* and *assertions*. The actions α are either atomic $a_1, a_2, a_3, \ldots$ or a negated action $\bar{\alpha}$, a sequential composition $\alpha_1;\alpha_2$ of actions α_1 and α_2, a choice $\alpha_1 \cup \alpha_2$ between α_1 and α_2, or a joint or simultaneous performance $\alpha_1 \& \alpha_2$ of α_1 and α_2. The assertions ϕ are either the propositional variable V, with liability to sanction as intended meaning, logical compositions $\neg\phi$, $\phi_1 \vee \phi_2$, $\phi_1 \wedge \phi_2$, or expressions of the form $[\alpha]\phi$ with intended meaning that ϕ holds after the performance of α. Furthermore, we use as abbreviations $<\alpha>\phi \equiv \neg[\alpha]\neg\phi$, $F\alpha \equiv [\alpha]V$, $O\alpha \equiv F\bar{\alpha}$ and $P\alpha \equiv \neg F\alpha$.

The semantics of PD_eL expressions is based upon state transformations due to the actions α: given a state σ, $[\![\alpha]\!](\sigma)$ yields the collection $W_{\alpha,\sigma}$ of states (worlds) which one gets into after having performed the action α entirely. We recapitulate the main clauses in an informal manner (For a rigorous approach see [M2] and the appendix of [M1]):

- $[\![a]\!](\sigma)$ yields the set of states one can get into when performing the atomic action a. This has to be given by some fixed function $\hat{a}'(\sigma)$.
- $[\![\alpha_1;\alpha_2]\!](\sigma) = [\![\alpha_2]\!]([\![\alpha_1]\!](\sigma))$: in the states that are yielded by the performance of α_1 in state σ, we perform α_2.
- $[\![\alpha_1 \cup \alpha_2]\!](\sigma) = [\![\alpha_1]\!](\sigma) \cup [\![\alpha_2]\!](\sigma)$: the set of states one can reach by performing a choice of actions is (more or less)[1] the union of the sets of states one can reach by performing those actions.
- $[\![\alpha_1 \& \alpha_2]\!](\sigma) = [\![\alpha_1]\!](\sigma) \cap [\![\alpha_2]\!](\sigma)$, the set of states one gets into by both α_1 and α_2, i.e. (more or less)[1] the intersection of the sets of states one can reach by performing the actions α_1 and α_2 on themselves.
- $[\![\bar{\alpha}]\!](\sigma) = [\![\alpha]\!]^{-}(\sigma)$, where $^{-}$ is some complementation operator defined on the domain of denotations (see [M1]).

Instead of giving a complete description of the semantics of actions we only state some properties of actions that we assume to hold:

Proposition

(i) $\bar{\bar{\alpha}} = \alpha$

(ii) $\overline{\alpha_1;\alpha_2} = \overline{\alpha_1} \cup (\alpha_1;\overline{\alpha_2})$

(iii) $\overline{\alpha_1 \cup \alpha_2} = \overline{\alpha_1} \& \overline{\alpha_2}$

(iv) $\overline{\alpha_1 \& \alpha_2} = \overline{\alpha_1} \cup \overline{\alpha_2}$

In this paper we will not need an understanding of the semantics of actions beyond what has been given above. The semantics of assertions is as usual for the logical operators; the meaning of $[\alpha]\phi$ is given by

$[\alpha]\phi$ holds in state σ iff $\forall \sigma' \in [\![\alpha]\!](\sigma) : \phi$ holds in σ',

i.e. ϕ holds in every state that one gets into after the performance of α.

For PD_eL expressions we can give a formal system that is sound with respect to the (informally) given semantics (see [M1]): ($\phi_1 \subset \phi_2$ stands for $\phi_2 \supset \phi_1$.)

Axioms

(T) All tautologies of propositional calculus

($\Box\supset$) $[\alpha](\phi_1 \supset \phi_2) \supset ([\alpha]\phi_1 \supset [\alpha]\phi_2)$

(;) $[\alpha_1;\alpha_2]\phi \equiv [\alpha_1]([\alpha_2]\phi)$

($\cup$) $[\alpha_1 \cup \alpha_2]\phi \equiv [\alpha_1]\phi \wedge [\alpha_2]\phi$

(&) $[\alpha_1 \& \alpha_2]\phi \subset [\alpha_1]\phi \vee [\alpha_2]\phi$ [2]

($\bar{\bar{\ }}$) $[\bar{\bar{\alpha}}]\phi \equiv [\alpha]\phi$

($\bar{;}$) $[\overline{\alpha_1;\alpha_2}]\phi \equiv [\overline{\alpha_1}]\phi \wedge [\alpha_1][\overline{\alpha_2}]\phi$

($\bar{\cup}$) $[\overline{\alpha_1 \cup \alpha_2}]\phi \subset [\overline{\alpha_1}]\phi \vee [\overline{\alpha_2}]\phi$ [2]

($\bar{\&}$) $[\overline{\alpha_1 \& \alpha_2}]\phi \equiv [\overline{\alpha_1}]\phi \wedge [\overline{\alpha_2}]\phi$

Rules

(MP)

$$\frac{\phi \supset \psi \ , \ \phi}{\psi}$$

(N)

$$\frac{\phi}{[\alpha]\phi}$$

Remarks.

(i) Conditional actions such as in [M1] have been deleted, since they play no role in this paper.

(ii) In [M2] it is shown that this system can be rendered complete by adding a special predicate that keeps track of the actual performance of atomic action.

Some Theorems (Cf. [M1])

(1) $[\alpha](\phi_1 \wedge \phi_2) \equiv [\alpha]\phi_1 \wedge [\alpha]\phi_2$

(2) $[\alpha](\phi_1 \vee \phi_2) \subset [\alpha]\phi_1 \vee [\alpha]\phi_2$

(3) $F(\alpha_1;\alpha_2) \equiv [\alpha_1]F\alpha_2$

(4) $F(\alpha_1 \cup \alpha_2) \equiv F\alpha_1 \wedge F\alpha_2$

(5) $F(\alpha_1 \& \alpha_2) \subset F\alpha_1 \vee F\alpha_2$ [2]

(6) $O(\alpha_1;\alpha_2) \equiv O\alpha_1 \wedge [\alpha_1]O\alpha_2$

(7) $O(\alpha_1 \cup \alpha_2) \subset O\alpha_1 \vee O\alpha_2$ [2]

(8) $O(\alpha_1 \& \alpha_2) \equiv O\alpha_1 \wedge O\alpha_2$

(9) $P(\alpha_1;\alpha_2) \equiv \langle\alpha_1\rangle P\alpha_2$

(10) $P(\alpha_1 \cup \alpha_2) \equiv P\alpha_1 \vee P\alpha_2$

(11) $P(\alpha_1 \& \alpha_2) \supset P\alpha_1 \wedge P\alpha_2$ [2]

$$(12)\ \frac{\phi_1 \supset \phi_2}{[\alpha]\phi_1 \supset [\alpha]\phi_2}$$

3. Forrester's Paradox in PD_eL

How are we to translate Forrester's Paradox (4),(5) in PD_eL? First let us see how we treated a similar contrary-to-duty imperative (cf. [M1]):

(8) You are forbidden to go.

(9) Yet, if you go, you have to close the door afterwards.

This is translated without any trouble into PD_eL by:

(10) Fg

(11) $[g]Oc$

where g stands for the action "to go" and c for the action "to close the door".

However, a similar attempt of translating (4),(5), does not work adequately, taking m for the action "to murder" and g for the action "to murder gently" (Note that $m\&g=g$ in this interpretation.):

(12) Fm

(13) $[m]Og$,

since (13) expresses the statement that *after* you have murdered you ought to be gentle. This is not the intention of (5), where g and m have to occur *simultaneously*.

So we try the following formulation:

(14) Fm

(15) $O(\bar{m} \cup g)$,

where (15) expresses that one ought either not to murder or to be gentle (when murdering). Although this seems to be the right formulation in PD_eL, it is not, because in PD_eL (15) is implied already by (14), which is equivalent to $O\bar{m}$. This is a consequence of the fact that we have in PD_eL the theorem

(R) $O\alpha \supset O(\alpha \cup \beta)$.

This is the (in)famous Ross' Paradox, but regarding the semantics of PD_eL it is a perfectly sound theorem, meaning that if the doing of not-α leads to punishment, the doing of not-α and not-β leads to punishment as well, since not-α has also been done in this case.

This, by the way, is related to the principle (P), which in PD_eL can be formulated by

(P')

$$\frac{\alpha \blacktriangleright \beta}{O\alpha \supset O\beta}$$

where $\alpha \blacktriangleright \beta$, meaning "the doing of α implies the doing of β" (in an extensional interpretation), has the formal semantics:

$\forall \sigma : [\![\alpha]\!](\sigma) \subseteq [\![\beta]\!](\sigma)$.

Now (R) is a special case of the application of (P'), since

$[\![\alpha]\!](\sigma) \subseteq [\![\alpha]\!](\sigma) \cup [\![\beta]\!](\sigma) = [\![\alpha \cup \beta]\!](\sigma)$,

so $\alpha \blacktriangleright (\alpha \cup \beta)$ holds.

Furthermore, note the following:

Since $g = g \& m$, we have that

$[\![g]\!](\sigma) = [\![g \& m]\!](\sigma) = [\![g]\!](\sigma) \cap [\![m]\!](\sigma) \subseteq [\![m]\!](\sigma)$ (for all σ).

So $g \blacktriangleright m$. Hence by (P') we have $Og \supset Om$ as well. But this does not give rise to the same paradoxical argument as in section 1, because here, by (15), we only have $O(\overline{m} \cup g)$ and this does *not* imply Og. Consequently we cannot infer Om, the formal counterpart of the paradoxical conclusion (7) in section 1.

But now back to our original problem. Intuitively we have the feeling that (4),(5) say more than (4) alone, whereas the PD_eL formulas (14),(15) do not express more than (14) on its own. This paradox is caused by the fact that in PD_eL by the definition of $F\alpha$ as $[\alpha]V$ only signals the event that doing α leads to some liability to sanction. So it only signals violation of some prohibition. It cannot tell whether by doing α perhaps more than one violation of the laws is committed.

So in (15) it signals a violation when $m \& \overline{g}$ has been done. But it already records a violation when m has been done on its own! The additional "crime" of not being gentle when murdering, is not expressed in the PD_eL statement (15).

This gives us the clue of how to do it properly. Apparently it is not sufficient in this case to say that by violation of *some* prohibition a sanction is imposed. We need the expressibility to formulate that when doing $\overline{g}$ - besides doing m - one is liable to an *additional* punishment! We shall see in the next section how easily this is formalised by a slight extension of PD_eL, viz. $PD_eL(n)$.

4. Forrester's Paradox Resolved : $PD_eL(n)$

The system $PD_eL(n)$ is the system PD_eL, but instead of *one* propositional variable V, indicating some (state of) liability to sanction, we have n distinct variables $V_1, V_2, \ldots, V_n$, indicating a specific liability to the first to n-th sanction. Furthermore, the abbreviations $F_k\alpha \equiv [\alpha]V_k$, $O_k\alpha \equiv F_k\overline{\alpha}$, and $P_k\alpha \equiv \neg F_k\alpha$ are introduced for $k = 1,2,\ldots,n$. PD_eL is now the special case that $n = 1$, so $PD_eL = PD_eL(1)$.

Now we formalize (4),(5) in $PD_eL(2)$ as follows:

(16) $F_1 m$

(17) $O_2(\overline{m} \cup g)$

Here (16) expresses that murder is forbidden on penalty of sanction No 1, and (17), or equivalently $F_2(\overline{m} \;\&\; g)$, states that a not-gently committed murder is forbidden under penalty of sanction No 2.

An interesting consequence of (16),(17) is the following:
From (16) we obtain $O_1\overline{m}$. By (R) and (MP) we get $O_1(\overline{m} \cup g)$, or equivalently $[m \;\&\; \overline{g}]V_1$. By (17) we also have $[m \;\&\; \overline{g}]V_2$. So, since

$$[\alpha]\phi_1 \wedge [\alpha]\phi_2 \equiv [\alpha](\phi_1 \wedge \phi_2)$$

is a theorem of PD_eL - and so also of $PD_eL(n)$ - we obtain $[m \;\&\; \overline{g}](V_1 \wedge V_2)$, meaning that the one who murders in a not-gentle fashion is liable to *both* the sanctions No 1 and 2. Which is a desirable result to have!

5. $PD_eL(n)$ and the Backward Chisholm Paradox

In [M1] we have already seen how in PD_eL we could solve the "forward" version of the Chisholm Paradox. The solution of this paradox came down to being able to give a sound treatment of the following two deontic expressions, which we saw already in section 3:

(18) You are forbidden to go.

(19) Still, if you go anyway, you have to close the door afterwards.

In PD_eL this can be expressed in a consistent way like this:

(20) Fg

(21) $[g]Oc$

where g stands for the action of "going" and c for "closing".

From (20),(21) it follows that it holds that $[g](V \wedge Oc)$: after having gone we are liable to punishment, but we are still obliged to do c. This is perfectly sound.

However, in PD_eL we could not yet cope with a "backward" version of (18),(19) like:

(22) You are forbidden to go.

(23) Still, if you go anyway, you will have to open the door first.

By realising that (23) is equivalent to

(24) You are forbidden to not-open-the-door and then go,

we can formulate (22),(23) in PD_eL as:

(25) Fg

(26) $F(\bar{o};g)$.

However, this is not quite good enough, since by PD_eL's rule (N) from (25) we also get

(27) $[\bar{o}]Fg$.

And this expression is equivalent to $[\bar{o}][g]V$, or equivalently $F(\bar{o};g)$, i.e. (26)! So (26) follows from (25), and adds no further information, although it was obviously intended to do so.

In $PD_eL(2)$, however, this problem is resolved by formulating (22),(23) as

(28) F_1g

(29) $F_2(\bar{o};g)$.

Now we can derive from (28),(29) the following:

From (28) we get $[\bar{o}]F_1g$ (by (N)), i.e. $[\bar{o}][g]V_1$; (29) yields $[\bar{o}][g]V_2$; so by the PD_eL theorem

$$[\alpha]\phi_1 \wedge [\alpha]\phi_2 \equiv [\alpha](\phi_1 \wedge \phi_2)$$

we obtain $[\bar{o}][g](V_1 \wedge V_2)$, meaning that if we do not open the door and go, we are guilty of two 'crimes': the violation of the prohibition to go and that of not opening the door before going. This is again a desirable statement to have.

6. Conclusion

We have seen that by extending the expressiveness of liability to sanctions we can treat Forrester's Paradox in an easy, almost trivial way. The extended system, $PD_eL(2)$, also proved to be sufficiently expressive to solve the "backward" Chisholm Paradox. These paradoxes are often viewed as the most profound paradoxes in deontic logic.

The extension of the number of propositional variables related to sanctions also raises the question whether it is meaningful to put an ordering (e.g. a partial ordering) on them. $V_i \leqq V_j$, for instance, would express that sanction j is more severe than sanction i. Perhaps even $V_j \supset V_i$ can be chosen as ordering. In this case $[\alpha](V_i \wedge V_j) \equiv [\alpha] V_j$, since V_j comprises V_i entirely.

The possibility to consider a measure on sanctions induces priorities on prohibitions and obligations, which may be useful to ethicians and jurists who may apply the system.

Notes

[1] Actually, this is a slight oversimplification (cf. [M1],[M2]), but it is sufficient for our present purposes.

[2] In fact, we have to demand that both the actions α_1 and α_2 involved in these axioms and theorems have the same duration. We have made this precise in [M2]. In this paper this requirement will always be fulfilled when these results are used. We have chosen to suppress this complication in the main text for the sake of simplicity.

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Distributivity

Craige Roberts
CSLI, Stanford University

The group/distributive ambiguity in examples such as *Four men lifted a piano* is explained by a simple theory, which is tested using criteria culled from the literature on distributivity, as well as new data concerning the anaphoric potential of NPs in distributive contexts. The theory involves a principled classification of NPs into two types, quantificational and individual- (or group-) denoting. In examples with individual-denoting subjects, distributivity may arise from an (implicit or explicit) adverbial operator.

In this paper,[1] I will examine in some detail a phenomenon which bears directly on a number of important issues in current linguistic theory, including the referential/quantificational split in NPs and the question of NP scope and its representation: that is, the phenomenon of DISTRIBUTIVITY, and the related ambiguity between group and distributive readings for some sentences. The issues which will concern us are reflected in examples (1) - (4):

(1) Four men lifted a piano.

(2) Bill, Pete, Hank, and Dan lifted a piano.

(3) Every man lifted a piano.

(4) Bill, Pete, Hank, and Dan each lifted a piano.

(1) and (2) are each ambiguous. For example, on the so-called 'group reading' of (1), the men in question lifted a single piano together, but it may be that none of them lifted it alone. The group reading of (2) is similar. On the distributive reading of (1) or (2) each of the men has the property of having singlehandedly lifted a piano (whether it was the same piano or possibly different pianos for the different men). The group and the distributive readings entail different facts about the world in which the utterance is true: for example, the distributive reading of (2), but not the group reading, entails that Bill lifted a piano. (3) is unambiguously distributive — there is no reading where the group composed of all the men together lifted a piano; again, they may have each lifted the same piano or different pianos, depending on whether the indefinite NP *a piano* receives widest scope, but each man lifted some piano alone. Likewise, (4), with adverbial *each*, is unambiguously distributive. If the context in which (3) is uttered is such that we know that there were just four men, Bill, Pete, Hank, and Dan, then the readings of (3) and (4) with the subject taking wide scope are true in just the same situations, that is, they entail each other.

Now compare the distributive readings of (1) and (2), and the readings of (3) and (4) where the subject NP has widest scope. All share this property: *a piano* may not serve as an antecedent for subsequent anaphors in discourse. This is shown by the infelicity of (5) following any of these examples (on the relevant readings), with *it* intended as anaphoric to *a piano*:

(5) It was very heavy.

But there is a difference in the anaphoric potential of the subjects of (1)-(4) on the relevant distributive readings. The subject of (3) may not license anaphora in discourse, so that (3) followed by (6), with *he* anaphoric to *every man*, is infelicitous:

(6) He developed a crick in his back later.

This reflects a well-known property of quantificational NPs, that they only license what Tanya Reinhart (1983) has called bound anaphora, and not anaphora across segments of discourse. However, the subjects of (1), (2) and even the unambiguously distributive (4) may license discourse anaphora. In Roberts (1984) I defined the term *discourse anaphora* to cover all those cases of anaphoric relations which are not licensed by (intrasentential) binding. Consider any of these examples followed by (7):

(7) They developed a crick in their backs later.

They may refer to *four men* or to *Bill, Pete, Hank and Dan*. In general, developing a crick in one's back is something only an individual can do. The singular indefinite direct object in (8), then, leads us to the distributive interpretation: we are concerned with a property of each of the four men denoted by *they*, not of the group as a whole. Another point of interest in this example is the plurality of *their backs*. This seems to be an example of the *dependent plural* phenomenon. Note that although this NP is plural, we do not understand the sentence as being about a single crick which is in all four backs. Rather, on the usual interpretation there is a different crick in each back. The plurality of *backs* is optional for many speakers, for whom the singular *their back* is equally acceptable. But even in this case, we must account for the obligatory plurality of the pronoun *their* on the intended reading.

I note that (3) may also be followed by (7), but notice the lack of number agreement between the subject of (3) and the pronoun in (7). This lack of agreement shows that the relationship between *every man* and *they* is indirect, and not that of anaphoric antecedent and anaphor.

One prerequisite for an adequate theory of distributivity is a theory of the semantics of group denoting expressions. In a series of recent papers (1983,1984,1986,to appear), Godehard Link has developed a semantics of plurality which treats groups as distinct individuals in a model, instead of sets. Here I will adopt a theory along the lines he suggests, where the domain of individuals in the model has the complex organization of a complete join atomic semi-lattice, and a plural NP denotes an individual in the lattice, the join of the atomic individuals which are, intuitively, the members of the group. These atomic individuals are then the ATOMIC-INDIVIDUAL-PARTS, or ATOMIC-I-PARTS of the denotation of the plural NP.[2]

The central hypothesis of Link's (1983) "The Logical Analysis of Plurals and Mass Terms: A Lattice-Theoretical Approach" is that plural NPs denote individuals, just like singular NPs, rather than sets of individuals. He is able to accomplish this while obtaining the proper truth conditions for sentences in which plurals occur by giving the domain of individuals in his model the complex organization of a complete join atomic semi-lattice. Formally, this mathematical structure is a partially ordered set in which any (potentially infinite) subset has a supremum, but there is no guarantee that each subset has an infimum. In the lattice, the supremum of any two individuals is called their individual sum, or i-sum. Informally, what this means is that for any individuals in the domain, say Annie, and Bernard, there is another individual, c which is the i-sum of Annie and Bernard, that is, which is the denotation of the expression "Annie and Bernard". In that case, Annie and Bernard are both individual-parts, or i-parts, of c. Furthermore, if there is another individual Danny in the model, then there is a further individual e which is the i-sum of c and Danny, that is, the denotation of "Danny and Annie and Bernard", with four i-parts: Danny, the i-sum c, and the i-parts of c, Annie, and Bernard. There are two kinds of individuals in an atomic lattice, the atomic individuals (those which have no i-parts, such as Annie, Bernard and Danny) and the non-atomic individuals (those which have i-parts, such as c and e), but both kinds are individuals. Because it is a distinct individual, an i-sum such as c may have properties which neither Annie nor Bernard have; for example, c may have the property of being a couple, though neither Annie nor Bernard does.

With Link's theory in mind, I will argue for a very simple theory of distributivity and the distributive-group distinction. I will argue that there are two kinds of NPs, quantificational and individual-denoting. In examples such as (1), (2), and (4), the subject has no quantificational force of its own. In these cases, the distributive reading is due to an adverbial operator, implicit in (1) and (2), explicit in (4) (the "floated quantifier" *each*). In (3), the subject itself is quantificational. The same reading arises in each case because of the quantificational force of an operator, though that force is contributed by an adverbial modifier on the predicate in (1), (2), and (4), and by the determiner in (3). A group reading arises when neither the subject nor an adverbial element of the predicate contributes the quantificational force underlying distributivity. If a plural subject is nonquantificational, we say that it is group denoting; it may serve as a discourse antecedent even when its predicate is modified by an adverbial distributivity operator.

Before looking at the details of this theory, I'd like to put it in perspective by looking at three of the most important prior approaches to distributivity. Though none of the previous authors has taken into account the facts about anaphora which we have just considered, each has contributed to our understanding of distributivity, and I think this review will help to clarify the criteria for an adequate theory of distributivity.

George Lakoff, in his 1970 paper "Linguistics and Natural Logic", provided an early treatment in the linguistic literature of the distributive-group distinction. He assumes that the scope of quantifiers should be indicated in deep structure by generating them as higher predicates which are then lowered transformationally in the derivation of surface structure. And he proposes that in examples such as (1), only what I have called the distributive reading should be derived by Quantifier Lowering an NP, in this case the subject. He seems to have in mind *in situ* interpretation to derive the group reading. So, either numerals are ambiguous between quantifier and non-quantifier interpretations, or the rule of Quantifier Lowering only applies optionally to them. Presumably the rule of Quantifier Lowering is obligatory for quantifiers such as *every*, in order to account for the lack of a group reading in examples like (3).

One can easily imagine how such a conception of the group-distributive distinction could be implemented in an approach such as the Government and Binding Theory, which utilizes a transformation of Quantifier Raising at a level of logical form, instead of Quantifier Lowering. From the point of view of the theory of distributivity, the two proposals would make the same predictions.

Although I believe that Lakoff's proposal is correct in recognizing the quantificational force underlying distributivity, there are a number of problems; here I will only mention the most serious. Example (8) shows that the function of Quantifier Lowering/Raising as an indication of the scope of an NP is incompatible with the proposal that it is restricted to distributively interpreted NPs:

(8) Five insurance associates gave a $25 donation to several charities.

(8) is multiply ambiguous. The reading which interests us is where a single group of five insurance associates gave a donation of $25 to each of several charities. This is the reading which might be suggested by the context in (9):

(9) A group of Rotarians in Terre Haute gave a $25 donation to the boyscouts. Not to be outdone, five insurance associates in nearby Urbana gave a $25 donation to SEVERAL charities.

On this reading, *five insurance associates* has a group reading, while *several charities* is distributive over *a $25 donation*, so that it has a quantifier reading. *Five insurance associates* has wider scope than *several charities*; i.e. the relative scopes of the NPs in (8) are as in (10):

(10) 5_{group} - $several_{distr}$ - $25

If the distributivity of *several charities* and its scope over *a $25 donation* are to be represented in a logical form by Quantifier Lowering or Raising, then *five insurance associates* would have to undergo that rule as well, despite its group reading. Thus, we cannot derive the proper truth conditions for this reading of (8) under Lakoff's proposal.[3]

Another approach to the distributive-group distinction has been to treat it as a function of predicate type. Some lexical items have been held to permit only a group or a distributive reading of sentences in which they occur. The examples in (11) and (12) illustrate this:

(11) (a) ⋆ John dispersed.
(b) The crowd dispersed.
(c) ⋆ John was numerous.
(d) The dogs were numerous.

(12) (a) John, Paul, George, and Ringo are pop stars.
(b) Paul is a pop star.

Michael Bennett, in his 1974 dissertation, observed that there are a number of lexical items which require a group denoting subject or complement. *Disperse* in (11a/b) seems to require such a subject; hence (11a) is unacceptable, since *John* does not denote a group. But (11b) is fine; it seems that *the crowd* denotes a group. *Numerous* in (c/d) seems to have a similar requirement. The fact that *the crowd* is syntactically singular while *the dogs* is plural shows that the group/nongroup distinction is not directly tied to syntactic number. Bennett accounted for this type of contrast by distinguishing two kinds of predicates (where CNs and VPs are regarded as predicates), individual level and group level. These two kinds were relegated to different syntactic categories, and corresponded to different semantic types, so that examples such as (11a) and (11c) were ruled out because their categories could not combine.

In (12), due to Godehard Link, there doesn't seem to be a group reading as distinguished from a distributive reading — the predicate *be a pop star* seems to be true only of individuals: if (a) is true, then it automatically entails (b). Thus, *be a pop star* is said to be a distributive predicate. In this class are often included verbs such as *walk*, *eat*, *talk*, and others which seem to be related to personal identity or individual will. Link defines a meaning postulate for this class of predicates which guarantees that whenever one of them takes a plural subject, it holds of all the individuals which make up the group denoted by the subject. From this, Link is able to guarantee the valid inference from (12a) to (b), on the assumption that the predicate 'be a pop star' is a Distributive Predicate.

Though Bennett's and Link's theories differ in many respects, they are alike in locating the distributive-group distinction primarily in lexical characteristics of predicates. But building this view of the distinction into the formal structure of a semantic theory is, on the one hand, unnecessary because it is redundant, and, on the other hand, it fails to capture some important generalizations about the nature of distributivity. First, the fact that a particular lexical item is a group predicate or a distributive predicate doesn't really need to be specified independently: it follows from the sense of the predicate itself. What is it to be a pop star or to walk or to die? The actions or states denoted by these verbs can generally only be performed or endured by an individual with a single will and consciousness. It is for this reason that we think of them as distributive. Although it may well be that only atomic individuals are in the extension of such distributive verbs in their strict sense, this follows from our knowledge of what is required for them to be true of an individual. Similarly, what does it mean to gather or to disperse? By virtue of the meaning of such a predicate, its subject must denote a group of individuals (or a mass of some substance), performing in a way peculiar to a group (or mass). Viewed in this way, these verbs are no more special than a verb such as *grasp*, which, on one of its senses, can only be true of an individual with a certain type of movable thumb. In fact, examples such as those in (13) show that the group/distributive distinction does not correspond to whether or not the predicate is only true of groups:

(13) (a) The crowds dispersed.
(b) The species were numerous.

Both (a) and (b) are ambiguous; for example in (a), there is one reading, the group reading, where some group of crowds has dispersed, so that each crowd goes its own way to rally. But there is also a distributive reading where each crowd disperses, so that there are no more crowds left. And in (b), it may either be that there are a lot of different species, the group reading, or that each species has a lot of members, the distributive reading.

Note also that many of the predicates which might be considered group predicates or distributive predicates are not composed of single lexical items. For example, it seems that only a group can *make a good team*. Under standard assumptions about the lexicon, there would be no entry for such a predicate, since its meaning could be compositionally determined on the basis of the meaning of its parts. But, given what it means to make a team, we would naturally assume that its extension contained only groups. The same is true of (14a), *win a relay race*, but not of *win a 100 meter dash* in (14b), the latter presumably a distributive predicate:[4]

(14) (a) win a relay race
(b) win a 100 yard dash

These classifications are a question of world knowledge about the denotations of the terms involved.

A third approach to distributivity is illustrated by Remko Scha's paper "Distributive, Collective and Cumulative Quantification" (1981), in which he locates the group-distributive distinction in a distinction between two types of determiners, instead of in the distinction between types of predicates.

The evidence for this treatment involves the class of "mixed verbs" (Link's terminology), whose subjects sometimes appear to be distributive, at other times collective. *Lifted*, as in examples (1)–(4) above, is one example of this very common class, which also includes *bring*, *carry*, *give*, *take*, *own*, and many others. The group reading of definite plural NPs is strongly preferred with mixed predicates. For example, (16), with the mixed predicate *bring (something)* is generally considered quite ambiguous. Now consider (17). As we might expect, this example, with a distributive-only subject, has only a distributive reading. But (18), with a definite plural subject, strongly suggests a group reading:

(16) Four women brought a salad to the potluck.

(17) Every woman brought a salad to the potluck.

(18) The women brought a salad to the potluck.

On the basis of similar evidence, Scha classifies determiners into two groups, depending on whether they can occur in distributive or collective examples. The table in (15) presents his classification of determiners:

(15) **Scha's Classification of Determiners**

Distributive	Collective
each	
every	
a	
both	
ϕ	ϕ
all	all
$some_{sing/pl}$	$some_{pl}$
$no_{sing/pl}$	no_{pl}
2,3,4 ...	2,3,4 ...
the_{sing}	the_{pl}

A number of determiners in this taxonomy are considered unambiguously distributive — all the singular determiners and *both*. The null determiner, *all*, plural *some* and the numerals are ambiguous; only the plural definite article is unambiguously a group determiner.

I think this asymmetry in the taxonomy should make us suspicious. Empirical problems with the theory also arise. One problem occurs with the mixed predicates such as *bring something* in (18), where the subject is a definite plural. In some contexts (18) can have a distributive reading. Consider the following discourse:

(19) Every woman brought a dish to the potluck.
The hostess asked those from Acton to bring a casserole.
The women from Boxborough brought a salad, and those from Littleton a dessert.

The underlined sentence is interpreted distributively in this context.

The problem here is that the markedness of the distributive reading of the definite plural subject in (18), as opposed to the distributive potential of the subjects of (16) and (17), seems to support Scha's classification of plural *the* as unambiguously collective. If *the* is not the source of the distributivity here, then it must lie elsewhere. If the only other source of distributivity were meaning postulates on predicates, then examples such as (18) would force one to claim that meaning postulates could be optional. But this seems incoherent.

Alternatively, one might claim that the verbs under consideration are ambiguous, with both a distributive and a collective sense which are otherwise identical in their entailments. This is undesirable, since it would require a proliferation of ambiguity, and in any case, it would still leave the markedness of the distributive reading of (18) unexplained.

Now let me summarize the criteria which we have discussed for a theory of distributivity:

1. First, the theory should obviously assign appropriate truth conditions for the group and distributive readings of examples such as (1) and (2). Besides reflecting our intuitions about the meanings of individual sentences, these truth conditions should also capture the truth conditional entailments between (4), with a floated quantifier, and the distributive reading of (2), as well as the entailments between these examples and (3), where the domain of quantification is the set consisting of Bill, Pete, Hank and Dan. I believe it is such entailments which motivated Lakoff's intuition that distributivity is quantificational in character.

2. However, Lakoff's theory mistakenly identifies quantificational force with NP scope. But, given the evidence in example (8), our second criterion for an adequate theory of distributivity is that it distinguish these two.

3. At the same time, our theory must account for the relationships we have observed between distributivity and the possibility of discourse anaphora. This will involve rationalizing the referential/quantificational split in NPs which is often assumed in the linguistic literature, a split which distinguishes the subject of (3) from those of (1), (2) and (4). And in clarifying this distinction, we may hope to provide an explanation for Scha's observation that determiners seem to differ in their potential for occurring in distributive interpretations.

4. Finally, we must account for dependent plurals, plural NPs in distributive contexts which have a quasi-singular interpretation.

I believe the theory I am proposing meets all these criteria. In order to see how, let's examine it in more detail.

First, I claimed that there are two kinds of NPs, quantificational and individual-denoting. Kamp (1981) and Heim (1982) both assume that there are two kinds of NPs, though they confine their discussions to singular NPs. One type, including pronouns and singular indefinites and definites, are interpreted as variables in a Discourse Representation or File, with conditions on the variables corresponding to the content of the CN in the NP, if there is one. The other type, exemplified in their theories by universally quantified NPs, has a treatment rather similar to that of generalized quantifier theory (cf., e.g., Barwise & Cooper (1981)), where the determiner sets up a relationship between the denotation of the CN and that of the predicate of which the NP is subject. The first type of NP I will call an *individual denoting NP*. I will argue that the *group denoting NPs* are a subset of the individual denoting NPs, those whose denotations include nonatomic elements, or i-sums, from the lattice-structured domain. The second type of NP, I will call the *quantificational NPs*.

By the criteria I will discuss below, the individual denoting NPs include proper names and pronouns, as well as those with indefinite or definite determiners. Among the indefinite determiners are *a*, singular and plural *some*, and the numerals. The definites include singular and plural *the* and the demonstratives (*this* and *that*, *these* and *those*). There are a number of modified versions of these which are also individual denoting, such as a definite or indefinite determiner followed by a numeral, *few*, or *many*.

Quantificational determiners include the universals *each* and *every*, both singular and plural *no*, and the plurals *most*, *few*, *many*, *both*, and *neither*.

The proposed taxonomy is summarized in (20):[5]

(20) **Classification of Determiners**

Individual Denoting	**Quantificational**
a	each
$\text{some}_{sg/pl}$	every
1,2,3 ...	$\text{no}_{sg/pl}$
$\text{the}_{sg/pl}$	most
this,that	few
these,those	many
	both
	neither

Implicit in this taxonomy is the hypothesis that determiners are unambiguous. There are a few cases, notably the numerals and *many*, where it is not yet clear if this hypothesis can be maintained. More investigation into the behavior of these determiners will be required before this matter can be settled. In the meantime, I have adopted the stronger hypothesis in the interest of making clear predications about the nature of distributivity.

As we saw earlier, Scha (1981) also has two classes of NPs, the collective and the distributive. But again, his taxonomy, in (15), does not coincide with mine. For example, the term *collective* suggests plurality, so he only includes in this class determiners which take plural CNs. Singular indefinites and definites are considered unambiguously distributive.

Since my treatment of the singular determiners has been argued by Heim and Kamp, on the grounds that they account for the different behavior of the two types of NP with respect to anaphora in discourse, I will focus on the classification of the plural determiners. The general rule of thumb in classifying plural determiners as group denoting or quantificational is that group denoting NPs can appear to have a distributive reading, by virtue of adverbial distributivity, whereas plural NPs with quantificational determiners never have group readings. So, for example, (1) and (2), with group denoting subjects, have both group and distributive readings. However, (3) has only a distributive reading, and this provides evidence that its subject is unambiguously quantificational. In classifying a particular determiner, the determination of whether or not it may have a group reading is the crucial factor.

There are a number of other tests for group readings. One of the most important is whether the NP formed by the determiner may serve as an antecedent for anaphors in discourse. Without going into technical details of Discourse Representation Theory, let me just sketch the basic idea of how it constrains anaphoric possibilities. In one respect, mapping a sentence into a Discourse Representation is rather like Quantifying In in Montague Grammar: we process one NP at a time, introducing a variable, or discourse referent for the NP into the Discourse Representation, and also introducing the original sentence with the variable in place of the NP as a condition in the Discourse Representation. This condition has a very similar truth conditional effect to that of a predicate derived by lambda-abstraction. In addition to introducing a variable, some NPs contain a quantificational determiner which introduces an operator, as well. The denotation of the CN is represented in the lefthand box of a pair, the denotation of the predicate in the righthand box, and the determiner *every* denotes a relation represented by an arrow connecting the two boxes, its "arguments". As noted above, this is similar to the relation between the denotations of CN and predicate established by a determiner in Generalized Quantifier theory.

When we say that an NP α "has scope over" another NP β, what this means in Discourse Representation terms is that β is in the abstracted predicate which remains after α has been changed to a variable. If α contains a quantificational determiner, then both the discourse referent for α and that for β will be in the scope of the operator introduced by the determiner. But in any case, the discourse referent for α will not be in the scope of any operator introduced by the determiner of β.

Antecedence in discourse is a relation between the discourse referents, or variables introduced by NPs. In general, a discourse referent α may only serve as antecedent to another discourse referent β if β is under the scope of any and all operators over α. In particular, when an NP is quantificational, and hence its discourse referent is in an argument of the operator introduced by its determiner, it may only serve as antecedent to a discourse referent which is also in an argument of that operator; since only elements within the same sentence can be arguments of that operator, this reflects the fact that quantifier scope, and hence bound anaphora, cannot extend across sentences. In addition, if an NP is represented in the derived predicate which is the second argument of an operator, its scope is also restricted by the operator. For example, on the reading of (3) where the quantificational NP *every man* has wide scope over the indefinite *a piano*, the anaphoric scope of the indefinite is restricted to that of the quantificational operator introduced by the determiner of the subject. Since the quantificational determiner can't have scope outside its sentence, the indefinite which is under its scope cannot serve as antecedent to pronouns outside the sentence, and hence the infelicity of (3) followed by (5). But if a discourse referent is not within the scope of an operator, so that it was introduced by a non-quantificational NP and was not in a predication on such an NP, it may serve as an antecedent to pronouns in subsequent sentences. (cf. (1), (2), and (4) above, which may be followed by (5).)

Above we have seen a number of examples of the availability of conjoined proper names, definites, and numeral NPs to serve as discourse antecedents. And we have seen that in general NPs with singular universal determiners may not license discourse anaphora. There are some complications in demonstrating the unavailability of plural quantificational NPs to serve as discourse antecedents, but I don't have the space to discuss these here. Suffice it to say that the first criterion for determining which class a particular NP falls under is whether or not it permits group readings.

There is another test for whether an NP is group denoting which is also based on the differential anaphoric potential of the two types of NPs. This is the NP's behavior in the so-called sloppy identity constructions which I believe were first discussed by Ross (1967). Consider (21) through (23):

(21) Sarah and Mike sent a card to their mother, and Alice did too.

(22) Each student sent a card to her mother, and Alice did too.

(23) Many students sent a card to their mother, and Alice did too.

(21) is ambiguous between the sloppy reading, where Alice sent a card to her own mother, and the strict reading, where she sent a card to the mother of Sarah and Mike. But (22) and (23) have only the sloppy reading, where Alice sent a card to her own mother. Tanya Reinhart (1983) has argued that the sloppy reading requires bound anaphora, involving c-command of the pronoun by its antecedent within the sentence. In Roberts (1984) I adopted this idea, and argued in addition that the nonsloppy reading arises due to discourse binding. Since only individual denoting NPs can license discourse anaphora, I predict that only when the subject of the first conjunct is individual denoting can we get the strict reading, and this seems to be correct, as evidenced by the strict reading available in (21), with the individual denoting conjoined proper names, but not in (22) or (23), where the subject is quantificational. Thus, the two kinds of NPs again appear to have a different binding potential.

There are actually a number of other tests for whether an NP is quantificational or referential, and I refer you to my dissertation for discussion of these.

Now let us assume that there are two classes of NPs, characterized more or less as I have suggested. I claimed earlier that the distributivity in examples with a group denoting subject, as in (1), (2), and (4), arises due to an adverbial distributivity operator. First let us consider examples in which this adverbial operator is explicit, cases such as (4). David Dowty and Belinda Brodie (1984) have called *each* in such examples a "floated" quantifier, and have argued for analyzing it as an adverbial operator. Abstracting away from the details of their particular account, they propose that when a predicate is modified by a floated quantifier and the whole is predicated of a group denoting subject, this amounts to the claim that each individual member of the group denoted by the subject has the property denoted by the VP.

Link (1986) adopts Dowty & Brodie's general view and incorporates their insight about the semantic contribution of such adverbials into his theory of the semantics of plurals by translating them as what he calls the D operator, whose effect on the interpretation of a predicate is suggested in (24):[6]

(24) $$^{D}\text{VP} := \lambda x \forall y[\text{atomic-i-part-of}(y, x) \rightarrow \text{VP}(y)]$$

Because in Link's theory plural individuals are of the same type as atomic individuals, he doesn't define D in terms of set inclusion, as Dowty & Brodie did, but uses instead the two-place i-part relation between individuals of the same type. What the formula means is that whenever D is applied to a VP, this yields the abstract property which an individual has if all the atomic i-parts of that individual have the property denoted by the VP. Assume we modify the VP *lifted a piano* with a floated quantifier, as in (4), with the result that in its logical translation the D operator applies to it. The result is shown formally in (25a):

(25) (a) $\lambda x \forall y[\text{atomic-i-part-of}(y, x) \rightarrow \text{lifted-a-piano}(y)]$

(b) $g = \text{Bill+Pete+Hank+Dan} \ \& \ \forall y[\text{atomic-i-part-of}(y, g) \rightarrow \text{lifted-a-piano}(y)]$

We then predicate (25a) of *Bill, Pete, Hank, and Dan.* This subject denotes an individual, the i-sum of the individuals denoted by the proper names *Bill*, *Pete*, *Hank*, and *Dan*. Let's call this individual g. If g has the property in (25a), then we know by lambda conversion that the formula in (25b) must be true. That is, each atomic i-part of g has the property of having lifted a piano. The atomic i-parts of g are just Bill, Pete, Hank, and Dan, and so we get the correct interpretation, along with the entailment, for example, that Bill lifted a piano.

Notice that in both (25a) and (25b), the indefinite NP *a piano* is under the scope of the universal quantifier introduced in the translation of the floated quantifier. Recall that when this is the case, the anaphoric scope of the indefinite is restricted to that of the quantifier. So here, although the subject is nonquantificational, the indefinite in the adverbially modified predicate is unavailable to serve as antecedent for a pronoun in subsequent sentences, as we saw in the infelicity of (5) following (4).

Recall too that the discourses formed by (1) and (5) or by (2) and (5) were also infelicitous on the distributive readings of (1) and (2); the source of the infelicity in these cases also seemed to be the intended anaphoric relation. If we assume that the source of the distributivity in (1) and (2) is an implicit adverbial operator, in fact the D operator of Link,[7] then we can explain this fact as well, since then the indefinite *a piano* will be under the scope of a universal quantifier, just as it was in (25).

There is another example which shows that the predicate modified by the adverbial distributivity operator need not be the VP, but can be a derived predicate. (26) has a reading where John gave a Valentine to each of the two girls in question:

(26) John gave a Valentine to two girls.

The NP *two girls* is individual denoting, according to the taxonomy in (20). The property *being an x such that John gave x a Valentine* is a mixed predicate in Link's sense, that is, it may be true of a group (a non-atomic i-sum) or of an individual (an atom). But if the sentence has a group reading, then *a Valentine* may serve as a discourse antecedent, while if the sentence has a distributive reading it cannot. Again, we need to explain how, if this singular indefinite is not under the scope of a quantificational NP, it is masked with respect to anaphora.

Here, I follow Link in suggesting that D may apply to a VP derived by lambda abstraction. A (simplified) logical form for (26) which incorporates D in this way is shown in (27a):

(27) (a) $^{D}[\lambda x(\text{gave}(j,\text{a Valentine},x))](\text{two girls})$

(b) $[\lambda x \forall y[\text{atomic-i-part-of}(y,x) \rightarrow \text{gave}(j,\text{a Valentine},y)]]$ (two girls)

Here, the property of having been given a Valentine by John is predicated distributively of two girls. When we apply the translation of D in (24) to the predicate it operates on in (27a), the result is as in (27b), so that each of the two members of the group denoted by *two girls* (atomic i-parts of the plural individual) has the property of having been given a Valentine by John.

Now *a Valentine* is under the scope of a quantificational operator introduced by the implicit adverbial on the predicate. This explains both the distributive reading of the sentence and the anaphoric masking of the object, and, since the subject of the abstract is not itself under the scope of the adverbial operator, we can understand why it is accessible for discourse anaphora.

One more point about the proposed translation for the adverbial distributivity operator: In (24), the quantification is restricted to range only over atomic i-parts of the individual denoted by the subject, rather than over all its i-parts. For example, In (4), the claim is that any atomic individual, such as Dan, lifted a piano, but not that the non-atomic i-parts, such as Dan+Bill lifted a piano. In fact, I think this requirement is not peculiar to adverbial distributivity. Rather, adverbial distributivity is just one case of quantification, and quantification in general only ranges over individuals which are in some sense atomic.[8] Link (1986) has argued to the contrary. For example, consider (28) and (29):

(28) Most competing companies have common interests.

(29) Two's company, three's a crowd.

Link claims that the quantification in these examples ranges over i-sums of companies or i-sums consisting of two or three individuals. In Roberts (1987), I argue against this proposal on the grounds that it predicts the wrong truth conditions for a variety of examples. The argument is too length to reproduce here; but my conclusion is that in such examples, we conceive of a group of competing companies or a group of two or three as a single unit. These might be treated as impure atoms, a type of individual introduced by Link (1984) to deal with another kind of problem, or as Landman's (1987) groups. But in any case, distributivity, like quantification more generally, only ranges over atoms.

Now let's review how this proposal meets the criteria of adequacy for a theory of distributivity which we established earlier. First, note that we have accounted for the ambiguity in examples (1), (2) and the like by positing the optional implicit distributivity operator, D. When D applies, we get the distributive reading; when it doesn't, we get the group reading. We also captured the relationship between (4) and the distributive readings of (1) and (2), since in each case the distributivity is due to D. And we saw that the similarity of the interpretation of (3) to the relevant readings of (1), (2) and (4) is due to the fact that each involves a universal quantification over some salient set of individuals, though that quantification was introduced by the determiner of the subject in (3), instead of an adverbial. This explains Lakoff's intuition that distributivity is quantificational in nature. And by tying this account to the theory of anaphora in discourse, we saw how the anaphoric possibilities in the various examples were tied to distributivity. I have yet to address the third criterion, the ability to distinguish between distributivity and NP scope. Recall that in deriving the reading of (26) in (27), the predicate was derived by abstraction on the direct object. This utilizes the same principles as Lakoff's Quantifier Lowering, Montague's Quantifying In, and May's Quantifying Raising, yet the NP is not quantificational. That is, I follow Montague in assuming that an NP may take any scope relative to other NPs in the sentence in which it occurs, regardless of whether it is quantificational or individual denoting. Thus, this theory can derive the truth conditions for (8) suggested in (10).

There remains one final requirement of our theory: it must provide an account of dependent plurals, especially plural pronouns in distributive contexts. Here, I can only talk informally about the pronouns.[9] Given the theory I have presented, Link's theory of the semantics of plurals, and the theory of anaphora in discourse which I have discussed extensively elsewhere, the facts about dependent plural pronouns fall out automatically. Consider the plural pronoun in the first conjunct of example (21).

(21) Sarah and Mike sent a card to their mother and Alice did too.

Recall that we are interested in the reading where Sarah and Mike may not be siblings, but each has given a card to his or her mother.

We have seen in the treatment of example (26) in (27) that one way of interpreting a sentence is to form a derived predicate by abstracting over some argument position, and then apply that derived predicate to the NP which originally filled the abstracted position. In (22) we abstract on the subject. Since the pronoun agrees in number with the NP in the position over which we're abstracting, the variable corresponding to the pronoun may be the same as that of the abstraction, so that it will also be bound by the abstraction operator. Hence, we have the property of being an x such that x sent a card to x's mother. In (30a), I have applied the D operator to this derived predicate:

(30) (a) ${}^{D}\lambda x$(x bought a card for x's mother)

(b) ${}^{D}\lambda x$(x bought a card for x's mother)(Sarah+Mike) & ${}^{D}\lambda x$(x bought a card for x's mother)(Ted)

(c) $\{y$ |atomic-i-part(y,Sarah+Mike)$\}$ = {Sarah,Mike} & $\{y$ |atomic-i-part(y,Alice)$\}$ = {Alice}

(d) Sarah bought a card for Sarah's mother, and Mike bought a card for Mike's mother, and Alice bought a card for Alice's mother.

In (30b), this distributive predicate is predicated of the subject of each conjunct of the original sentence. The atomic i-parts of the denotation of the NP *Sarah and Mike* are just the two individuals Sarah and Mike, and there is only one atomic i-part of the denotation of *Alice*, that is, the individual Alice. Given this fact and the translation of D in (24), we derive truth conditions along the lines suggested in (30d).

Finally, in (31) we see an example which may be interpreted so that the plural pronoun occurs in a distributed predicate which was derived by abstraction on a non-subject NP:

(31) Lou sends the kids a card on their birthday.

On the reading in question, each of the kids receives a card from Lou on his or her birthday. This reading may be derived as shown in (32):

(32) (a) Lou sends [the kids]$_i$ a card on their$_i$ birthday.

(b) λx_i[Lou sends x_i a card on x_i's birthday]

(c) ${}^{D}\lambda x_i$[Lou sends x_i a card on x_i's birthday]

(d) ${}^{D}\lambda x_i$[Lou sends x_i a card on x_i's birthday](the kids)

(e) $\forall y$[atomic-i-part-of(y, $\{x$ |kid(x)$\}$) $\rightarrow$ Lou sent y a card on y's birthday]

The fact that a treatment of examples such as (22) and (31) falls out without additional stipulation, strongly supports the theory of distributivity which I have offered here.

Notes:

[1]I would like to thank Nirit Kadmon, Hans Kamp, Angelika Kratzer, Fred Landman, and John Nerbonne for helpful discussion and criticism of earlier versions of this work. I am particularly grateful to Barbara H. Partee, who first introduced me to the problems considered here and provided invaluable assistance in clarifying my ideas. Of course, I alone remain responsible for any errors which remain.

[2]This proposal can also be implemented quite naturally in the slightly different semantics of plurals proposed by Fred Landman at the conference, Landman (1987).

[3]Note that one could not maintain that all group denoting NPs interpreted in situ automatically have wide scope. (cf. Aoun, Hornstein, & Sportiche (1981), who argue that *any* is interpreted in situ but has a special logical translation which always, in effect, gives it wide scope.) On this view, the wide scope of the subject of (8) would not entail that it had been moved. But this approach would also predict that the subject of (8), on its group interpretation, could not have narrow scope with respect to the quantificational (and hence raised) *several charities*. However, there is such a reading of (8), where each charity was given $25 by a possibly different group of five insurance associates. Therefore, the scope of the group denoting subject with respect to the quantificational indirect object is free, and so the assumption that distributive NPs undergo quantifier movement while group denoting NPs are interpreted in situ is inadequate.

[4]These particular examples were suggested to me by Barbara Partee (personal communication).

[5]Other theories have recognized a split into two types of determiners, but the split is not made in the same way as I propose. For example, May (1977,1985), along with other theorists in the Government and Binding framework, assumes that there are two kinds of NPs, the referential and the quantificational, only the latter undergoing Quantifier Raising at LF. However, he would classify a number of NPs as quantificational which I consider individual denoting. For example, *some CN* is quantificational in his theory. His criteria for what is quantificational are unclear; in May (1985), he claims that even plural pronouns may at times be quantificational.

[6]In Roberts (1987), the theory which I discuss here is implemented in terms of Discourse Representation Theory, and logical forms such as are used in this paper play no role. I include them here only to suggest the proper truth conditions, since limitations on length prevent me from introducing the full apparatus developed in the longer work.

[7]Or Landman's (1987) * operator.

[8]At least in the count domain.

[9]See Roberts (1987) for discussion of dependent plurals more generally, and for a formal treatment of the pronouns in terms of Discourse Representation Theory.

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PRESUPPOSITION AND DISCOURSE STRUCTURE

abstract:

The present paper discusses several implementations of presupposition projection in theories of discourse representation. It is shown that, in spite of some recent claims, Karttunen type approaches fail. An alternative is suggested which relies crucially on the method of contextual acceptability.

Rob A. van der Sandt
University of Nijmegen
Department. of Philosophy
Postbus 9108
6500 HK Nijmegen

PRESUPPOSITION AND DISCOURSE STRUCTURE *

1 Introduction

One of the main tasks of presupposition theory is to compute the presuppositions of complex sentences on the basis of the presuppositions of its component parts and other relevant parameters. This task is far from trivial as the subsequent failure of many 'solutions' to the projection problem shows. And, as has become increasingly clear, no solution is to come about unless we pay proper attention to context change and a variety of pragmatic factors that determine the admissibility or acceptability of sentences in discourse

Suppose that we have available a procedure to determine the presuppositions associated with each elementary non-compound sentence. I will call these entities the elementary presuppositions of a sentence. The problem is then, first, to determine which factors are responsible for the fact that some sentences inherit the presuppositions of their component parts and others don't and, secondly, to specify a recursive procedure which, given the elementary presuppositions of the component sentences and other relevant determinants, computes the presuppositions of the compound sentence.

If presupposition is taken to be a logical notion, the problem is part of the general problem of determining the meaning of a whole sentence in a compositional way on the basis of its constituent parts. This way of thinking has its roots in Frege's work. Given his view of compositionality and his conception of presupposition the solution would be remarkably simple. In Frege's view presupposition failure arises out of failure of reference of denoting expressions and since the denotation of a sentence is a function of the denotation of its components it holds that if one of these components lacks a denotation, the whole sentence must lack a denotation and thus a truth value. Since this holds for any truth-functional compound as well as for simple sentences, it follows immediately that any truth-functionally compound sentence inherits all the presuppositions of its parts. Trivalent (or multi-dimensional logics) on the other hand offer the possibility of letting the third value determine presuppositional behaviour under embedding. If presupposition is defined in the Strawsonian way as those sentences that are entailed by both the carrier sentence and its negation, the projection rules simply fall out as a result of the definition of negation and the logical connectives.

This fact can easily be illustrated . For suppose that we want to predict that a complex sentence φ presupposes χ, if one of the constituent parts ξ presupposes χ, then we have to define the connectives in such a way that if $v(\chi) \in \{0,*\}$ and thus $v(\xi) = *$, φ will be assigned the third value as well. If, however, we want to predict for a complex sentence φ that the presupposition χ associated with one of the constituent sentences is lost we need a definition that assigns 0 or 1 to φ if $v(\xi) = *$.

The following examples show that both requirements cannot be met in many cases where the elementary presuppositions do not surface as presuppositions of the whole sentence:

(1a) If *John's children* are fertile, he will have grandchildren.
(1b) If John has children, he will be happy and if *his children* are fertile, he will have grandchildren.
(1c) John has children.

(2a) If John has *started* beating Harry, he will not be happy.
(2b) If John has *stopped* beating Harry, he must be happy, but if he has just *started* doing so, he certainly won't be happy at all.
(2c) John did beat Harry before.
(2d) John did not beat Harry before.

(3a) If John has fifty grandchildren, *his children* will be happy.
(3b) John has children
(4a) If someone at the conference solved the problem *it was Julius who* solved it (Soames 1982: 498)
(4b) Someone solved the problem.

Sentence (1a) clearly preserves the inference that John has children. A presuppositional explanation of this fact would require an assignment of the third value to the whole conditional in case the antecedent has the third value. And this is incompatible with the assignment that would account for the fact that the presupposition in the corresponding sentences (1b) is not preserved. Thus if we design our truth tables in such a way that the presupposition for (1b) is preserved, sentence (1c) turns out to be an irreparable counterexample.

Similar remarks can be made with respect to (2a) and (2b). The antecedents of both conjuncts of (2b) contain the conflicting presuppositions (2c) and (2d). While an adequate semantic account of (2a) would again require an assignment of the third value in case to the whole conditional in case the antecedent has the third value, such an analysis would predict that (2b) is a contradiction.

Both (3a) and (4a) exhibit the following characteristics

a. they are of the form $\varphi \rightarrow \chi\ \psi$ (where $\chi\ \psi$ indicates that ψ is and elementary presupposition of χ.)

b. φ entails ψ

c. ψ does not entail φ.

The logical relations between the component sentences and the elementary presupposition of (3a) are identical to those of (4a). Both sentences satisfy the characteristics just given. But the intuitive inferences are different. While in (3a) the presuppositional inference is preserved, (4a) clearly allows a non-presuppositional reading. No definition of the conditional operator can satisfy both demands.

In all these cases a proponent of a semantic notion of presupposition is faced with a dilemma. A – certainly unattractive - alternative would consist in postulating an ambiguity in the logical connectives. Another alternative would consist in denying that the inferences discussed are instances of semantic presupposition and instead invoke principles of a conversational nature to explain the "suggestions" conveyed by (1b), (2a), and (3). Such an account would however deprive the semantic notion of presupposition of all empirical content. Both the presuppositions associated with the antecedent and the presuppositions associated with the consequent of a conditional would be neutralized. [1]

2 Presuppositions as default inferences

Sentence (1b) is one of the most convincing examples of the context dependency of presuppositions.[2] Note that the same phenomenon occurs in juxtaposition:

(5) If John has children, he will be happy. If *his children* are fertile, he will have grandchildren.

And that the reversals of (1b) and (5) are equally unacceptable:

(6) If *John's children* are fertile, he will have grandchildren. If he has children, he will be happy.
(7) If *John's children* are fertile, he will have grandchildren, and if he has children, he will be happy.

Stretches of text thus display exactly the same phenomena as simple conjunctions, both with respect to left to right ordering and presupposition projection.

This makes it abundantly clear that contextual parameters are among the crucial factors in determining the set of presuppositions actually associated with a sentence. Two possibilities are open.

We may associate with each sentence a set of interpretations and then define a function which maps each sentence-context-pair onto a member of this set. This function which we may call the contextual selection function thus selects for each sentence S, given a context, an interpretation of S. The whole empirical issue would then consist in giving an adequate set of restrictions to eliminate impossible readings. Moreover a pragmatic preference ordering could be imposed on the members of this set to assign the preferred reading in case contextual constraints would leave open more than one possibility. [3] Alternatively we may assign one interpretation which is general enough to be compatible with the several presuppositional readings of a sentence and determine the set of presuppositions right away on the basis of contextual information and other relevant parameters. The interpretation of the sentence in a context would then consist of the intersection of the proposition expressed by S and the set of presuppositions assigned to S in this context.

If we identify utterances with sentence context pairs [4], both options contain the claim that presupposition cannot be conceived as a binary relation between sentences, but should be analysed as a three place relation between sentences, contexts, and propositions

In 1982 Van der Sandt proposed a theory which follows the second path. This theory is based on a contextual notion of presupposition and relies crucially on the notion of contextual acceptability. Since both the general motivation and the technical details are well set out elsewhere [5], I will limit myself to a short survey of the basic principles. A simplified summary of the main definitions is given in the appendix.

The basic ideas underlying the contextual acceptability account are two simple common sense assumptions regarding the notion of interpretation and presupposition. The understanding of sentences often requires that we construct contexts in which those sentences can be interpreted. Furthermore presuppositions are normally supposed to belong to these contexts. Given these assumptions it is easy to understand the role of elementary presupposition in determining the presuppositions of sentences offered in isolation. They can be conceived as syntactic or lexical indicators of context selection or context construction. Context selection, of course, is not an arbitrary process , but is regulated by a number of restricting factors of which contextual acceptability and coherence are the main determinants.

Conditions of contextual acceptability are the crucial factor in determining presuppositional behaviour. Elementary presuppositions associated with a sentence are supposed to be part of contexts in which the carrier sentence can be interpreted, unless the principles governing the acceptable use of sentences in contexts prevent their inclusion. Elementary presuppositions thus function as indicators of context selection and a presupposition theory can accordingly be conceived as a set of principles for selecting or constructing partial contexts.

In conformity with the approaches discussed in the previous sections it is assumed that in semantic representation logical operators take scope over the presupposing elements . Sentence (8) will not entail that Buru Buru has a tribal chief:

(8) *The tribal chief* of Buru Buru is not bald.

But in conjunction with the elementary presupposition it will:

(9) There is a tribal chief of Buru Buru. He is not bald

This holds no matter how deeply the elementary presupposition is embedded:

(10) If is is not possible that John discovered that Clara has started cheating her husband, ...

Their contextual dependency explains why presuppositional elements escape effortlessly from scope islands and it explains their tendency to take scope over negation, logical connectives and intensional operators. In fact, if the presuppositional status of a presuppositional element is established it will not take part in whatever other scope relations are exhibited in the sentence, but will always take maximally wide scope, regardless of the nature and depth of embedding.

Thus if we take elementary presuppositions as indicators of context construction, all contexts thus constructed will entail the relevant presupposition. These context dependent entailments fall out as default inferences, arising from the assumption that conversation goes as it normally does and people behave as they normally do. Speakers normally don't use presuppositional sentences unless the presupposition induced is part of the common background knowledge or at least taken to be uncontroversial and hearers normally expect speakers to do so. This assumption will remain in force unless overridden by stronger factors. One such factor is sheer inconsistency with generally shared contextual information, as happens in the variant of (8) featuring the king of France instead of this obscure tribal chief. Another factor is a violation of the principle of informativeness, as happens with the interpretation of (1a) in a context which contains the implicative proposition expressed by the first sentence of (1b), and yet another is a violation of the principle of sequential interpretation, as is shown by (6) and (7).

Violation of any of these principles results in unacceptability of the presupposing sentence, if interpreted in a context which contains the elementary presupposition. Contextual unacceptability can thus be taken as a general notion, constraining presuppositional behaviour under embedding.

The following two principles hold for all cases of presupposition projection:

(11) When a sentence has an elementary presupposition and the text coming about as a result of the addition of the presupposition to the context (i.e. the text consisting of the elementary presupposition followed by the sentence in question) is unacceptable, the presupposition is never preserved.

(12) When a sentence has an elementary presupposition and the text coming about as a result of the addition of this elementary presupposition to the context is acceptable, the sentence allows a presuppositional interpretation.

Sentences (1a) and (1b) may illustrate these principles. Since (1a) is judged to be presupposing when offered in isolation (12) predicts that the addition of the elementary presupposition to the context should yield an acceptable and coherent result. (13) confirms this prediction:

(44) John has children............If his children are fertile, he will have grandchildren.

(1b) however, which is intuitively non-presupposing resists interpretation in a context which contains the elementary presupposition, as is correctly predicted by (11):

(14) ?? John has children...........If he has children, he will be happy and if his children are fertile, he will have grandchildren.

These two principles enable us to give to a general and relatively simple definition of presupposition as a three-place relation between sentences, contexts, and propositions:

(15). A sentence φ presupposes a proposition χ in a context c iff

(i) χ belongs to the elementary presuppositions of φ, and

(ii) φ is acceptable in the c-extension of χ (i.e. the context that only differs from χ in that its context-set is extended by $[\chi]_c$)

The whole predictive force of such a definition depends, of course, on an adequate definition or at least restriction of the notion of contextual acceptability. For a set of restrictions that are sufficient to compute the projection cases I refer again to the appendix.

4 Contextual satisfaction and context change potentials

In a short paper Heim (1983) applied the theory of file change semantics, developed in Heim (1982), to the problem of presupposition projection. In this paper she revived an earlier, but essentially equivalent formulation of Karttunen and Peters' (1979) theory. This formulation, which was presented by Karttunen in 1974, does not take the notion of presupposition, but the notion of presuppositional satisfaction (or admittance) as the basic concept of the theory. Due to limits of space I will confine myself to a discussion of conditionals.

Assuming that we can give for each simple sentence a list of the elementary presuppositions, the notion of presuppositional satisfaction can be defined as a relation between sets of logical forms contexts, and sentences. For simple non-compound sentences the definition runs as follows:

(16) A context c satisfies-the-presuppositions-of φ iff c entails all of the elementary presuppositions of φ.

For compound sentences this relation is recursively defined by associating with each constituent sentence a different context:

(17) If χ is of the form ' if φ, then ψ' then c satisfies-the-presuppositions-of χ just in case:

(i) c satisfies-the-presuppositions-of φ, and

(ii) $c \cap [\varphi]$ satisfies-the-presuppositions-of ψ.

Let us denote the set of elementary presuppositions associated with φ as φ^i and its truth-conditional content as φ^e .Given (16) and relying on some standard equivalences the conditions given in (17) can then be written as in (18):

(18) If χ is of the form 'if φ, then ψ', then c satisfies-the-presuppositions-of χ just in case:

(i) c entails φ^i, and

(ii) c entails $\varphi^e \rightarrow \psi^i$

But this is just the rule Karttunen and Peters' present in their 1979 article. Karttunen and Peters speak about conventional implicatures instead of presuppositions. But they also stipulate that "ideally, every conventional implicature ought to belong to the common set of presumptions which the utterance of the sentence is intended to increment"(1979: 14), which is exactly the condition for presuppositional satisfaction required in (18)

The notion of presupposition as a two place relation between sentences is now interdefinable by means of the following theorem:

(133) φ presupposes ψ iff all contexts which satisfy-the-presuppositions-of φ entail ψ.

Building on her theory of file change semantics Heim associates with each logical functor its so-called context change potential and then goes on to show that once this is given both their truth-conditional and the heritage properties fall out as a result.

Context change potentials specify updating operations on contexts. Formally they can be seen as functions from sentence-context pairs to contexts. Assuming that contexts are to be constructed as sets of possible worlds, the contexts change potential of simple sentences is then as expected. For a simple assertion it consists of an instruction to enrich the subsequent context with the content of the proposition expressed.

(20) If φ is a simple non-compound sentence containing no free variables, then
CCP $(\varphi, c) = c \cap [\varphi]$

The definition for the conditional runs as follows::

(21) If φ is of the form 'if ψ then χ',
CCP $(\varphi, c) = c \backslash (c \cap [\psi] \backslash (c \cap [\psi] \cap [\chi]))$

If Heim simply assumed a standard two-valued semantics nothing would be gained by this definition. Its logical counterpart, which is given in (22) just conveys the standard truth definitions for the material implication. Thus, as far as context change is concerned (20) would, without any further complication, do the job equally well.

(22) If φ is of the form 'If ψ then χ',
CCP $(\varphi, c) = c \wedge \neg [[c \wedge [c \wedge \psi] \wedge \neg [c \wedge \psi \wedge \chi]] = c \wedge [\psi \rightarrow \chi]$

But Heim assumes a partially valued language. Nothing follows about the truth of φ in case c (the conjunction of propositions constituting the context) is false. The equivalences given in (22) thus need not hold necessarily.

Now Heim reinterprets Karttunen's presuppositional satisfaction relation as a condition on the definedness of **CCP**:

(23) **CCP**(φ, c) is defined just in case c satisfies-the-presuppositions-of φ.

CCP is thus defined for a sentence φ and a context c iff c entails φ^i. Consequently an utterance of φ will only have a classical truth-value in case c entails its presuppositions. And this amounts to the well-known Strawsonian notion of presupposition.

Heim's primary objective is to show that Karttunen's heritage conditions fall out as a result from the definition of **CCP** given above. She claims that the **CCP** of a conditional 'if ψ, then χ' is only defined in a context c if both $c \cap [\psi]$ and $c \cap [\psi] \cap [\chi]$ are defined and concludes from this that c satisfies-the-presuppositions-of 'if ψ then χ' only if c satisfies-the-presuppositions-of ψ and $c \cap [\psi]$ satisfies-the-presuppositions-of χ, which would give us precisely Karttunen's heritage property for the conditional.

This conclusion is not warranted, however. It is certainly true that if a context c admits $[\psi]$ and $c \cap [\psi]$ admits $[\chi]$, both $c \cap [\psi]$ and $c \cap [\psi] \cap [\chi]$ are defined and thus CCP(if ψ then χ, c). This follows immediately from the definitions given above, but does not establish Heim's point. The converse, which would establish her point, does not necessarily hold. This is most easily demonstrated by reference to the logical equivalences given under (22).

If we assume that a conditional is undefined in case the antecedent is undefined and that a conjunction is undefined in case the first conjunct is undefined, the equivalences given hold and the heritage property is easily derivable. This is, in fact, the interpretation Peters (1977) attached to Karttunen's connectives.[6] This interpretation is however, only one of many possible interpretations. If we stick to Kleene's (1938) interpretation, which was likewise motivated by the notion of undefinedness, the equivalence given under (22) breaks down. Assume that a conditional will be assigned the value true in case its consequent is true and consider the case in which φ is undefined and ψ true. Now 'if ψ then χ' will be defined even if neither $[c \wedge \varphi]$ nor $[c \wedge \varphi \wedge \psi]$ is defined. It turns out that only the weaker heritage property (24) is derivable: [7]

(24) If χ is of the form ' if φ then ψ' then c satisfies-the-presuppositions-of χ just in case:

(i) $c \cap [\neg \psi]$ satisfies-the-presuppositions-of φ, and

(ii) $c \cap [\varphi]$ satisfies-the-presuppositions-of ψ

Similar results are obtained if we take Bochvar's or any other interpretation of the logical connectives. It follows that Heim presupposes Karttunen and Peters' underlying logic, and thus takes their inheritance conditions for granted, instead of deriving them from the definition of CCP.

To handle the obvious inadequacy of Karttunen's rules Heim adopts Lewis' notion of contextual accommodation. This mechanism was introduced by Lewis (1979) to account for the well-known fact that presuppositional sentences are often used to convey new information. Now the Karttunen and Peters/Heim approach requires that presuppositions are already present in the context for a sentence to be uttered felicitously. Since normal conversation does not proceed in this 'ideal' fashion and normally no infelicity results when a required presupposition is missing, a mechanism that adjusts the context under a specified set of conditions certainly seems called for. The problem of course is to specify exactly under what conditions adaptation applies, updates the context and thereby restores felicity, and under what conditions it can't, yielding true presupposition failure.[8] A further point is that Heim also aims at applying this mechanism to account for the phenomenon of presuppositional 'cancellation'. Unfortunately she only discusses the working of this mechanism in connection with the well-known non-presuppositional reading of negative sentences. The underlying rule seems to be that under the threat of inconsistency the context is accommodated in such a way that the presupposition seems lost. If this is indeed the way accommodation is supposed to work, Heim has to face at least three problems:

Such a notion is unable to handle sentences like (7) or stretches of text like (6). As we already noted, the reason for cancellation of the elementary presupposition of the antecedent of the second conjunct (or sentence) is not a threat of inconsistency, but the fact that after the first sentence is uttered the context will contain an implicative proposition, which would make the utterance of the second sentence unacceptable, if it were presupposing. A simple stipulation that a suitable kind of accommodation applies in case the predictions of the recursive mechanism do not come out, of course, will not do.

It is, furthermore, unclear how such a mechanism could restore a presupposition once it is neutralized by the inheritance conditions. Thus a sentence like (3a) will wrongly be predicted to be non-presupposing.

One possible solution would consist in making the adaptation mechanism dependent on contextual acceptability, but this would in fact boil down to adopting part of the solution proposed in section 3. An alternative solution which would be much more in the spirit of Heim's view on discourse representation would be to claim that the antecedent of the first implication functions as a provisional context for second conjunct of (7) or that the whole stretch of discourse given under (6) should be subordinated to the antecedent of the first sentence. I will discuss this possibility in the following section.

5 Discourse representation and subordination

The interdefinability laid down in (19) shows that the Karttunen/Heim approach is simply a variant of the classical notion of presupposition as a binary relation between sentences (or sentences and propositions). It will thus come as no surprise that the theory handles none of the examples we discussed in the first section. The contextual acceptability approach on the other hand handles them all and does this in an easy way. We already showed this for sentence (1b), That the same prediction ensues with respect to (2b) will be obvious. No sentence can be interpreted with respect to a context that contains contradictory information. I will discuss (3) an (4) in the last section.

Part of the context dependency of presuppositions can be recaptured in theories of discourse representation. Since I will be concerned here with the hierarchical order according to which sentences in discourse can be related I need not make any specific assumption with respect to the actual implementation of the relevant notions in any particular variant.[9]

Common to most versions of discourse representation theory is the postulation of an intermediate level of representation, consisting of discourse representation or discourse domains. Such representations consist of discourse entities (markers or addresses), the basic objects that are introduced in the course of a discourse and basic predicates which are assigned to these entities. Discourse entities may thus store whatever information accumulates on them in the course of a conversation. Discourse representations are related by logical relations in a hierarchical structure, thus yielding discourse representation structures.

A discourse can be conceived as a finite sequence of sentences each of which induces one or more discourse representations. When a discourse simply consists of simple sentences without logical connectives or universal quantifiers each subsequent sentence serves as an increment to the information already established, thus extending prior representations. Sentences that are constructed by means of logical connectives or universal quantifiers are analysed as more complex structures. A conditional can be analysed as creating two structures: an antecedent representation and a consequent representation, related to each other by subordination. Disjunctions and many kinds of conjoined modal sentences may split up a discourse and give rise to two lower level structures, both of which can independently accumulate information that specifically concerns them.

The relative position of a discourse entity in a discourse representation structure determines whether it may serve as the antecedent of an anaphor. The possibility of anaphoric reference is determined by the accessibility of a discourse entity. In general a discourse entity is accessible only if it is already contained in the discourse representation or in a discourse representation that is on a superordinate level.

It has been argued by Roberts (1987) that the notion of subordination can be generalized to account for some puzzles that were already discussed by Karttunen as early as 1971:

(25) If John caught a fish, he will be eating it by now.
*It is a trout.

(26) If John caught a fish he will be eating it by now.
It will be a trout.

In both cases no antecedent would be available for the pronoun in the second sentence, if this sentence were added to the main level of discourse. To account for the fact that the discourse marker introduced in the antecedent of the first sentence of (26) may serve as antecedent for the pronoun in the second sentence, Roberts argues that the second sentence falls under a principle she calls modal subordination. While the second sentence of (25) can only be interpreted as and independent assertion added to the top level of discourse, the second sentence in (26) does not seem plainly asserted, but may be interpreted as a continuation of the preceding conditional. Such an analysis accounts not only for the inferences we draw from such sentences in context but also provides an accessible antecedent for the anaphor.

Subordination provides an easy solution for the problem (1b) and (5) pose for the Karttunen/Heim approach. If we add the representation of the second conjunct of (5) or second sentence of (1b) to the consequent representation of the first sentence, the discourse structure will look like (27) instead of (28):

(27) $<<\varphi> \rightarrow <<\chi>, <\psi_\varphi> \rightarrow <\xi>>$

(28) $<<\varphi> \rightarrow <\chi>>, <<\psi_\varphi> \rightarrow <\xi>>$

But while the presupposition predicted according the Karttunen/Heim rules for (28) is (30) thus entailing φ., the presupposition of (27) is (30), an noncommittal tautology. The elementary presupposition is thus predicted to be neutralized.

(*) $\varphi \rightarrow [\chi \rightarrow \varphi]$

(*) $[\varphi \rightarrow \chi] \rightarrow \varphi$

It should be noted that the method of subordination is totally compatible with the contextual acceptability account. The same prediction follows according to the contextual acceptability account. It yields moreover the right predictions. Like (28), (27) is unacceptable given the contextual assumption of the elementary presupposition, which predicts a non-presuppositional reading. But subordination of the second conditional to the consequent of the first does have the advantage of the accessibility of the antecedent in the first if-clause.

The method of insertion just sketched is not adequate in all cases. Roberts and Landman discuss cases in which a sentence cannot simply be seen as a continuation of some preceding sentence, but should be interpreted as an extension of the discourse representation structure on the supposition of some contextually accommodated information. In many sentences which are not of a conditional form the relevant information can be extracted from prior discourse, thus providing an antecedent under which the sentence is conditionally asserted:

(31) A wolf might walk into the house. It would eat you first.

Sentence (*) would thus not be interpreted as:

(32) It is possible that a wolf walks in and eat you first.

but as the stronger:

(33) It is possible that a wolf walks in. And if it does, it would eat you first

A variant of modal subordination, called modal splitting has been discussed and applied to presupposition theory by Landman. I already mentioned that disjunctions and some conjoined modals may split up a discourse and introduce two lower level discourse representations each of which can independently accumulate information of alternatives newly presented in discourse. In case anaphoric links, contextual information or information contained in the newly introduced alternatives make clear that both alternatives can be regarded as a continuation of the alternatives already present, a representation of (34) thus would look like (35a) rather than (35b):

(34) $[\varphi \vee \chi].\ [\psi \vee \xi]$

(35a) $<<\varphi, \psi> \vee <\chi, \xi>>$

(35b) $<\varphi \vee \chi>, <\psi \vee \xi>$

The same effect can be achieved by modal subordination and accommodation of the antecedent:

(36) $<<\varphi> \vee <\chi>, <\varphi> \rightarrow <\psi>, <\chi> \rightarrow <\xi>>$

It is unclear which method is preferable. Both options allow binding of anaphors by the relevant alternatives in an equally simple way. And both are equivalent in case contextual information makes clear which structure should be regarded as a continuation of which disjunct (which is a requirement of splitting anyway). Moreover both options give an equally simple solution for the problem (2b) poses for the Karttunen/Heim rules of presupposition projection. I will adopt (35a).since it is a simpler structure anyway

It is reasonable to suppose that (2b) will only be uttered in a situation where the question of John beating Harry is at issue. (2b) will thus only be uttered given the assumption that John either did or did not beat Harry. .

(2b) If John has *stopped* beating Harry he must be happy, but if he just has *started* doing so, he certainly won't be happy at all.

The sentence has the form:

(37) $[\varphi_{\varphi'} \rightarrow \psi].\ [\chi_{\varphi''} \rightarrow \xi]$. where φ' and φ'' are incompatible alternatives.

Modal splitting applied to the presuppositions yields the following discourse structure:

(38) $<\varphi', <\varphi \rightarrow \psi>> \vee <\varphi'', <\chi \rightarrow \xi>>$

Application of the Karttunen/Heim rules gives the result that both presuppositions are neutralized. A similar result is achieved by applying the method of contextual acceptability. Addition of the presuppositions to the main level would yield an inconsistent context and of course no sentence will be judged acceptable given such a situation.

6 Pragmatic ambiguity and the inadequacy of Karttunen type approaches

Modal subordination and modal splitting account for many of the counterexamples of the Karttunen type theories. This has been shown by Landman with respect to disjunctions where the disjuncts have conflicting presuppositions. In the previous section we illustrated this with respect to the presuppositions associated with the antecedent of conditionals. We also noted that application of this technique does not affect the predictions of the contextual acceptability account and has the advantage of providing referents for anaphoric pronouns in many cases where these would not be accessible according to the standard assumptions of quantifier scope.

One might then wonder whether the Karttunen/Heim approach in spite of the many counterexamples cited in the literature could not be transformed in a descriptively adequate theory after all. In the present section I will show that it cannot. I will illustrate this by means of a type of sentences which has, curiously enough, been adduced in support of Karttunen's approach.[10]

The relevant sentences exhibit the following characteristics

a. they are all of the form $\varphi \rightarrow \psi_\chi$

b. φ (possibly in conjunction with contextual information) entails χ,

c χ does not entail φ

According to Karttunen and Heim's a context satisfies-the-presuppositions-of such a sentence just in case the context in conjunction with the antecedent does. Since in this case the antecedent entails the presupposition of the consequent, the presupposition is always trivially satisfied. It is thus predicted that this type of sentences thus will never have a presuppositional reading. The following sentences show that this prediction is too weak.

(39) If John has fifty grandchildren, his children are married
(40) If John has grandsons, his children will be happy.

In both cases the antecedent entails the presupposition of the consequent, but neither of these sentences allows a non-presuppositional reading.

It has been observed by Soames that many other sentences which exhibit the same logical and presuppositional structure, give rise to different intuitions. Associated with the consequent of (41a) is the elementary presupposition (41b) and associated with the consequent of (42a) the elementary presupposition (42b). But contrary to (39) and (40) both (41a) and (42a) allow a non-presuppositional reading.

(41a) If someone at the conference solved the problem, it was Julius who solved it.
(41b) Someone solved the problem
(42a) If John murdered Mary, he will be glad that she is dead.
(42b) Mary is dead.

For the present purpose it it important to observe that these sentences exhibit a systematic ambiguity with respect to contextual parameters, a characteristic they share with many other presuppositional inferences.[11] Both (41a) and (42a) allow a presuppositional and non-presuppositional reading, the choice between which depends systematically on the contextual information selected.

Consider first the predictions of the contextual acceptability account with respect to (41a), the example that Soames presented as a counterexample to the implicature cancelling account. Utterance of (41a) in a context in which only problem solving at the conference is at issue, yields a non-presuppositional reading. One way to represent such a context is to add the proposition expressed by (43) to the context. This induces an equivalence between the antecedent and the elementary presupposition, which suffices to force a non-presuppositional reading.[12]

(43) If the problem was solved, it was solved at the conference.

On the other hand it is easy to force an interpretation of (41a) over a class of contexts which does definitely *not* contain the information given In (43). A simple way to achieve this is to read *at the conference* with contrastive stress:[13]

(44) If someone AT THE CONFERENCE solved the problem, it was Julius who solved it.

In absence of any other relevant contextual information the presupposition is preserved as a presupposition of the whole sentence..[14] This observation is confirmed by the fact that the continuation of (18) given in (45) is completely natural, and clearly presupposition preserving:

(45) If someone AT THE CONFERENCE solved the problem, it was Julius who solved it, but if it was solved at the Nijmegen Institute of Technology, it certainly wasn't Julius.

Analogous remarks can be made with respect to (42a). Like (41a) this sentence allows two interpretations, depending on whether the possible death of John's wife is interpreted as a result of a murdering action of John, or as a situation that might have had some other cause. The non-presuppositional reading is forced upon us if it is clear from the context that John intended to murder her and no other possibilities are considered. A tentative representation of this situation might be given by adding the information given in (46) to the context-set:

(46) If John's wife is dead, she has been murdered.

In conjunction with the elementary presupposition this again induces an equivalence between the antecedent and the elementary presupposition. However, if the context is neutral with respect to the question what might have been the cause of her death and other possibilities are considered, (42a) does have a presuppositional reading, as is confirmed by (47) which is again a clear counterexample to Karttunen type approaches.

(47) If John murdered his wife, he will be glad that she is dead, but if she took those pills herself.......

This behaviour is exactly what we would expect on the contextual acceptability account. As long as the assumption can reasonably be upheld that no contextual information is relevant for the interpretation of the sentence, it will be processed on the assumption that P(c) is empty. In this case the sentence will have a presuppositional reading. This interpretation can however easily be overruled by the addition of contextual information. If this information would make the carrier sentence unacceptable if it were presupposing, a non-presuppositional reading is forced. [15]

The second factor involved is anaphora. This is most easily demonstrated with respect to examples which contain simple indefinites and which parallel the examples given above both in logical structure and presuppositional behaviour. In both (48) and (49) the antecedent entails the presupposition of the consequent, but while (49) is clearly presupposition preserving, a presuppositional reading for (48) is hard to find.[16]

(48) If Mary has a son, her child is a philosopher.
(49) If Mary has a grandson, her child is happy.

The antecedent of (48) contains an indefinite. Thus a discourse marker is set up for *Mary's son* in the representation of the if-clause and may subsequently function as an antecedent for anaphors that appear in subordinated structures. Since in this case there is no other discourse marker available, the discourse marker just established is the obvious candidate to bind the anaphor in the consequent. Since it is moreover established by now that *Mary's son* and *her child* denote the same individual the sentence will be unacceptable given the contextual assumption of the presupposition *Mary has a child.* This suffices to block the projection of the presupposition to the main level of discourse, and prevents it from establishing an accessible discourse referent for sentences that are subsequently entered at the main level. The following sentence is infelicitous for the simple reason that the discourse referent established in the antecedent of the conditional fails to provide an accessible antecedent for the pronoun of the second sentence.

(50) *If Mary has a son, her child will be a linguist. He started his studies long ago.

When discussing (41a) and (42a) I did already point out that sentences of this type normally allow two readings. Although in the case of (48) the non-presuppositional reading is strongly preferred due to the fact that an anaphor will preferably be bound by the nearest marker which is accessible, contextual information can force a different reading. The following sentence illustrates this phenomenon:[17]

(51) If John has a ford, his car will be black.

When it is clear from the context that Harry has a car, no anaphoric link can be established between *a ford* and *his car*. The reason for this is simple. If the two phrases would denote the same individual the whole conditional would be unacceptable given the contextual information that John has a car. The information contained in the antecedent would already be entailed by the context. Now pronominalization is possible in subsequent sentences:

(52) If John has a ford, his car will be black. It is fast anyway.

The important point to observe is that the pronoun will not be bound by the inaccessible discourse marker established by *a ford* in the antecedent structure, but by the discourse marker which has already been established in the preceding discourse(or which will be established by projection of the presupposition to the main level in case no contextual information is available)..[18]

The situation with (49) is different. This sentence will never have a presuppositional reading. Due to the conflict between the conditions on the discourse marker in the antecedent and the lexical material of the potential anaphor the description in the consequent cannot be linked to the discourse referent established for her grandson in the antecedent representation. And since (49) is acceptable given the contextual assumption of the presupposition that Mary has a son, the contextual acceptability approach predicts that this presupposition will be projected to the main level of discourse. It will thus create a discourse referent for Mary's son which will be accessible for anaphors of sentences that are subsequently entered on the main level. The felicity of the following discourse illustrates this point:

(53) If Mary has a grandchild, her child will be happy. He wanted to have children long ago.

The advantages over a Karttunen type approach will be clear. On such an account the presupposition of a sentence exhibiting the logical and presuppositional structure of the examples discussed in this section is always neutralized. Thus (48) can only presuppose the tautology *If Mary has a son she has a child* and (49) only the equally uninformative sentence *If Mary has a grandson, she has a child.* This prevents not only an account of the interpretational possibilities these sentences allow, but also precludes the possibility to establish a discourse entity on the main level of discourse.

7 Concluding remarks

The approach sketched here has several advantages over the initial account given in van der Sandt (1982, in press).

One advantage is that it relates the phenomenon of presupposition projection directly to anaphora. Exactly the same mechanism that determines the accessibility of anaphors in sentences like (48) accounts for the fact that in many cases presuppositions cannot be projected to the main level of discourse.

It should be remarked that a similar account can be given for the non-presupposing reading (44), (46) and many other examples of potentially presupposing sentences that exhibit the pragmatic ambiguity discussed above. Such an account would however rely on the claim that all presuppositions can be seen as a special kind of anaphors, mainly differing from normal denoting pronouns in that they do have some descriptive content. It would moreover rely crucially on a theory of pronominal anaphora. Such an account is beyond the limits of this paper.

A second advantage is conceptual. The original theory had to stipulate that presuppositions either do not survive or take maximally wide scope. While the intuitive motivation for the fact that presuppositions, if they survive, always take maximally wide scope is wholly satisfactory, and although the rules originally given account correctly for all the cases in which presuppositions do not survive, it still remains unclear what it means to say that some part of content simply disappears. To avoid terms like cancellation of neutralization we had to say that in case the contextual assumption of the presupposition.would give rise to unacceptability of the carrier sentence the rules of contextual acceptability force an interpretation over a different class of contexts (i.e. a class of contexts in which does definitely not contain the presupposition). And although this is true, it does not explain what precisely happened to them.

On the current picture notions like neutralization or cancellation simply make no sense. Presuppositions are never cancelled or neutralized. In fact they always survive, but in many cases rules of discourse construction or contextual acceptability prevent them from reaching the main level of discourse.

The intuition that presupposition projection is determined by a bottom up procedure in the course of which they can be stuck at any level is first found in Morgan's (1969) article on world creating verbs. The view sketched here is in total conformity with the theories of presupposition proposed by Seuren (1985) and Fauconnier (1985). In both theories presuppositions attach at any level of representation and in both theories presuppositions of embedded clauses tend to spread upwards though domains or spaces up to the level where they are blocked. In these accounts, as in the present one, the projection problem boils down to the definition of an algorithm that determines under what conditions presuppositions attached to subordinate levels can reach the main level of discourse.

Appendix

A SIMPLIFIED PROJECTION ALGORITHM

The method of contextual acceptability [19]

Semantic an pragmatic interpretation

A semantic interpretation **SI** is a triple

SI= <W, C, f>

W is a set of possible worlds, C is a set of contexts, and f is a two-place function from L X C to $\{0,1\}^W$. For a given f we write $[\varphi]_c$ for the proposition f(φ, c). A context is an n-tuple the first co-ordinate of which is the context-set, a set of propositions, indicated as **P**(c). $c/_{[\varphi]}$ is the φ-extension of c, i.e. a context c' that differs from c only in that **P**(c') = **P**(c) ∪ {φ}.

Entailment and consistency are defined as usual

A pragmatic interpretation PI is a quadruple
PI = <SI, EP, A, g > where:

a. **SI** is a semantic interpretation.

b. EP: $L \rightarrow \wp(L)$ is a function from sentences to sets of sentences. This function assigns to every sentence a set of elementary presuppositions. This set is represented as EP(φ). The set of propositions that are expressed by the members of EP(φ) in a context c is called $EP_c(\varphi)$.

c. $A \subseteq L \times C$ is the acceptability relation; a two-place relation between sentences of L and contexts. A(φ, c) means intuitively that the assertion of φ is acceptable in c.

d. g: $L \times C \rightarrow C$ is the contextual change function, a function from sentences of L and contexts to contexts.
P(g (φ, c)) denotes the context-set that results from the assertion of φ in c.

The acceptability relation

a. A (φ, c) only if not $P(c) \models [\varphi]_c$

b. A (j, c) only if Con $(P(c) \cup \{[\varphi]_c\})$

c. If φ is not of the form $[\chi \wedge \psi]$, $[\chi \vee \psi]$ or $[\chi \rightarrow \psi]$ and φ contains embedded in a sentence ξ such that
(i) ξ is not the complement of a verb of propositional attitude (*believe, hope*...), and
(ii) $\xi \notin$ EP(φ), then
A (φ, c) only if A (ξ, c)

d. If φ is of the form $[\chi \wedge \psi]$ or $[\chi \rightarrow \psi]$ then
A (φ, c) only if A (χ, c) and A (ψ, $c/[\chi]_c$)

e. If φ is of the form $[\chi \vee \psi]$ then
A (φ, c) only if A (χ, $c/[\psi]_c$) and A (ψ, $c/[\chi]_c$)

Presupposition

Presupposition is a three-place relation between sentences, contexts, and propositions. A locution like 'φ presupposes χ' thus should be interpreted as an elliptical abbreviation for Given an empty context set φ presupposes the propositions expressed by χ.

For any φ and c such A (φ, c)
P (φ, $[\chi]_c$, c) iff
(1) $\chi \in$ EP (φ)
(2) for any $y \in$ EP (φ):
Con ($P(c) \cup \{[\chi]_c, [\psi]_c\}$)
(3) A (φ, $c/[\chi]$)

The set of presuppositions associated with a sentence φ in a context c is indicated by $\mathbf{PRES_c}$ (φ).

$$\mathbf{PRES_c}(\varphi) = \{[\chi]_c \mid \mathbf{P}(\varphi, [\chi]_c, c)\}$$

Confining ourselves to the contribution of the propositional content and presuppositions of a sentence the informative content of a sentence in a context is the union of the set of presuppositions that are associated with a sentence φ in a context c with the proposition expressed by φ

$$\mathbf{IC}(\varphi, c) = \{[\varphi]_c\} \cup \mathbf{PRES_c}(\varphi)$$

This notion allows us to give a partial definition, limited to assertions and their effect on **P**(c), of the contextual change function:

$$\mathbf{P}(g(\varphi, c)) = \mathbf{P}(c) \cup \mathbf{IC}(\varphi, c)$$

Acceptability and presupposition in discourse

A discourse is a sequence of speech acts. An acceptable discourse is a sequence of speech acts each of which is acceptable with respect to the previous ones. Confining ourselves to assertions a discourse can be conceived of as a sequence of sentences. The notion of 'acceptable discourse' can then be laid down as follows:

$\Sigma = <\varphi_1, \varphi_2, ... \varphi_n>$ is a finite sequence of sentences.

A discourse Σ is acceptable --**A** (Σ, c)-- iff
there is a sequence of contexts $<c_1, c_2, ... c_n>$ such that
(1) $c_1 = c$
(2) for all i ($1 \leq i \leq n$) $c_{i+1} = g(\varphi_i, c_i)$ and $\mathbf{A}(\varphi_i, c_i)$

The definition of presupposition for acceptable discourses or texts now parallels the definition of sentential presupposition:

Let $\Sigma = <\varphi_1, \varphi_2, ... \varphi_n>$ and **A** (Σ, c)
then $\mathbf{P}_\Sigma(\Sigma, [\chi]_c, c)$ iff
(1) there is an φ_i such that $\chi \in$ EP (φ_i)
(2) for all φ_j ($j \leq i$): $\mathbf{Con}(\mathbf{P}(c) \cup \mathbf{EP_c}(\varphi_i) \cup \{[\chi]_c\})$
(3) $\mathbf{A}(\Sigma, c/[\chi]_c)$

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1 This extreme position is exemplified in the external forms of Bochvar's logical connectives. A compound statement will always have a classical value whether or not its components suffer from indeterminateness. Presupposition failure of one component can thus never result in presupposition failure of the compound.

2 See Gazdar (1979), Soames (1979, 1982) and Van der Sandt (1982, in press) for many more examples which show the context dependence of presupposition. The phenomenon of presuppositional asymmetry is discussed at length in Stalnaker (1973, 1974) and Van der Sandt (1982, in press).

3 See Link (1986) for a defense of this kind of approach.

4 The view that utterances can be identified with sentence-context pairs was first put forward by Bar Hillel (1954). Technical elaborations of this idea are found in Hamblin's (1971) dialogue models, and applications of these models to presupposition theory in Gazdar (1979).

5 Van der Sandt (1982, to appear). This work contains moreover a large number of applications by means of which it is demonstrated that the formalism defined handles all the counterexamples presented against existing approaches.

6 The truth table for the conditional is given below. I leave it to the reader to verify that the equivalences hold and that the table for the conditional defines Karttunen's heritage condition.

¬	1	0	*
	0	1	*

∧	1	0	*
1	1	0	*
1	0	0	0
*	*	*	*

→	1	0	*
	1	0	*
	1	1	1
	*	*	*

7 Kleene's truth-tables are as follows.

¬	1	0	*
	0	1	*

∧	1	0	*
1	1	0	*
0	0	0	0
*	*	0	*

→	1	0	*
	1	0	*
	1	1	1
	1	*	*

A discussion of Kleene's system in connection with Karttunen and Peters' heritage conditions is found in Karttunen and Peters (1979: 44-45).

8 Neither Lewis nor Heim presents such a set of conditions. Lewis' rule of accommodation for presupposition runs as follows:
"If at time t something is said that requires presupposition P to be acceptable, and if P is not presupposed just before t, then *-ceteris paribus* and within certain limits- presupposition P comes into existence at t." (1979: 340)
In absence of any clarification of the parenthetical remark such a rule is, of course, vacuous. It should however be remarked that Lewis is not concerned with the actual formulation of the various rules of accommodation, but with clarifying the common characteristics his individual examples exhibit.

9 A number of theories have been developed, several of which are related. See in particular Seuren (1975, 1985), Kamp (1981), Heim (1982), Fauconnier (1985) and various approaches in psychology and artificial intelligence.

10 See Soames (1982), Heim (1983) and Landman (1986) for some statements. Many other counterexamples exist which cannot be eliminated by an appeal to the notions of subordination and splitting. Disjunctions for example will never give rise to substantial presuppositions on Karttunen's account. I refer to Gazdar (1979) and Van der Sandt (1982, in press) for a great number of counterexamples.

11 See Gazdar (1979), Van der Sandt (1982, in press), Seuren (1985), and Fauconnier (1985) for a number of examples.

12 It is easy to check that this is correctly predicted by the system defined in the appendix. See Van der Sandt (1982, in press) for detailed derivations.

13 See Seuren 1985: 295-304 for an analysis of contrastive stress and cleft constructions in grammatical terms.

14 This is again easy to check. No application of the rules will give rise to unacceptability on the assumption of the elementary presupposition.

15 It should be noted that such an explanation cannot help the implicature cancelling account for the simple reason that implicatures are properties of utterances and not of sentences. This most easily demonstrated by applying Gazdar's formalism. Although an utterance of (43) would invoke the

implicature P ¬ (the problem was solved) and thus cancel the pre-supposition K (someone solved the problem), this prediction does not ensue when (43) is simply taken for granted in the context of utterance. Implicatures are invoked by utterances and the mere assumption of (43) does neither induce the cancelling implicature nor itself suffice to cancel the pre-supposition.

16 It does, however, exist as one would expect on the contextual acceptability account.

(i) If Mary has a son, her child will be a linguist, but if she has a daughter, ...

17 I owe this example to Pieter Seuren(p.c.).

18 Compare this with cases where the presupposition of the consequent entails the antecedent or cases where an equivalent relation obtains between the antecedent and the presupposition of the consequent:

(i) If John has a car, his car will be black.

For reasons of contextual acceptability the presupposition can never be projected to the main level. The discourse given in (ii) is clearly unacceptable:

(ii) *John has a car. If John has a car, his car will be black.

It thus follows that no accessible discourse marker can be established to function as an antecedent for subsequent sentences.

(ii) If John has a car, his car will be black.
* It is fast anyway.

19 See Van der Sandt (1982, in press) for full details and applications.

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BOUND VARIABLES IN SYNTAX
(ARE THERE ANY?)

Anna Szabolcsi

Research Institute for Linguistics
Hungarian Academy of Sciences
H-1250 Budapest, P.O.Box 19

Current theories of grammar handle both extraction and anaphorization by introducing variables into syntactic representations. Combinatory categorial grammar eliminates variables corresponding to gaps. Using the combinator **W**, the paper extends this approach to anaphors, which appear to act as overt bound variables.

0. OUTLINE

Most current theories of grammar handle "extraction" as well as "anaphoric binding" by introducing variables into syntactic representations. A radical alternative is offered by the theory of combinatory categorial grammar, one salient property of which is that it eliminates syntactic variables corresponding to gaps. The question arises whether such an approach can be extended to anaphors, which act as overt bound variables. The paper proposes a natural syntactico--semantic treatment for the core cases of binding, and examines its interaction with extraction and coordination processes.

The paper is organized as follows. Section 1 reviews some of the fundamental assumptions concerning the motivation and format of combinatory categorial grammar. Section 2 introduces the problem posed by anaphors and presents the essence of its solution. Section 3 takes up the problem of two-complement verbs, and Section 4 pied piping. Section 5 concludes with a brief discussion of the status of locality and pronouns.

1. BACKGROUND

The Government--Binding (GB) theory works on the assumption that all grammatical relations, including those relevant for the assignment of theta-roles, are to be defined in strictly local terms. There is a precise analogue of this assumption in various versions of categorial and phrase structure grammar (CG/PSG): the restriction of the interpretation of concatenation to functional application (FA). The common assumption leads to essentially the same problems and associated solutions in GB and in CG/PSG. To express their equivalence in the pertinent respect, I will refer to all these theories as FA-grammars.

FA-grammars make the prediction that natural language functors are to be adjacent to their arguments. One set of data that may constitute a glaring counterexample to this includes sentences informally describable as containing a gap left by a leftward or rightward extracted constituent:

(1)a. **You think that Mary likes Bill.**
WHO do you think that Mary likes —?

b. **I put the cup on the table.**
I put — on the table THE BIGGEST CUP YOU HAVE EVER SEEN.

The standard solution to this problem goes as follows. In accordance with the FA-strategy, the gap is filled by a placeholder interpreted as a variable and, in necessary deviation from the FA-strategy, the extracted constituent is affixed to the sentence in a syncategorematic fashion resembling the introduction of binding operators in logic. In view of what such sentences mean, the procedure seems semantically correct.

Notice, however, that this solution makes one expect that the possibilities for gaps and extracted constituents to occur in natural language are the same as those for variables and operators in logical syntax. This expectation is not borne out. Consider the following paradigmatic cases of divergence noted in the literature:

(2)a. Free variables: **fx**
  * **— saw Bill.**

b. Vacuous operators: $\lambda x[a]$
  * **What did Mary see Bill?**

c. Crossed binding: $\lambda x \lambda y[fx(gy)]$
  * **What$_1$ do you wonder who$_2$ to talk about —$_1$ to —$_2$?**

d. Binding over arbitrary domains: $\lambda x[...x...]$
  * **Who$_1$ did you meet John, who likes —$_1$?**
  ? **Who$_1$ did you go home without meeting —$_1$?**

The only way-out is to supplement the grammar with filters, i.e., well-formedness conditions imposed on the input or the output of rules. These may be formulated in terms of government projections (Kayne 1983), feature percolation conventions (Gazdar et al. 1985), or storage mechanisms (Cooper 1983) etc. Common to all is the property that, having the status of axioms, these filters can at best state the facts correctly but cannot explain why the facts are as they are.

Ades--Steedman (1982) observe that there is an alternative way to approach structures like (1). They abandon the FA-restriction and propose to add functional composition to the apparatus of categorial grammar. This extension allows the grammar to assign the same interpretation to extraction structures without invoking placeholder variables, syncategorematic operators, and filters:

(3) Composition: If £ e $CAT_{a|b}$ and \$ e $CAT_{b|c}$ then £\$, \$£ e $CAT_{a|c}$ with the interpretation $\lambda x[£'(\$'x)]$.

E.g.: **who do you think that Mary likes**

```
E.g.:  who  do  you  think  that  Mary   likes
       NP                         S|VP   VP|NP
                                  ____________  S|NP
                            __________________  .
                     _________________________  .
                _______________________________ .
           ____________________________________ S|NP
```

The introduction of an argument can now be delayed if, and only if, the items intervening between it and its functor can combine with it or its functor. "Combination" means application or composition. Note that this extension does not merely allow us to derive the well-formed extraction structures of (1), it also offers an explanation of the ill-formedness of the structures in (2). (2a) is fine but not an S, and the ungrammaticality of (2b,c,d) must follow from the lack of proper matching in the participating categories.

(Steedman 1987 actually imposes directionality constraints on composition, some of which follow from the "semantics" of composition and some of which amount to empirical claims about English. They will be reviewed at the end of this section.)

Promising as this line of research seems to be, it is immediately clear that FAC-grammar can only handle sentences with a one-to-one correspondence between "extracted" constituents and "gaps". It is therefore challenged by the existence of so-called parasitic gap sentences like (4):

(4) Multiple binding: $\lambda x[\ldots x \ldots x \ldots]$
What$_1$ did you file —$_1$ without reading —$_1$?
He is a man who$_1$ everyone who knows —$_1$ ends up liking —$_1$.
*** What$_1$ do you think —$_1$ got filed without John reading —$_1$?**

The possibility of multiple binding is predicted by the variable introduction strategy in FA-grammars. Note, though, that the restrictions on the relative positions of the two gaps, discussed by Engdahl (1983) and others, call for further filters in those theories.

Szabolcsi (1983) observes that (4) need not constitute an argument against the variable-free approach. The conditions under which multiple gaps are possible are suggestive of a further specific operation on functors being at work here. The operation introduced in that paper under the name connection (after Kayne) will make the correct predictions: **1**

(5) Connection: If £ e $CAT_{(a|b)|c}$ and \$ e $CAT_{b|c}$ then £\$, \$£ e $CAT_{a|c}$ with the interpretation $\lambda x[£'x(\$'x)]$.
E.g.: **what you filed without reading**
NP S|VP VP|NP (VP|VP)|NP
———— VP|NP by connection
———— S|NP by composition

It can be demonstrated that there is a fairly close parallelism between the working of composition and connection on one hand, and of the rules and filtering mechanisms employed in FA-grammars on the other. We are not dealing with notational variants, however. As was pointed out above, the relevant apparatus of FA-grammars is stipulative in nature. The apparatus of FACC-grammar is not. The availability of composition and connection follows from the fact that we modelled lexical items with function-argument structures -- it is just as natural for functions to compose and to connect as it is to apply. To put it that way, FACC-grammar explains why the construction of empirically adequate FA-grammars is possible; but not vice versa.

Steedman (1985b) raises the question of what inventory of operations composition and connection are drawn from. He observes that they are identical to the combinators **B** and **S** of Curry--Feys (1958), respectively, and suggests that categorial grammar should in general be based on combinators. Given that one of the fundamental results of combinatory logic, as Curry puts it, is that "variables are a logically unnecessary but practically very useful device", the exclusion of placeholder variables from derivations will no longer be a mere expedient but receives coherent mathematical support. More precisely, Steedman argues on both grammatical and computational plus parsing grounds that adequate grammars for natural language are to be based on (some extension of) the following system: **2**

(6) **B** $\equiv \lambda fgx.f(gx)$ [composition]
S $\equiv \lambda fgx.fx(gx)$ [connection]
C $\equiv \lambda fxy.fyx$ [permutation]
I $\equiv \lambda x.x$ [identity] **CI** $\equiv \lambda xf.fx$ [raising]

While it may be a matter of debate whether **C** is to be used in syntax, he argues that **I** (as well as the constant function creating combinator **K**, $\lambda x[a]$) is to be excluded because it would allow unrecoverable deletion, so to speak. On the other hand, the composite combinator **CI** has for long been known to be operative in grammar.

CI, i.e., type raising is the operation Montague (1974) used to ensure that all noun phrases denote generalized quantifiers. But, apart from the treatment of scope, raising seems necessary to provide the appropriate categories for subjects that undergo composition (cf. the example in (5)), and for "non-constituents" that undergo extraction or coordination. The following is due to Dowty (1985), who develops a proposal in Steedman (1985a):

(7) **John gave** $(VP/NP_{acc})/NP_{dat}$ — **Mary** (VP/NP)\((VP/NP)/NP — **a book** VP\(VP/NP)

VP\((VP/NP)/NP)

VP

The raised categories allow **Mary** and **a book** to compose into the "non-constituent" **Mary a book**, of category VP\((VP/NP)/NP). This may apply to the two-complement verb **gave** directly, or it may first conjoin with **Susan a record** of the same category.

Finally, let me summarize the actual operations to be used below on the basis of Steedman (1987). A word about notation: given that I do not have a backwards slash, <u>!</u> will be used instead.

(8)

Application:	A/B B = A	
	B A!B = A	
Composition:	A/B B/C = A/C	(indexed as **B**)
	B!C A!B = A!C	(indexed as **B**)
	B/C A!B = A/C	(indexed as **B!**)
$Raising_{syn}$:	A ⇒ B/(B!A)	(indexed as **CI**)
	A ⇒ B!(B/A)	(indexed as **CI**)
$Raising_{lex}$:	A ⇒ S/(S/A)	

2. ANAPHORIC BINDING -- THE BASIC IDEA

We are now in a position to appreciate the problems posed by reflexives and reciprocals (anaphors). Standard theories follow Chomsky (1981) in assigning the following primitive properties to anaphors:

(9)a. An anaphor is a variable that must not remain free.
b. The binder must be an argument that is hierarchically more prominent than the anaphor.
c. The binder must be local.

The first property is reminiscent of property (2a) noted for gaps. In fact, Pollard's (1984) FA-grammar, for instance, assigns the same free variable interpretation to **himself** that he assigns to the placeholder **t** for gaps. The difference is that **himself** and **t** are accompanied by somewhat different algorithms for finding their antecedents and for actually getting bound by them. Now, there are obvious reasons why we cannot follow him and likeminded theorists in straightforwardly assimilating anaphors to gaps left by extraction.

First, we did not use placeholder variables for gaps. In our theory, the fact that "gaps" must not remain free simply followed from the fact that the pertinent argument must be supplied sooner or later if we are to get a full sentence. Given that "gaps" are not visible, it was easy to argue that the only item whose placement and interpretation we need to account for is the "gap filler". But anaphors are surely visible arguments, and their binders are also independently necessary arguments. So there is every reason to expect that we need bound variables for the treatment of anaphors. The problem is, though, that we did not merely opt for a framework which allows us to handle specifically extraction structures without using bound variables in syntax. We committed ourselves to combinatory logic, which does not have bound variable items at all.

It appears, therefore, that the treatment of anaphor binding is kind of a test case for the tenability of the general claim that natural language grammar is to be based on (the proposed kind of) combinatory logic. In what follows I will examine anaphors in this light. Rather than trying to provide a sophisticated empirical analysis of binding facts, I will focus on the essential properties of anaphors within the context of the theory reviewed in Section 1.

Pending the discussion of locality, reflexives appear to have two uncontroversial properties. One, they are a kind of noun phrase. Two, they differ from other members of the species in their meaning. Both **John** and **himself** can serve as the object of **hit**, for instance. But by combining **John** with **hit** we get the VP-meaning $\lambda x[\mathbf{hit'(j)(x)}]$, and by combining **himself** with **hit** we get the meaning $\lambda x[\mathbf{hit'(x)(x)}]$.

While combinatory logic has no bound variables and therefore we cannot identify **himself** with the first bound instance of **x** in $\lambda x[\mathbf{hit'(x)(x)}]$, it does have operations (combinators) that identify the arguments of the function they apply to. One such combinator is **W**, the duplicator:

(10) $\mathbf{W} \equiv \lambda f x.fxx$

(11) If **g** is $\lambda y \lambda z[hyz]$, then **Wg** is $\lambda f \lambda x[fxx](\lambda y \lambda z[hyz]) = \lambda x[hxx]$.

Let **g** be multiplication, for instance -- a two-argument function whose arguments can of course be distinct. Then **Wg** will be squaring - a one-argument function which need not be looked upon as a primitive but can be defined as multiplying its argument by itself. Now, it is clear that the contribution of **himself** to **hit himself** is the same as the contribution of **W** to the meaning of **Wg**. This entails (12):

(12) The meaning of **himself** is the same as the meaning of **W**.

With this we have a straightforward account of the semantics of reflexives. Note, however, that the fact that they are a kind of NP appears to be unaccounted for. The multiplication/squaring analogy may not seem revealing in this respect. After all, **W** is a function over multiplication in squaring, while **himself** is the first argument of **hit**. But notice that what **W** does to its input is to turn it from a two-place function into a one-place function, which is essentially the same as to provide the first argument. The conceptual gap will be bridged by function-argument structure reversal, i.e., raising:

(13) **CI** $\equiv$ $\lambda xf.fx$

(14) $\lambda f[fa](\lambda y\lambda z[hyz]) = \lambda y\lambda z[hyz](a) = \lambda z[haz]$

This tells us what kind of a noun phrase a reflexive is: nothing but a raised kind. Given that raising is amply motivated in the grammar, reflexives are by no means exceptional in this regard.

The above reasoning, leading to the recognition that reflexives must be raised noun phrases can also be put in the following way. **W** may be taken to be a primitive combinator. If it is not, however, one of its definitions is (15):

(15) **W** $\equiv$ **S(CI)** $\lambda g\lambda h\lambda x[gx(hx)](\lambda y\lambda f[fy]) = \lambda h\lambda x[hxx]$

That is, **W** is obtained by applying the connector to the raiser.

In yet other words, every expression that is interpretable as **W** has a raised kind of category, although not every expression with a raised kind of category is interpretable as **W**. Compare:

(16)a.	**everyone**	**Mary**	**heself**
	S/(S!NP)	S/(S!NP)	S/(S!NP)
	$\lambda f\forall x[fx]$	$\lambda f[fm]$	
b.	**everyone**	**Mary**	**himself**
	(S!NP)!((S!NP)/NP)	(S!NP)!((S!NP)/NP)	(S!NP)!((S!NP)/NP)
	$\lambda g\lambda y\forall x[gxy]$	$\lambda g\lambda y[gmy]$	$\lambda h\lambda x[hxx]$

Himself has the standard raised NP category of ("narrow scope") objects. But just as the interpretation of **everyone** differs from that of **Mary**, **himself** has its own interpretation, too. The gap with **heself** of category S/(S!NP) is due to the fact that **W** is by definition a two-place function, whence it cannot be the interpretation of a one-place functor.

Consider now the derivation of a simple example:

(17)	**everyone**	**hit**	**himself**
	S/(S!NP)	(S!NP)/NP	(S!NP)!((S!NP)/NP)
	$\lambda f\forall x[fx]$	$\lambda y\lambda z[hit'yz]$	$\lambda h\lambda u[huu]$
		S!NP	$\lambda u[hit'uu]$
		S	$\forall x[hit'xx]$

Summarizing the basic idea: **himself** is assigned a lexical interpretation which (i) is consonant with it being a standard kind of NP, and (ii) allows us to derive the requisite interpretation for **Everyone hit himself** without further tricks. [3]

Prior to proceeding to more complex cases, let me briefly comment on the significance of the fact that **W** is a lexical and not a syntactic combinator. Consider the sentence **John turned.** If we could argue convincingly that this is synonymous with **John turned himself** and, moreover, if this "transformation" of transitive verbs were fully productive, we could use **W** in syntax:

(18) **John** **turned**

$$\frac{(S!NP)/NP}{S!NP}\ \mathbf{W}$$

English is certainly not a language with such properties; whether there is a language like that I will leave open. But what can we make of all this?

Szabolcsi (1986) noted that if we just identified the set of possible syntactic operations with the set of possible combinators, we would be faced with an undesirable embarras de richesse. Composite combinators can perform indefinitely complex operations in one swoop. It is obvious that at most a very small set of combinators are plausible as operations on natural linguistic functors. Now, it may not at all be accidental that the combinators **B**, **S**, **CI** that have been found useful in English syntax constitute a primitive set -- a set whose members are not interdefinable. We may take this to indicate that natural languages restrict the operations freely available in syntax to members of such primitive sets -- or, at least, to very modest extensions of such primitive sets. Composite combinators definable in terms of those primitives will only be allowed if they are embodied by some lexical item; the categories and/or interpretations of those lexical items can then be regarded as mere abbreviations for composite combinators of the given system. **4**

Now, this restriction (which clearly has promising implications for acquisition as well) may turn out too good to be true. Note however that the use of **W** outlined above conforms to it. **W** is a composite combinator in the system we envisage for English, and it can be argued to be lexical. Now, suppose there is in fact a language in which all transitive verbs can be used intransitively with a reflexive meaning (without morphological indication). In the ideal case we expect this language to be based on a combinator system in which **W** is a primitive -- for instance, **B**, **W** and **CI**. We predict, then, that this language has no free parasitic gaps because **S** is not available in its syntax. (It may have across the board extractions since connectives, whose semantics is closely related to **S**, are lexical items.) We have thus opened a line of research for mathematically coherent parametric variation.

3. TWO-COMPLEMENT VERBS

So far we have only dealt explicitly with reflexives as objects of simple transitives. In this section the term "two-complement verb" will be applied indiscriminately to **give**, **introduce**, and **talk** etc., that is, to any verb that takes two non-subject arguments, whether those be prepositional or not. **About himself** and its brothers will also be treated as syntactically primitive until Section 4.

What does the **W**-proposal imply for these cases? Let us again begin by sketching the general picture. An expression interpreted as **W** says, 'I am the first argument of a function, and its second argument will inescapably bind me'. But this only singles out what **W** cares about. It is by no means necessary that the function at issue be an atomic two-place function, and hence **W** is not specific for direct objects. In principle, we have all the following possibilities, with **g** an atomic three-place verb:

(19) $\lambda f \lambda x[fxx](\lambda y \lambda z \lambda u[gyzu]) = \lambda x \lambda u[gxxu]$

(20) $\lambda f \lambda x[fxx](\lambda z \lambda u[gazu]) = \lambda x[gaxx]$

(21) $\lambda f \lambda x[fxx](\lambda y \lambda u[gyau]) = \lambda x[gxax]$

In (19) **W** applies to **g** directly, so **g**'s 1st and 2nd arguments will be identified and its 3rd (subject) argument is left intact. We might have said that **W** applied to a two-place function whose value is VP, not S. In (20) and (21) **g** had managed to combine with its 1st and 2nd argument, respectively, before **W** aplied to it. Again, **W** actually applied to two-place functions that contain, but are not identical to **g**. This shows that **W** captures the prominence condition (9b) on the binder quite generally.

Let us now spell out what all this means and presupposes in grammatical terms. First of all, the general discussion relied on the type-freeness of combinatory logic. In such terms **CI** is just **λxλf[fx]** and **W** is just **λfλx[fxx]**, with **f** any function. Our grammar is typed, however, so the degree of raising needs to be specified. Assuming that both complements are NPs, and ignoring the directionality of categories (as is indicated by the use of strokes instead of slashes), (19)-(20)-(21) can be redone as follows. **Arg** is the irrelevant item:

```
(19')  verb              reflexive                         binder   arg
       ((S|NP)|NP)|NP    ((S|NP)|NP)|(((S|NP)|NP)|NP)      NP       NP
       ______________________________________________
                         (S|NP)|NP
       _______________________________________________________
                         S|NP

(20')  verb              arg       reflexive               binder
       ((S|NP)|NP)|NP    NP        (S|NP)|((S|NP)|NP)      NP
       ______________________
        (S|NP)|NP
       ______________________________________________
          S|NP
       _______________________________________________________
          S

(21')  verb              arg                     reflexive               bnd
       ((S|NP)|NP)|NP    (S|NP)|((S|NP)|NP)      (S|NP)|((S|NP)|NP)      NP
       __________________________________________
        (S|NP)|NP
       _________________________________________________________________
          S|NP
       _________________________________________________________________________
          S
```

The first thing these show is that the orientation of the reflexive is dependent on the degree of raising used to obtain its syntactic category. In (20') and (21') the reflexives are subject-oriented (recall also (17)), while in (19') the reflexive is object-oriented, due to its higher-order raised category. Assuming that the 1st argument of a three-place verb may raise either as in (19') or as in (21'), this is just fine.

This analysis reveals two problematic presuppositions, however:

(22) a. The surface order of arguments must normally be the same as their "semantic order" (the "semantically first" argument should be closest to the verb etc.), and

b. It must be possible to compose the (raised) second argument with the verb.

The problem posed by (22a) is only too familiar from every theory of binding. Its most recent formulation is, perhaps, Barss--Lasnik's (1986) discussion of two-object verbs of the **show**-type. They point out that there are several phenomena demonstrating an asymmetrical relation between two NPs, all of which indicate that the linearly first (dative) NP is more prominent than the second (accusative) NP. (They discuss the binding principles, QNP-pronoun relations, WH-movement and weak cross-over, superiority, **each ... other**, and polarity **any**.) Nevertheless, phrase structures that do not allow for discontinuous constituents will either make the opposite prediction or make no distinction at all. Now, while the realization of this may be a novelty in GB literature, Montagovian literature has for long used a wrap operation to obtain the surface order in two-complement verbs of various sorts (cf. Bach (1979) and his followers Pollard (1984) and Chierchia (1985), to name only a few.)

Now, while it may be a matter of debate whether the theory I presuppose allows wrap operations, the particular version developed in Ades--Steedman (1982) and used in Steedman's subsequent work does not. In fact, even the conflict between "surface order" and "semantic order" is not acknowledged. Steedman establishes verbal categories on the basis of neutral surface order and sees no reason to believe that the "semantic order" may be any different (p.c.). His procedure is adopted in Dowty (1985), who adds, "the correct translation of **John showed Mary Bill** will therefore be **showed'(m)(b)(j)**, not **showed'(b)(m)(j)**".

If we adopt Steedman's proposal, we have to exclude complement oriented anaphors from this treatment. Of (23a,b) only the ungrammatical version could be derived:

(23)a.* **John showed herself Mary.**
b. **John showed Mary herself.**

(24)	**John**	**showed**	**herself**	**Mary**
	NP	((S!NP)/NP)/NP	((S!NP)/NP)!(((S!NP)/NP)/NP)	NP
			(S!NP)/NP $\lambda x \lambda y$ [show'xxy]	
			S!NP λy [show'mmy]	

Steedman (p.c.) suggests that this conclusion is actually correct. Only the existence of subject-oriented object reflexives is universal. A number of languages have no complement-oriented reflexives at all; in a number of others, prepositional reflexives, whether subject or complement oriented, are in fact stressed pronous. These latter should be treated in some principally different way, and the superficially misleading case of English (and Hungarian, for that matter) is to be assimilated to theirs.

In what follows I will experiment with an analysis that includes, rather than excludes, complement-oriented anaphors. My reason is as follows: (i) The cross-linguistic argument is not watertight. Not every language exhibits unbounded dependencies in its surface syntax, for instance. This however does not seem to prevent one from believing that unbounded dependencies are a natural phenomenon that needs to be accounted for in, say, English. (ii) Subject orientation is not an unmarked concept in our theory. The subject is nothing but the last argument of an atomic functor. While it is always possible to seek out the last argument of functors of a given arity, there is no general way to refer to last arguments in combinatory logic. (iii) On the basis of arguments related either to binding in the broad sense or to other phenomena, I do believe that English verbs have a "semantic" argument order that is different from the surface order. That is, I believe in the reality of something like a wrap operation. (iv) The treatment of extraction in two-complement cases makes some slightly questionable predictions in Steedman (1987), a point to be returned to in Section 4. So his assumptions do not make life so easy in purely syntactic terms that it would make no sense to try to modify them.

In view of these considerations I have to choose between adopting or simulating the wrap operation. To retain the coherence of the framework, I will opt for simulation. In addition to the standard raised category VP!(VP/NP), cf. (25a,b), objects will also be assigned the non-standard raised category VP/(VP/NP), cf. (26).

```
(25)a. introduce     Mary                to Bill [PP or]
       (VP/NP)/PP    VP!(VP/NP)  B!      VP!(VP/PP)
                     VP/PP
       -----------------------------------------------
                     VP

    b. introduce     to Bill [PP or]        every celebrity who...
       (VP/NP)/PP    (VP/NP)!((VP/NP)/PP)   VP!(VP/NP)
       VP/NP
       --------------------------------------------------------
       VP
```

The VP!(VP/NP) category used above is standard in the sense that it preserves the directionality of combination, wherefore it is freely obtainable in syntax and may be input to any of the operations that we picked for English (cf. (8) and Steedman (1987)). I will assume that objects may have this category iff they are "heavy", i.e., iff they are heavier than any complement that comes between them and the verb. (Heaviness in this sense is a filter applicable to strings that are already assembled: it will throw out ***John introduced to Bill me**, for instance.)

The category VP/(VP/NP) is not standard in the same sense. It is like the lexically assigned preposing categories of WH-words, S/(S/NP) and its brothers. Furthermore, to avoid disastrous effects it must be restricted to being input to **B/**, the forward mixing version of composition otherwise not operative in English syntax: **5, 6**

```
(26) introduce    Mary         to Bill
     (VP/NP)/PP   VP/(VP/NP)   (VP/NP)!((VP/NP)/PP)  B/
                               VP!((VP/NP)/PP)
     --------------------------------------------
                               VP
```

Although this would suffice for the coming discussion, a few comments are in order here to clarify the status of this way of simulating wrap. The fact that VP/(VP/NP) is restricted to **B/** contradicts the spirit of our theory, according to which legitimate combinators are to apply quite unconstrained in syntax. The only decent way to accomodate the requisite restriction is to encode it in the lexicon. And there is an easy way to do it. Instead of VP/(VP/NP) we will assign the category (VP!((VP/NP)/PP))/((VP/NP)!((VP/NP)/PP)) to such objects in the lexicon. It is easy to see that the latter category is obtained from the former by applying Lambek's (1958) division to it, in our terms, by applying composition to one argument. Thus **B** is put into the lexicon (with a special main slash direction) and the relevant part of (26) can be rewritten by using application in syntax:

```
(27) Mary                                       to Bill
     (VP!((VP/NP)/PP))/((VP/NP)!((VP/NP)/PP))   (VP/NP)!((VP/NP)/PP)
     ---------------------------------------------------------------
     VP!((VP/NP)/PP
```

This is, of course, a generally applicable method of simulating wrap in our grammar. Nevertheless, given that the monstrous category in (27) would make it impossible to arrange examples in one line, I will retain (26) -- marking **B/** as **Blex** in the rest of the paper.

Ideally, the introduction of the "wrapping category" for objects should allow us to simplify Steedman's apparatus: it should allow us to get rid of **B!**, the backwards mixing composition operation as well. Unfortunately, it does not. Apart from the treatment of adjuncts, the exclusion of **B!** would only allow the following derivation of **to whom you introduced NP**, for instance: 7

```
(28)  to whom              you    introduced     NP
      (S/NP)/((S/NP)/PP)   S/VP   (VP/NP)/PP
                           ------------------BBB
                                  (S/NP)/PP
      ------------------------------------
                                  S/NP
```

This may be tolerable if NP is something like **Bill** -- it is not tolerable if **NP** is a reflexive (**yourself**), however. My proposal for reflexivization implies that the binder must be directly accessible to the reflexive. In a derivation like (28) the subject **you** inescapably combines with the verb prior to the object reflexive being able to come to the picture. Coordination data indicate that this really excludes reflexivization: (29) is grammatical but (30) is not. (I wonder if this is predicted by other theories.)

```
(29)  Mary   hates   while   Judy   admires   Bill
      S/VP   VP/NP           S/VP   VP/NP     NP
      ------------           -------------
      ------------------------------------
                     S/NP
      ------------------------------------------
                     S
```

(30)* **Mary hates, while Judy admires herself.**

The sentence **To whom did you introduce yourself?** is grammatical, however, so it must be derived in analogy to (25a):

```
(31)  to whom   you       introduced        yourself = W
      S/(S/PP)  S/(S!NP)  ((S!NP)/NP)/PP    (S!NP)!((S!NP)/NP)
                          ------------------------------------B!
                                            (S!NP)/PP
                ----------------------------------------------B
                                            S/PP
      ------------------------------------------------
                                            S
```

With these observations in mind, let us return to the phenomenon that serves as the main topic of this section: anaphors that are first arguments of three-place verbs.

The discussion of (19') through (21') presupposed that we are dealing with the ideal situation in which surface order and semantic order coincide. This coincidence may actually obtain in English but, as we have seen, it does not always obtain. Consider complement-oriented anaphors first. In cases of argument order coincidence we may follow (19') -- see (32)-(33), while otherwise we may rely on the new possibility opened up in (26)-(27) -- see (34):

```
(32)  Mary  introduced   to himself = W        everybody who...
            (VP/NP)/PP   (VP/NP)!((VP/NP)/PP)  VP!(VP/NP)
            ---------------------------------
                         VP/NP
            ----------------------------------------------------
                         VP

(33)  who       Mary   introduced   to himself = W
      S/(S/NP)  S/VP   (VP/NP)/PP   (VP/NP)!((VP/NP)/PP)
                       ---------------------------------
                         VP/NP
                -----------------------------------------B
                         S/NP
      -------------------------------------------
                         S
```

(34) **Mary** **introduced** **everyone** **to himself** = **W**
(VP/NP)/PP VP/(VP/NP) (VP/NP)!((VP/NP)/PP) —Blex
VP!((VP/NP)/PP)
VP

(Caveat: The examples in (32) through (38) do not sound very good. I am informed, however, that this is due to the fact that they are not idiomatic/pragmatically plausible. Similar examples involving reciprocals are much better, e.g., **Mary introduced the boys to each other** or **The boys introduced Mary to each other.** The only reason why I use reflexives is that I do not wish to propose an explicit interpretation for reciprocals here.)

Consider subject-oriented cases next. As (21') showed, a simple treatment is possible iff the irrelevant argument (in our case, the direct object) can compose with the verb before the reflexive enters the picture. This is possible on the neutral order, (35), but not if the direct object is preposed or heavy NP shifted, (36) and (37):

(35) **Mary introduced John to herself.**
(36) **Who did Mary introduce to herself?**
(37) **Mary introduced to herself everybody who came into the room.**

Notice, though, that not only (36) and (37) are a problem. A derivation in which the direct object forms a constituent with the verb does not allow the possibility of non-constituent conjunction that involves reflexives:

(38) **Mary introduced John to herself and Bill to himself.**

The grammaticality of (38) indicates that both **John to herself** and **Bill to himself** are possible representatives of the category (S!NP)!(((S!NP)/NP)/PP). Moreover, the coordination in (38) is not only categorially but also semantically coherent, i.e., it has the interpretation **λfλx[f(to x)(j)(x) & f(to b)(b)(x)].** These facts indicate that the derivation that could be used for (35) is really not generally useful.

It appears that the only way to account for the possibility of 3rd argument oriented 1st argument reflexives is to build the skip of the irrelevant argument into the interpretation of the reflexive. This can be done by using the composite combinator **B(BW)C** instead of **W** as its interpretation: [8]

(39) **B(BW)C** = λgλxλz[gzxz]

(40) **John** **to herself** = **B(BW)C**
(S!NP)/((S!NP)/NP) ((S!NP)/NP)!(((S!NP)/NP)/PP) —Blex
(S!NP)! (((S!NP)/NP)/PP)

and

Bill **to himself** = **W**
(S!NP)/((S!NP)/NP) ((S!NP)/NP)!(((S!NP)/NP)/PP) —Blex
(S!NP)! (((S!NP)/NP)/PP)

The derivations of the conjuncts are syntactically identical; the difference in the orientation of the reflexives is merely due to lexical ambiguity.

It is to be noted that the need to postulate reflexives interpreted as either **W** or **B(BW)C** is not specific for my proposal which divorces surface order from semantic order. On Steedman's assignment of verbal categories, subject-oriented direct object reflexives need to be **B(BW)C** if the verb has two complements. In fact, this interpretation, inspired by E. Jowsey, was suggested to me by Steedman to derive (41) his way:

(41)	**Mary**	**introduced**	**herself** = **B(BW)C**	**to Bill**
	S/(S!NP)	((S!NP)/PP)/NP	((S!NP)/PP)!(((S!NP)/PP)/NP)	PP
			(S!NP)/PP	

In other words, this ambiguity between **W** and **B(BW)C** is specific for 3rd argument oriented 1st argument reflexives, irrespective of which complement is taken to be 1st. The difference that category assignment to verbs makes is that Steedman's categories would require that we explicitly prohibit the **W** interpretation for such objects (or else we get the ungrammatical pattern illustrated in (24)) and substitute **B(BW)C** for it. On my categorization, **B(BW)C** is merely one additional option; no categorially justified interpretation needs to be prohibited. (And, as we have seen, only this treatment allows for complement oriented reflexives at all.) By "categorially justified" I mean this. **W** is a two-place function. Therefore any raised kind of category that can be looked upon as an at least two-place function can be interpreted as **W**. On the other hand, **B(BW)C** is a three-place function, wherefore it is only available as an interpretation to raised categories that can be looked upon as at least three-place functions. ((S!NP)/NP)!(((S!NP)/NP)/PP) can be interpreted in either way.

With this we have covered all the relevant cases of subject and complement oriented anaphors. Note that the same procedures will apply irrespective of whether the verb is finite or infinitival. **To hit himself** is interpreted as **λx[hit'xx]** just like **hits himself.** Whatever procedure makes sure that the matrix subject or object "controls" the infinitival "subject" will automatically provide the binder for the reflexive. Cf. Steedman (1985b).

4. PIED PIPING

Up until now prepositional anaphors have been taken to be syntactically primitive. **To himself** was just assumed to be a lexical PP with the interpretation **λfλx[f(to x)(x)]**. This is obviously not the final solution. Reflexivehood is a property to be attributed to bare **himself**, and it is to be guaranteed that the preposition that takes it as an argument preserves this property in its value.

In other words, we are dealing with pied piping. Pied piping is, of course, not particular to reflexives but is also operative in WH-expressions and quantifiers. A general scheme to handle it was suggested to me by Steedman: the pied piper must know in advance that there will be an extra function over it.

(42) If the standard raised category of NP is interpreted as **£**, its pied piper version is interpreted as **C(B(B£)B)**. Cf. X!(X/NP) and (X!(X/PP))!(PP/NP).

Consider **himself** and **everybody** as pied pipers:

(43) **C(B(BW)B)** = $\lambda g\lambda f\lambda x[f(gx)(x)]$

(44) **C(B(B($\lambda f\forall x$[fx]))B)** = $\lambda g\lambda h\forall x[h(gx)]$

B(BW)B introduces the extra function **g** (PP/NP) into the first argument and **C** merely changes the surface order in the result (as we have **talk about himself**, rather than **talk himself about**); and similarly for the quantifier. This gives us precisely the interpretation assumed above, so the derivation of, say, **Mary talks about herself** can be spelled out as follows. (**Mary introduces Bill to herself/himself** poses no new problem, so it will not be given.)

```
(45) Mary   talks       about    herself = C(B(BW)B)
     NP     (S!NP)/PP   PP/NP    ((S!NP)!((S!NP)/PP))!(PP/NP)
                                 ----------------------------------
                                 (S!NP)!((S!NP)/PP) = W
            -------------------------------------------------------
                                 S!NP
```

Now that we have seen that anaphors may legitmately be prepositional, let us ask whether binders may be, too. It seems they may:

(46) **Mary talks to everybody about himself.**

Such examples constitute a notorious problem for the claim that the binder must c-command the anaphor, since the PP on top of **to everybody** is a branching node. The standard GB solution to this problem is to assume that **talks to** is reanalyzed as a complex verb in such cases and **everybody** acts like a direct object. The claim that examples like (46) may not refute the validity of the c-command requirement is corroborated by the fact that in case the binder is a WH-phrase, the preposition must be stranded:

(47)a.* **To whom did Mary talk about himself?**
b. **Who did Mary talk to about himself?**

The problem of (46) can be approached in the present theory in two ways.

First, notice that what we have so far does not allow the binder to be pre positional in the sense that it forms a constituent with the preposition. The reasons are twofold. On one hand, the reflexive interpreted as **W** or **B(BW)C** takes an argument of the verb as its binder. If that arument is complex, then the whole of it will be the binder. **To everybody** and, say, **brothers of everybody** do not differ in this respect. On the other hand, "binderhood" is not a property at all, so it is certainly not something that a complex expression may inherit from some part of it. This is a welcome result. Our proposal preserves the prominence condition on the binder not only in the sense that the binder may not be an argument lower in the hierarchy, but also in the sense that it may not be part of an argument higher in the hierarchy. Therfore we must follow GB in assuming that the raised PP **about himself** takes **talks to**, rather than **talks**, as one of its arguments. The exact execution will be discussed shortly. (Note, by the way, that binderhood could pied pipe in just one case: if we assumed the preposition **to** to be meaningless, i.e., if it were interpreted as **I**, $\lambda x.x$. In this case **to everybody** would be the same as **everybody**. But the contrast in (47) shows that this cannot be correct. If it were, **to whom** could serve as a binder.)

The other way to look at the problem of (46) is as follows.

The **W** interpretation of reflexives surely preserves the c-command requirement in its entirety. However, what prevents us from devising an interpretation for reflexives that allows the binder to be part of a "higher argument"? We might let the reflexive know in advance that its binder will be hidden in a PP and retrieve it. Essentially, this could be achieved by interpreting reflexives also as some (slightly reordered) version of the combinators **S** or ϕ:

(48) $\mathbf{S} \equiv \lambda fgx.fx(gx)$ cf. connection

(49) $\phi \equiv \mathbf{B(BS)B} \equiv \lambda fabx.f(ax)(bx)$

An **S**-reflexive would itself be prepositionless but its binder would be prepositional, and with ϕ, both the reflexive and the binder would be prepositional. Such interpretations would allow us to circumvent the second part of the c-command requirement: the binder could be a part of an argument higher in the hierarchy.

This is a serious problem because it raises the question to what extent this proposal deduces, rather than merely captures, the empirical properties of binding. Given that our combinators yield the power of the lambda calculus, we cannot expect our system to exclude the wildest binding relations in principle. In this strong sense the empirical properties of binding cannot be just deduced. We have two alternatives here. One is to say that it is an ad hoc property of anaphors that they have the **W**-kind of interpretation, rather than the **S**-kind. After all, these are lexical interpretations, and natural languages do not have every conceivable quantifier interpretation in the lexicon, either. Another possibility is to look for an empirical but in some sense still principled way to exclude **S**-reflexives. For instance, it may be conjectured that the division of labor between syntactic combinators and lexical combinators is even stricter than was tentatively suggested at the end of Section 2. Namely, we might observe that **S** is a combinator operative in syntax, while **W** is not. Maybe primitive combinators of a given system are not merely allowed in, but are also restricted to, syntax. I will not pursue this idea in this paper. Nevertheless, it seems like one quite reasonable line for further research. [9]

Let us now return to the problem how the complex verb **talks to** should come about. The easiest way to get the effect would be to require **talk** and **to** to compose in an ordinary fashion. Due to the argument order we are working with, however, this is impossible. **To** cannot compose with **talk**, regardless whether it is assigned the normal category PP/NP or the extravagant category (VP!(VP/PP))/NP:

```
(50)  talk                  to
      (VP/PPto)/PPabout     PP/NP
      - - - - - - - - - - - - - - - *
                            (VP!(VP/PPto))/NP
      - - - - - - - - - - - - - - - - - - - - *
```

This is in fact encouraging. Suppose **brothers of** is NP/NP etc. If **to** composed with **talk**, **brothers of** could also compose with **introduce**:

(51)* **Mary will introduce brothers of** $[$**everybody**$]_i$ **to himself**$_i$.

We must assume, then, that there is a real lexical item **talk to** of category (VP/NP)/PPabout. On the other hand, we will not assume the existence of any lexical item **talk about** (VP/NP)/PPto. The lack of such an item will explain why (52) is ungrammatical, even though it is generally understood that **talk** can be either (VP/PPto)/PPabout or (VP/PPabout)/PPto.

(52)* **Mary talked about everybody to himself.**

I expect that the absence of a lexical **talk about** has deeper reasons but I will not investigate the matter here. The absence of a lexical **introduce brothers of** seems quite natural.

At this point it seems necessary to return to a syntactic aspect of the verbal argument orders I assume, in conjunction with the assumption of lexical **talk to.** Steedman (1987) is able to predict all the following data correctly: [10]

(53)a.* **Who did you entrust to — the heavy responsibility of...?**

(54)a. **What do you wonder who to talk to about?**
b. **Who do you wonder what to talk about to?**
c.* **What do you wonder who to talk about to?**
d.* **Who do you wonder what to talk to about?**

Providing that verbal categories reflect the neutral surface order of their arguments, (53a) as well as (54c,d) are strictly excluded. Now, using the converse orders I am assuming, the **talk** data of (54) will still be predicted correctly (the proof is left to the reader). However, (53a) will also predicted to be grammatical:

(55)

who	you	entrusted	to	the heavy...
(S/NP)/((S/NP)/NP)	S/VP	(VP/NP)/PP	PP/**NP**	NP
		(VP/NP)/**NP** (BBB)		
	(S/NP)/**NP**			
S/NP				
S				

This may sound disastrous. Nevertheless, as I. Sag (p.c.) points out, (53a) improves significantly if we use **to the brother of:**

(53)b.? **Who did you entrust to the brother of — the heavy...?**

Whatever the account of the contrast between (53a) and (53b) should be, this possibility of improvement suggests that the pattern common to these two sentences should not be excluded in the strongest sense. Therefore, in this respect **entrust** as (VP/NP)/PP seems justified. Notice, however, another prediction my proposal makes. Given the fact that I have **talk to**, not only **talk,** as a lexical item, (54d) also has a legitimate derivation: **talk to** is (VP/NP)/PPabout. Therefore, we expect that (54d) can be improved exactly like (53a) can, but we do not expect the same for (54c), in the absence of lexical **talk about**:

(54)e.** **What$_1$ do you wonder who$_2$ to talk about pictures of$_1$ to$_2$?**
f.? **Who$_1$ do you wonder what$_2$ to talk to the brother of$_1$ about$_2$?**

My informants report that the predicted effect is in fact very strong. (Note, by the way, that the contrast in (54e,f) shows that improvement has nothing to do with performance factors related to length.)

After this excursus, let me point out that even if **to** and **brothers of** are unable to compose with the verb in sentences like (46) and (51), there are various undesirable possibilities for composition.

(56)a.* **Mary believes that John loves herself.**
    b. **Who does Mary believe that John loves?**

(57)a.* **Mary talks about brothers of herself.**
    b. **Who does Mary talk about brothers of?**

Of these, (56a) may arise if the functor **herself** applies to is **believes that John loves**, and (57a) may arise if the PP/NP **herself** uses in pied piping is **about brothers of**. While this latter pattern is in fact grammatical with **picture**-nouns, those obviously do not represent the general case.

5. LOCALITY AND PRONOUNS

Three properties of anaphors were listed in (9): the necessity for there to be a binder, the prominence condition on the binder, and the locality condition on the binder. I have argued that the **W** interpretation essentially captures the first two of these and can, at the same time, be handled in the same system that takes care of extraction and coordination etc.

Turning to locality now, it is to be observed that locality cannot appear as a natural condition in a system that includes composition and similar "unboundedness operations". If the treatment of anaphor binding is to be part of this system, we must resort to brute force to capture the locality condition. The brute force method is, basically, to require that **W** apply to functors that are lexical in some sense.

Without going into details with the precise definition of lexicality, let us ask how sad one should be about this. Is the locality condition part and parcel to the notion anaphor, where by "anaphor" we mean an item that must be bound by a c-commanding argument (i.e., which is interpreted as **W**)?

The existence of long-distance anaphors has for long been well-known. Most long-distance anaphors necessarily reside within NPs and are exclusively subject-oriented etc., that is, appear to have a rather peculiar restriction. A very interesting case from Modern Greek is reported by Iatridou (1986), however. Greek has two anaphors in the **W**-sense, of which **ton eafton tou** is to be bound locally, and **ton idhio** can be bound, as she puts it in GB terms, outside its governing category. The data Iatridou presents indicate that this latter long-distance anaphor does not exhibit the peculiar restrictions mentioned above. For example:

(58) **O Yanis**$_i$ **ipe** **ston Costa**$_j$ **oti** **i Maria** **aghapa** **ton idhio**$_{i/j/*k}$
said to that loves himself

This seems to indicate that locality can in general be divorced from the core notion of anaphor in the **W**-sense, contrary to what current theories suggest. The locality condition (lexicality requirement) may in fact be a brute force device employed by natural language to facilitate processing. Clearly, it is very useful for the hearer if binding ambiguities are reduced by having different forms for **W**; but there may be nothing more to it. While my proposal (as it stands, at least) is unrevealing with respect to what locality conditions different languages may impose on their anaphors, it may be taken to be revealing in the sense that it predicts locality to be a more or less ad hoc matter. And, besides exotic data like (58), acquisition studies seem to suggest that even "the English kid" thinks so.

There is another phenomenon that this proposal makes a prediction for, namely, bound versus unbound pronouns.

While anaphors (reflexives and reciprocals) must be bound, pronouns may or may not be. One important discovery has been that it is easier to characterize the conditions under which pronouns cannot be bound than the conditions under which they can. This discovery is built into the Binding Principles of GB as well as other theories. Compare the clauses for anaphors and pronouns:

(59)a. An anaphor must be bound (= coindexed with a c-commanding argument) in its governing category.
b. A pronoun must be free in its governing category.
c. A referential expression must be free.

Although factually correct, this formulation has something funny about it. If I contemplate about the meaning of **himself** (that is, about what distinguishes it from other NPs), the fact that **himself** must be bound will certainly come to my mind. If I contemplate about **him**, however, my first thought will certainly not be, 'Well, **him** is an item that cannot be bound to something too close to it'. In other words, the negative characterization given for pronouns is intuitively on a very different level than the positive characterization given for anaphors.

What does combinatory logic have to say here? As was pointed out above, it has no bound variable items. It does have free variables. But those are like any name: they start out free and remain free. This does not prevent them from coreferring with another name, though: the same thing may happen to have more than one way to name it, so to speak. And there are combinators like **W**, of course, which give the same effect as variable binding in usual theories.

The moral of this story seems to be the following. The items known as pronouns are multiply ambiguous. We must distinguish bound pronouns and free pronouns in the first place. Bound pronouns are members of the class of anaphors. As a very first approximation, they can be assigned a **W** kind of interpretation (and the anti-locality condition can be captured by making them obligatory pied pipers). Free pronouns on the other hand are essentially deictic and, given the assumptions above, are infinitely many ways ambiguous. (In comparison with the usual formulation, we may say that **he[free]** is not one variable to which infinitely many different values can be assigned but rather it represents infinitely many different variables, each having its value fixed once for all.)

On the grammatical side, the implications of this theory are in line with Reinhart's (1983). It is common to treat instances of "binding by a name" and "binding by a (possible) quantifier" in the same way. Reinhart separates true binding from mere coreference, observing that the prominence conditions in the former case are much stricter. This is what my proposal captures. It seems, therefore, that both the merits and the drawbacks of the present proposal for pronoun binding are essentially the same as hers. Strict limitation on space fortunately prevents me from discussing them in detail, however. **11**

ACKNOWLEDGEMENT

This proposal for anaphors develops an idea sketched in Szabolcsi (1985, 1986). In discussing how to incorporate it into a joint paper (in progress), I received many valuable comments from Mark Steedman, as is indicated in the text.

NOTES

1 Connection is renamed "substitution" in Steedman (1985b, 1987).

2 These definitions are quoted from Curry--Feys (1958, 152-153), so I follow their notation. Recall that their logic is typefree.

3 Arnim von Stechow has kindly pointed out to me that my proposal is anticipated in Quine (1960), adopted in his (1979). I am duly ashamed of this gap in my philosophical education.

4 One composite combinator that is apparently operative in English is **BBB** (generalized composition). For instance, (54a,b) and (55) cannot be derived without it.

5 Michael Moortgat points out to me that VP/(VP/NP) needs to be restricted to simple **B/** in fact. Generalized composition, in conjunction with the pied piper categories of Section 4, would derive the string **to Mary Bill** interpreted as 'Mary to Bill'. The alternative proposed below avoids this unwanted consequence as well. I am grateful to him for discussion about this issue.

6 In GB terms we might say that two-complement verbs really have two complements but a small clause can be obtained via A-bar adjunction. This seems like having the cake and eating it, too.

7 **B!** might be expelled from syntax by assigning a special divided category to every raised category in the lexicon. While it may be ultimately useful to free syntax from any kind of disharmonic composition, note that the big empirical difference between **B/** and **B!** in English is that the latter appears to be quite generally available.

8 The reader may check that **B(BW)C** gives the same effect as if we **C**'d the verb, applied it to the object, and used **W** for the reflexive. The use of simple **C** would not in general solve our problems, though, and would not allow the derivation of (38) either.

9 It might be tempting to use **S** to interpret pronouns not strictly c-commanded by their binders. At least a simple adoption of this idea would have undesirable effects, however.

10 This is not literally true but, as far as verbal categorization is concerned, his grammar would indeed derive those results.

11 Another set of data that I cannot discuss here despite the fact that they are pertinent to the topic of this paper includes extracted anaphors, cf. Barss (1984):

(i) **Which pictures of himself**$_{i/j}$ **does John**$_i$ **think Bill**$_j$ **likes?**

(ii) **Which stories of himself**$_{i/*j}$ **did John**$_i$ **publish without Bill**$_j$ **signing?**

These are not too difficult to handle, however, given some extension of the proposal in the text.

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ASPECT, QUANTIFICATION AND NEGATION

H. J. Verkuyl(RUU)

This paper attempts to solve two problems: (a) why is it that negation blurs the distinction between terminative and durative aspect? (b) why is it that negation can blur the distinction between collective and distributive readings of terminative sentences? It will be shown that the problems can be solved by a unified account.

1. **Two problems.** In this paper I would like to propose a solution to two problems. The first one is the problem of why and how terminative aspect in sentences like (1) is neutralized under negation, as shown in (2).

(1) a. The two men lifted three tables
    b. They broke a glass
    c. Three men lifted a table

(2) a. The two men did not lift three tables
    b. They didn't break a glass
    c. Nobody lifted a table

The sentences (2) are durative: they take durational adverbials like **for an hour**, whereas they cannot occur happily with **in an hour**, as shown in (4). The sentences (1) display a complementary pattern as can be seen by comparing (3) with (4).

(3) a. The two men lifted three tables in an hour
    b. ?They broke a glass for a week
    c. ?The whole afternoon three men lifted a table

(4) a. ?The two men did not lift three tables in an hour
    b. They didn't break a glass for a week
    c. The whole afternoon nobody lifted a table

That negation turns terminativity into durativity has been observed in the literature on aspect (e.g. Forsyth 1970, Verkuyl 1972). However, to my knowledge, no account has been given as yet that can even meet a reasonable standard of explanatory force.

The second problem is why and how the distinction between collective and distributive readings in (1) and (2) is neutralized under negation. In the literature on plural quantification sentences like (1a) have been given a lot of different treatments ranging from just one vague meaning to about nine different readings.[1] I will assume two different readings, a distributive and a collective one. The distinction between them will be called 'the D/C-distinction'.

In the collective reading (1a) is taken to mean that the two men lifted three tables collectively i.e. they acted together as partial agents in the lifting of three tables. They share the predication 'lift three tables', so to say, because none of them could truthfully claim that he alone lifted three tables. But (1a) has also a reading in which each of the men is a "complete" agent in the sense that one man, say m1, lifted three tables singlehandedly, i.e. without m2 being involved as a participant in m1's lifting three tables.

Both readings pertain to two sets of different situations. For example, the collective reading includes a situation in which the two men collectively lifted three tables one after the other, or first two tables and then one table, or three tables all together at once. In Verkuyl (1987; to appear a) it has been argued that there are no reasons for associating these situations with readings.

To my knowledge, no treatment of the D/C-distinction has been proposed as yet that has taken into account the fact that it is eliminated, or at least blurred by negation. Perhaps the reluctance to perceive this phenomenon is due to the fact that the verb **lift** in (2a) seems to always evoke the lexical information that lifting can be done in two sorts of way. Hence it seems natural to maintain the D/C-distinction in negative sentences.

However, by the same argument we would have to say that (2a) is to be characterized as having terminative aspect which "is there" due to the presence of the terminative VP **lift three tables**. Of course, this argument breaks down as soon as we acknowledge that **not** cancels the terminative aspect. My point is that **not** can also be argued to cancel the D/C-distinction, because the construction of terminative aspect relates to the way information about collective or distributive participancy of arguments of a verb is conveyed by a sentence. Moreover, (2c) is a case showing that **lift** does not evoke this distinction at all: no table was lifted at all, let alone collectively or distributively.

As negation is a rather complicated concept, some additional remarks are necessary to strengthen the point. As soon as one acknowledges that negation affects the participancy of the arguments of the verb **lift**, it is much easier to see that it is senseless to distinguish between distributive and collective non-lifting. If there is no participation in the lift-predication, there is no distributive or collective non-participation. Note that in (1) the D/C-distinction is closely tied up with the concept of situation, or event or occasion. For example, the distributive reading of (1c) requires that there be three different occasions (events, situations) of lifting. The collective reading expresses that there is just one occasion (event, situation). Now, if **not** is to say that there is no such act or event or occasion, then it makes hardly sense to speak about a distributive or a collective non-occasion.

On the other hand, it must be acknowledged that it is very hard to precisely define the meaning of negative sentences, because the negation element can operate just locally but also more globally, dependent on constrastive stress. This fact complicates the position I am defending. Thus it should be observed, that sentences like (2a) can be interpreted as showing a D/C-distinction . This is only if we put some stress on **three** as in (1d), so that (2a) is going to express that the two men have been engaged in lifting some unknown number of tables, only not in the lifting of three tables. This form of negation does not appear to neutralize the D/C-distinction. Indeed, sentences like (1d) show that this is the case:

(1) d. The two men did not lift THREE tables
    e. The two men did not lift THREE tables, but FOUR

Here the need for the D/C-distinction is called for. Note also that (1e) is characterized by terminative aspect: the sentence **For hours the two men did not lift three tables but four** is iterative. Given the distinction between contrastive and non-contrastive negation made in Jacobs (1982), this phenomenon can be explained in terms of the solution to the two problems at issue. I shall return to that in section 5.

In my view the two problems under investigation in this paper should be solved in one unified account, because the elimination of terminativity also affects the way arguments are involved as participants in the predication. In fact, it was concluded from the analysis of terminativity in Verkuyl (1987) that the two problems are related. The solution offered in the present paper, will be given first in its bare outlines in this introductory section, so that the readers will be able to embark upon the formal machinery in the following sections with some idea about what they can expect.

Terminative aspect appears at two levels: (a) at the level of the VP; (b) at the level of S. The construction (i.e. the compositionally formed interpretation) of the terminative VP-aspect results in the assignment of a set of so-called terminative intervals to the VP. In two-place predications a set of terminative intervals is a set of functions from partitioned subsets of the direct object denotation onto the set of intervals constituting the temporal structure generated by the verb. That is, ||VP|| (i.e. the denotation of VP) consists of (or possibly, is) a collection of sets of pairs, each pair consisting of a subset of direct object individuals and an interval generated by the verb. Let us call this collection of sets I_T. In the case of (1a) I_T would be a set as shown in (5), where t1, t2, ..., tn are tables lifted by the two men, and where Ti is an arbitrary set of three tables in a domain.[2)]

(5) $I_T = \{<T1,i_1>, <<\{t1,t3\}, i_1> \cup <\{t2,i_2>>, <T2,i_1>, <T2,i_2>, \ldots, <<\{t1\},i_1> \cup <\{t2\},i_2> \cup <\{t3\},i_3>>\}$

The construction of each member of I_T is defined by a terminative function t which produces temporal (sub-)structure generated by the verb to which the partitioned subsets of direct object denotata are related. In fact, t determines the ways in which a VP like **lift three tables** can be be related to situations and subsituations in which three tables are lifted. What we know about (1a) is that whatever lifting of three tables took place in the specific model which we speak about, it will always involve a member (collective) or two members (distributive) of (5). In either case the terminative interval(s) can have internal structure dependent on how the partition of the set of object denotata has taken place. Of course, we do not know which partition was chosen. The only thing we do know is that some must have been selected in the particular domain.

At the sentential level, aspect is formed by a procedure that relates the subject denotata by mapping them to members of I_T. To account for the distributive and collective interpretations, this procedure makes an (arbitrary) choice between two functions p having the same domain and the same co-domain. The distributive function p_d is defined injectively. It assigns (one-one) to each member a of the set A of subject denotata a unique image from I_T: if $a \neq a'$, then $p_d(a) \neq p_d(a')$. The collective function p_d is defined as a constant function. It assigns to each individual of the subject denotation the same image in the co-domain I_T: if $a \neq a'$, then $p_c(a) = p_c(a')$.

The general idea behind this analysis can be captured by describing an imaginary processing procedure which requires that sentence (1a) apply to a specific domain in which one man lifted three tables at once, whereas the other man lifted three different tables at a later time, one after the other. How would we proceed? Two choices must be made. The first one is the choice between expressing whether or not the subject NP denotata are involved as a full agent (distributively) or as a partial agent (collectively). That is, we make a choice between the functions p_d and p_c, by selecting p_d. Then a second choice must be made: for each of the men a specific member of I_T must be selected. To meet the requirement we select from (5) the appropriate terminative intervals (given appropriate values for the intervals) ending up with a the (Boolean) sum of the function applications:

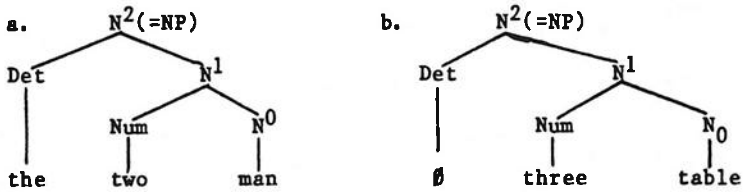
(6) $\langle m1, \langle T1, i_1\rangle\rangle \cup \langle m2, \langle\langle\{t4\}, i_2\rangle \cup \langle\{t5\}, i_3\rangle \cup \langle\{t6\}, i_4\rangle\rangle\rangle$

Of course, the meaning of (1a) is much vaguer than this specific situation. So the meaning of (1a) should be taken as a set of possible function applications.

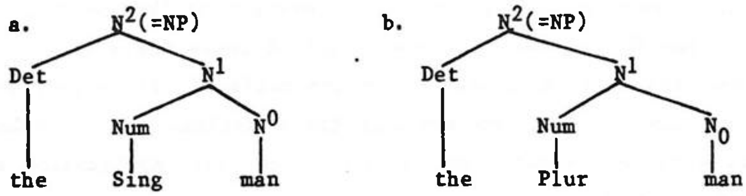
Now, the negation in sentences like (2) can be taken as an instruction blocking the operation of either of the functions p. This can be done in a very simple way by assuming that negation does not operate at a first order level taking us from a subset of individuals to its complement, but rather that it operates at a higher level asserting or denying the existence of a set of individuals. Thus it can be argued that in (2a) **not** eliminates the existence of an appropriate co-domain for the functions p: p_d and p_c cannot be applied, because no image can be found. Hence there is no p and consequently there can be no terminative aspect. Likewise, it can be argued that in (2c) negation eliminates the existence of the domain A. Then the functions p cannot operate, of course, because no function can be defined without a domain. Hence there can be no terminative aspect. Thus (2a) and (2c) represent two cases in which neither of the functions p can operate. It follows that there can be no distinction between a distributive and collective reading in the two sentences. This is how I would like to solve the two problems.

2. A higher order treatment of Noun Phrases. In Verkuyl (1981) an attempt was made to bridge the gap between generative grammar and Montague grammar by showing that the generative X-bar structures can be given a categorially based semantic modeltheoretic interpretation. With this end in view, the NPs **the two men** and **three tables**

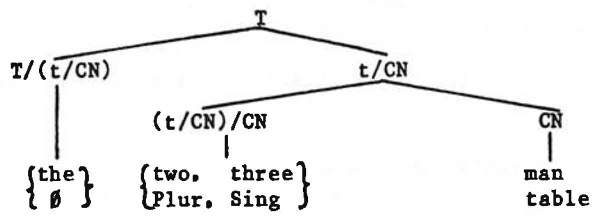
were analysed syntactically as (7a) and (7b) respectively.

(7)


In these X-bar structures, numerals are treated as constituents that take N^0 to form an N^1. The set of numerals Num includes the morphemes Sing and Plur, as can be seen in (8), where **the man** is assigned structure (8a), whereas the plural **the men** is assigned (8b).[3)]

(8)


As pointed out in Verkuyl (1981) these syntactic structures can be translated into Montegovian categorial structure, as in (9):

(9)


The categories belong to a set of categories CAT. Members of CAT having the form A/B are called functors. The functor A/B takes a category B to form category A. Numerals take CN to form a member of the category t/CN. In this approach a member of the category CN is neutral as to number: only at the level of t/CN (= N^1) can plural or singular meanings be attached. If number is realized lexically as in **one, two, three**, etc., there is no need for Sing or Plur.

The decision to treat Sing and Plur as numerals has important consequences which can be seen immediately if the categories in (9) are given a type-logical translation. Let us assume a set **T** which is the smallest set of types satisfying (10):

(10) a. $e, t \in \mathbf{T}$;
b. if $a, b \in \mathbf{T}$, then $\langle a,b \rangle \in \mathbf{T}$
c. if $a \in \mathbf{T}$, then $\langle s,a \rangle \in \mathbf{T}$

The translation from syntactic categories into types proceeds (standardly) with the help of a translation function f from CAT into **T** which is defined (non-standardly) as in (11):

(11) a. $f(S) = t$
b. $f(CN) = \langle e,t\rangle$
c. $f(A/B) = \langle\langle s, f(B)\rangle, f(A)\rangle$

Applied to the categories in (9) this yields:

(12) a.	$f(CN)$	$= \langle e,t\rangle$	N^0
b.	$f((t/CN)/CN)$	$= \langle\langle s,\langle e,t\rangle\rangle, \langle\langle s,\langle e,t\rangle\rangle,t\rangle\rangle$	Num
c.	$f(t/CN)$	$= \langle\langle s,\langle e,t\rangle\rangle,t\rangle$	N^1
d.	$f(T/(t/CN))$	$= \langle\langle\langle s,\langle e,t\rangle\rangle,t\rangle, \langle\langle s,\langle\langle s,\langle e,t\rangle\rangle,t\rangle\rangle,t\rangle\rangle$	Det
e.	$f(T)$	$= \langle\langle s,\langle\langle s,\langle e,t\rangle\rangle,t\rangle\rangle,t\rangle$	N^2

Assuming that T is an abbreviation of category t/IV, a VP of X-bar syntax or an IV of categorial syntax is to be treated as a category of type t//CN, which translated into type $\langle\langle s,\langle e,t\rangle\rangle,t\rangle$. In other words, the third-order status of f(T) requires that $\|VP\|$ be taken as a set of properties rather than just a set of individuals as in PTQ. Let us now translate structure (9) on the basis of (10) - (12) with respect to the NPs **the two men** and **three tables.** As in Verkuyl (1981) it will be assumed that rules of functional application are translated on the basis of (13).

(13) a. if $\beta \in P_{X^{i+1}/X^i}$ and $\alpha \in P_{X^i}$, then $F(\alpha,\beta) \in P_{X^{i+1}}$, where $F_m(\alpha,\beta) = \beta\alpha$
b. given (13a): if α translates into α' and β into β', then $F_m(\alpha,\beta)$ translates into $\beta'({}^\wedge\alpha')$

Furthermore, I will characterize some variables of intensional logic as in (14).

(14) a. x, y, ... are variables of type e
b. A, B ,...,P,Q, ... are variables of type $\langle s,\langle e,t\rangle\rangle$
c. $\mathbf{P}$, $\mathbf{Q}$, ... are variables of type $\langle s,\langle\langle s,\langle e,t\rangle\rangle,t\rangle\rangle$
d. $\mathbf{P}^*$ is a variable of type $\langle s,\langle\langle s,\langle\langle s,\langle e,t\rangle\rangle,t\rangle\rangle,t\rangle\rangle$

Given these provisions, consider the following basic translations from English into IL, the language of intensional type logic.

(15) a. man ~> Man
b. table ~> Table
c. Sing ~> $\lambda Q\lambda P[\forall x[{}^\vee P(x) \rightarrow {}^\vee Q(x)] \;\&\; |{}^\vee P| = 1]$
d. Plur ~> $\lambda Q\lambda P[\forall x[{}^\vee P(x) \rightarrow {}^\vee Q(x)] \;\&\; |{}^\vee P| \geq 1]$
e. n ~> $\lambda Q\lambda P[\forall x[{}^\vee P(x) \rightarrow {}^\vee Q(x)] \;\&\; |{}^\vee P| = n]$
f. the ~> $\lambda Q\lambda\mathbf{P}\theta A({}^\vee Q(A) \;\&\; {}^\vee\mathbf{P}(A))$
g. Ø ~> $\lambda Q\lambda\mathbf{P}\exists B({}^\vee Q(B) \;\&\; {}^\vee\mathbf{P}(B))$

In Verkuyl (1981) it is argued that determiners like **the, these,** and

all are to be treated similarly in sentences like (16):

(16) a. She lifted the tables
b. She lifted these tables
c. She lifted all tables

They are all given the representation (15f) in which θA pertains to a set A which has been identified deictically, contextually or anaphorically. The "definiteness-operator" θ is defined as in (17):

(17) $\theta A[\alpha(A) \leftrightarrow \exists! A$ if and only if A is deictically or contextually or anaphorically given and α is true of A.

The three determiners in (16) differ only in their degree of θ-ship, **these** pertaining to a "more definite" set A than **the** or **all**.

Given this explanation of (15f), let us derive the translations of the structures associated with **the two men** and **three tables**, as in (18) and (19) respectively. Their modeltheoretic semantic interpretation is standard, so I will not complicate the exposition with its burdensome formalism. The use of '... $\leftrightarrow$' indicates that some familiarity is to be assumed with derivations involving lambda-conversion, down-up cancellation (${}^{\vee\wedge}$), etc. in intensional logical representations.[4)]

(18) The two men
man ~>
a. Man
two men ~>
b. $\lambda Q\lambda P[\forall x[{}^\vee P(x) \rightarrow {}^\vee Q(x)] \,\&\, |{}^\vee P| = 2]({}^\wedge Man)$ ...$\leftrightarrow$
c. $\lambda P[\forall x[{}^\vee P(x) \rightarrow Man(x)] \,\&\, |{}^\vee P| = 2]$
the two men ~>
d. $\lambda Q\lambda P\theta A({}^\vee Q(A) \,\&\, {}^\vee P(A))({}^\wedge\lambda P[\forall x[P(x) \rightarrow Man(x)] \,\&\, |{}^\vee P| = 2])$ ...$\leftrightarrow$
e. $\lambda P\theta A({}^{\vee\wedge}\lambda P[\forall x[{}^\vee P(x) \rightarrow Man(x)] \,\&\, |{}^\vee P| = 2](A) \,\&\, {}^\vee P(A))$ ...$\leftrightarrow$
f. $\lambda P\theta A([\forall x[A(x) \rightarrow Man(x)] \,\&\, |A| = 2] \,\&\, {}^\vee P(A))$

(19) Three tables
table ~>
a. Table
three tables ~> ...$\leftrightarrow$
b. $\lambda P[\forall y[{}^\vee P(y) \rightarrow Table(y)] \,\&\, |{}^\vee P| = 3]$
$\emptyset$ three tables ~> ...$\leftrightarrow$
c. $\lambda P\exists B[[\forall y[B(y) \rightarrow Table(y)] \,\&\, |B| = 3] \,\&\, {}^\vee P(B)$

This concludes our account of the NPs in (1a) and (1c). Informally, **the two men** is to be interpreted as a function, which applied to a semantic object of type $\langle s,\langle\langle s,\langle e,t\rangle\rangle,t\rangle\rangle$, yields a deictically or contextually or anaphorically identified two-membered set in the set of subsets of the power set of the set Man in the domain. Analogously, **Three tables** picks out an unidentified three membered set of tables.

3. A higher order treatment of the Verb Phrase. In the previous section the NP was being treated as a functor taking an IV to yield a sentence S. Accordingly, the VP was lifted type-logically as compared with the standard PTQ-treatment, where it is of type $\langle e,t \rangle$. As said, VP is of type $\langle\langle s,\langle e,t\rangle\rangle,t\rangle$ here.

The introduction of verbs in PTQ is quite prosaic. The English verb α is tranlated into α'. A verb like **lift** would simply be translated as **lift'** or as Lift (which I will do here). Meaning Postulate 4 of PTQ would be used to make clear that **lift** is an extensional verb. MP4 provides the structure necessary to account for the proper relation between the individuals denoted by the first argument individuals and individuals denoted by the second argument of the verb. However, it is also possible to express the extensional character of a verb directly by way of a translation rule. Hence, the two-place verb **lift** in (1) can be translated as in (20):

(20) lift ~> $\lambda \mathbf{P}^{*} \lambda P\,{}^{\vee}\mathbf{P}^{*}({}^{\wedge}\lambda Q \forall x[{}^{\vee}P(x) \rightarrow \exists y[{}^{\vee}Q(y) \; \& \; Lift_{*}(x,y)]])$

This representation is rather standard in that it characterizes **lift** as a verb taking an NP to form an IV. (The type-lifting may hamper easy recognition). The first order quantificational scheme following λQ will be constrained in the next section in (23) and (28). Given (19) and (20) the VP **lift three tables** can now be derived with the help of (13):

(21) lift three tables ~>

a. $\lambda \mathbf{P}^{*} \lambda P\,{}^{\vee}\mathbf{P}^{*}({}^{\wedge}\lambda Q \forall x[{}^{\vee}P(x) \rightarrow \exists y[{}^{\vee}Q(y) \; \& \; Lift_{*}(x,y)]])$
$({}^{\wedge}\lambda \mathbf{P} \exists B([\forall y[B(y) \rightarrow Table(y)] \; \& \; |B| = 3] \; \& \; {}^{\vee}\mathbf{P}(B))$ $\leftrightarrow$

b. $\lambda P\,{}^{\vee\wedge}\lambda \mathbf{P} \exists B([\forall y[B(y) \rightarrow Table(y)] \; \& \; |B| = 3] \; \& \; {}^{\vee}\mathbf{P}(B))$
$({}^{\wedge}\lambda Q \forall x[P(x) \rightarrow \exists y[Q(y) \; \& \; Lift_{*}(x,y)]])$ $\leftrightarrow$

c. $\lambda P \exists B([\forall y[B(y) \rightarrow Table(y)] \; \& \; |B| = 3] \; \&$
$\lambda Q \forall x[P(x) \rightarrow \exists y[Q(y) \; \& \; Lift_{*}(x,y)]]\;(B))$ ...$\leftrightarrow$

d. $\lambda P \exists B([\forall y[B(y) \rightarrow Table(y)] \; \& \; |B| = 3] \; \&$
$\forall x[P(x) \rightarrow \exists y[B(y) \; \& \; Lift_{*}(x,y)]])$

Note that the direct object NP is represented only in extensional position. It should be pointed out here that terminativity and extensionality are related to each other in some systematic fashion. I have not been able to discover any intensional verb contributing to terminative aspect. Intensionality appears to be a sufficient condition for durativity, whereas extensionality is a necessary condition for terminativity (see also footnote 4).

4. **Aspect construal and a higher order treatment of NP VP.** By combining (21e) and (18f) the representation of (1a) can be derived. It is given in (22).

(22) The two men lifted three tables ~>

a. $\lambda P\theta A([\forall x[A(x) \rightarrow Man(x)] \;\&\; |A| = 2] \;\&\; {}^{\vee}P(A))$
$({}^{\wedge}\lambda P\exists B([\forall y[B(y) \rightarrow Table(y)] \;\&\; |B| = 3] \;\&\; \forall x[P(x) \rightarrow \exists y[B(y)$
$\&\; Lift_{*}(x,y)]]))$ ... $\leftrightarrow$

b. $\theta A([\forall x[A(x) \rightarrow Men(x)] \;\&\; |A| = 2] \;\&\; \exists B([\forall y[B(y) \rightarrow Table(y)]$
$\&\; |B| = 3] \;\&\; \forall x[A(x) \rightarrow \exists y[B(y) \;\&\; Lift_{*}(x,y)]]))$

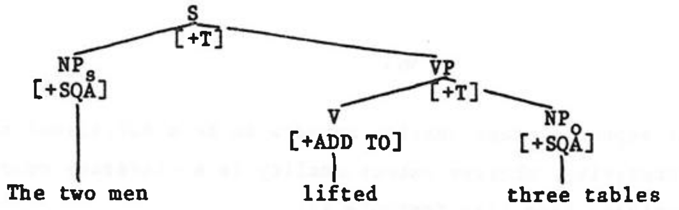
Representation (22b) says that there is an identified unique set A consisting of two men and for A there is a set B consisting of three tables such that all members of A are in a $Lift_{*}$-relation to members of B. It should be observed that nothing has been said about the role of tense. I will assume that tense can be accounted for in a way compatible with the present analysis.

Representation (22b) has two "layers", a second order layer and a first order layer, which becomes clear by considering its general structure (23).

(23) $\exists A(\ \ldots\ \&\ \exists B(\ldots\ \&\ \forall x[A(x) \rightarrow \exists y[B(y)\ \&\ R_{*}(x,y)]]))$

The representation introduces two sets A and B either definitely (by θ) or indefinitely (by the simple $\exists$). It also contains the functional scheme associated with the verb, saying that the relation R_{*} can be interpreted in terms of a function from A into B. The layering of (23) turns out to be useful in view of the fact that negation can now be taken as denying the existence of the domains A or B, rather than bringing us to the complements of individuals within a certain set. This property of (23) will be discussed in the next section.

In this section I would like to first relate a number of properties of representation (22b) to the aspectual theory developed in Verkuyl(1987; to appear a and b). I shall restrict myself here to a bare minimum, and only in connection with the problems under discussion. So let us assume that the terminative aspect in (1a) is formed on the basis of the following syntactic structure, where the factors contributing to the terminative aspect of (1a) can be represented (informally and provisionally) with the help of features:

(24) 

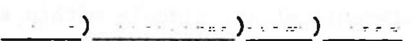
Both NPs pertain to 'Specified Quantities of A' where A is the denotation of N^0, so they are given a specification [+SQA]. In terms of (22), this information is given by $|A| = 2$ and $|B| = 3$, provided that A and B are involved in the $Lift_*$-predication. In NPs like **some men**, **few men** and **(at least) two men**, the cardinality information is also [+SQA]. Here, the cardinality information would be $|A| \geq 2$, $|A| = n^{\$}$ (where \$ represents the information that n is determined by a certain norm, given a domain), and $|A| \geq 3$, respectively. In all these cases this information is finite even though we do not know the exact cardinality, as argued in Verkuyl (1987).

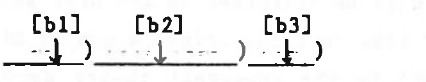
An NP like **nobody** in (1c) would be [-SQA], as its cardinality is the empty set. In the present framework **nobody** would be represented as in (25b).

(25) Somebody ~>
a. $\lambda P \exists A([\forall x[A(x) \rightarrow Human(x) \; \& \; |A| \geq 1] \; \& \; {}^{\vee}P(A))$
Nobody ~>
b. $\lambda P \sim \exists A([\forall x[A(x) \rightarrow Human(x) \; \& \; |A| \geq 1] \; \& \; {}^{\vee}P(A))$

That is, whereas **somebody** assures that there is a group A consisting of one or more human beings of which a predicate of type P can be asserted, **nobody** denies the existence of such a group.

The verb **lift** is characterized (provisionally and informally) by the presence of a lexical feature [+ADD TO]. This feature is interpreted in terms of a function s (actually in terms of a set of functions s) which generates temporal structure associated with the verb **lift**, as illustrated in (26a) with respect to one arbitrarily chosen application of s.

(26) a. 

b. 

The compositional interpretation of the VP in (24) proceeds by the mapping of NP_o entities into temporal structure produced by s. Suppose that $\|NP_o\| = B$, and that B^+ is the set of all arbitrarily partitioned subsets of B, then this mapping can be seen as a mapping of all members of B^+ into temporal structure induced by the verb. In the case of (26a), one could think of a mapping as illustrated in (26b). The crucial feature of this analysis is that we **know** that B^+ is finite, so the mapping comes to a stop, making the VP terminative, as is indicated (provisionally and informally) by [+T] in (24).

A VP is not terminative if the NP is [-SQA] as in **The two men lifted tables** or if the V is [-ADD TO], as in **The two men dreamt of two tables.** Intensional verbs like **believe, hope, seek,** etc. are [-ADD TO]: they do not induce temporal structure.[5]

The function s associated with verbs like **lift** and the mapping of members of B^+ into the temporal structure generated by s together constitute a composite function, which is the terminative function t producing terminative intervals as described in (5) and (6) in section 1.

(27) $\|[+T]\| = I_T$ = the set of injective functions t: $B^+ \rightarrow I$, s.t. $t([b]_j) = i_j$

where $[b]_j$ is the j-th subset of B^+, and where I is the set of intervals i. Thus $i_t \subset B^+ \times I$, that is, a terminative interval i_t is a proper subset of the cartesian product of B^+ and I. Note that we do not know which B^+ has been picked out. In (1a), diagram (25b) would pertain to a situation in which the two men lifted three tables together one by one. To make a long story short. We assume that the injective functions p_d or the constant function p_c described in section 1 will pick out the proper terminative intervals.

Returning now to (23), we could say that given a [+SQA]-specification of both A and B, this scheme could be given the following interpretation:

(28) If $\exists A$ ([.... |A| = finite]...& $\exists B$([... |B| = finite ..], then $\forall x[A(x) \rightarrow \exists y[B(y) \ \& \ Lift_*(x,y)]]$ is true iff there is a function p: $A \rightarrow B^+ \times I$ s.t. $p(a) = i_t$

where $p = p_c$ or p_d, and where i_t is a set of pairs from $B^+ \times I$ produced by the terminative function t, each pair consisting of a subset of B and an interval produced by the $Lift_*$-function s, and where the number of applications of the function t is (ultimately) determined by |B|. In (6) some examples of possible i_t's are given.

In the following section I shall interpret formulas like (22b) on the basis of (28). It is important to see that (28) in fact determines the preconditions for calling certain temporal entities 'events'. In the literature on aspect the most promising ontology seems to be the tripartition proposed by Mourelatos (1978), who distinguished between States, Processes and Events, the latter being terminative. Galton (1984:24) pointed out that this distinction is a way of presenting information rather than a distinction inherent in what goes on. That is, we can use language such that we talk about some situation presenting it as a process (e.g. **Two men were lifting three tables**), whereas we also can talk about this situation presenting it as an event (e.g. (1a)). Applying this insight to the compositional interpretation of (24), we can say that (28) defines exactly the notion of (terminative) event by introducing two sets, A and B, and by pointing out that there is a function p relating A to a set of terminative intervals determined by the cardinality of B.[6]

This analysis predicts that the non-application of the functions p and t will prevent us from presenting sentences as pertaining to events. In the next section, it will be shown that negation prevents the functions p and t from having a domain or a co-domain.

5. **Negation.** In this section I would like to derive the representations of the following sentences:

(29) The two men didn't lift three tables (= 2a)
(30) Nobody lifted three tables
(31) Nobody did not lift three tables
(32) The two men did not lift three tables, but four

In my treatment of negation, I will apply the formal tools made by Jacobs (1982), an important study on negation in the modeltheoretic framework. Jacobs does not propose a higher order treatment of NPs and the VP, but his formal machinery can easily be adapted such that the present analysis can benefit from it. Jacobs characterizes the difference between (29) and (30) on the one hand, and (31) on the other in terms of a distinction between non-contrastive and contrastive negation rather than the usual division between sentence negation and term negation. The difference between contrastive and non-contrastive negation will be made clear in the course of my treatment of (29) - (32).

Following Jacobs, **not** in (29) would be translated as $\lambda q[\sim{}^{\vee}q]$, where q is of type <s,t>. **Not** is taken as a functor operating on all sorts of different categories. In order to account for this versatile property Jacobs developed - much in the spirit of Geach (1972)

- a variable scheme in which $\lambda q[\sim{}^{\vee}q]$ is incorporated, having variables over different types. For example, **not** in **not NP** would be covered by (33),

(33) $\lambda\beta(\lambda q[\sim{}^{\vee}q]({}^{\wedge}\alpha(\beta))$

where α is the translation of the NP and β is a variable for a category of type <s,<<s,<e,t>>,t>> in the present framework, the result being a category of the type <s,t> which can replace the variable q. The functor **not** can take adjectival phrases, verbal phrases and sentential phrases too. In these cases either the types of α and β can be different or some other variables are to be introduced by lambda-abstraction dependent on the number of arguments for α.

Applying this insight to the results of the previous section **not** applied to the VP **lift three tables** would yield (34a).

(34) a. $\lambda Q(\lambda q[\sim{}^{\vee}q]({}^{\wedge}Lift\ ({}^{\wedge}3\ Tables)(Q)))$
b. $\lambda Q(\sim Lift({}^{\wedge}3\ Tables)(Q))$

Note that (Lift(^3 Tables)) is of type <<s,<e,t>>,t>, as can be seen in (21d). If applied to a category Q, which is of type <s,<e,t>>, the result will be a category of type t. The intension prefixed on Lift will result in a category of type <s,t> which can replace the variable q. Thus (34a) can be reduced to (34b).

We can now combine (18), (21) and (34) into the following derivations:[7]

(35) not lift three tables ~>
a. $\lambda Q(\lambda q[\sim{}^{\vee}q]({}^{\wedge}\lambda P\exists B(\forall y[B(y) \rightarrow Table(y)]\ \&\ |B| = 3]\ \&\ \forall x[P(x) \rightarrow \exists y[B(y)\ \&\ Lift_{*}(x,y)]]])(Q))$ ... $\leftrightarrow$
b. $\lambda Q(\sim(\lambda P\exists B(\forall y[B(y) \rightarrow Table(y)]\ \&\ |B| = 3]\ \&\ \forall x[P(x) \rightarrow \exists y[B(y)\ \&\ Lift_{*}(x,y)]]))(Q))$

(36) The two men did not lift three tables ~>
a. $\lambda P\theta A([\forall x[A(x) \rightarrow Man(x)]\ \&|A| = 2]\ \&\ {}^{\vee}P(A))({}^{\wedge}35b)$ $\leftrightarrow$
b. $\theta A([\forall x[A(x) \rightarrow Man(x)]\ \&|A| = 2]\ \&\ \lambda Q(\sim(\lambda P\exists B(\forall y[B(y) \rightarrow Table(y)]\ \&\ |B| = 3]\ \&\ \forall x[P(x) \rightarrow \exists y[B(y)\ \&\ Lift_{*}(x,y)]]))(Q))(A))$ ... $\leftrightarrow$
c. $\theta A([\forall x[A(x) \rightarrow Man(x)]\ \&\ |A| = 2]\ \&\ \sim(\lambda P\exists B(\forall y[B(y) \rightarrow Table(y)]\ \&\ |B| = 3]\ \&\ \forall x[P(x) \rightarrow \exists y[B(y)\ \&\ Lift_{*}(x,y)]])\ (A))$ ... $\leftrightarrow$
d. $\theta A([\forall x[A(x) \rightarrow Man(x)]\ \&\ |A| = 2]\ \&\ \sim\exists B([\forall y[B(y) \rightarrow Table(y)]\ \&\ |B|=3]\ \&\ \forall x[A(x) \rightarrow \exists y[B(y)\ \&\ Lift_{*}(x,y)]]))$

On the basis of (28), representation (36d) is to be interpreted as saying that for the identified set A containing two men there is no set B consisting of three tables such that the members of A are in a $Lift_{*}$-relation to members of B. Thus the VP-negation of (2a) eliminates the set B from being mapped into the temporal structure induced by the verb. Thus the second order part of (23) will read here as $\exists A(\ldots \ \& \ {\sim}\exists B \ \ldots)$. This explains why (2a) does not pertain to a (terminative) event: there is no event because (2a) fails to meet condition (28). In other words there is no co-domain for the functions p_c and p_d.

The derivation of (30) **Nobody lifted three tables** proceeds by combining (25b) and (21d) into (38):

(38) Nobody lifted three tables ~>

$$\sim\exists A([\forall x[A(x) \rightarrow Human(x)] \ \& \ \exists B(\forall y[B(y) \ \& \ Table(y) \ \& \ |B| = 3] \ \& \ \forall x[A(x) \rightarrow \exists y[B(y) \ \& \ Lift_*(x,y)]]))$$

Here we meet the situation in which it is denied that there exists a domain A whose members can be the input of the function p. That is, in the domain no set of human beings can be found such that its members are involved in lifting three tables. Here we have, at the second order part of (23), $\sim\exists A(\ldots \ \& \ \exists B \ \ldots)$. Again there can be no event because (30) fails to meet (28): there is no domain to define the functions p_c or p_d.

We can now derive (31) **Nobody did not lift three tables.** Its representation can be found by applying (25b) to (35b), which results in (39).

(39) Nobody did not lift three tables ~>

$$\forall A([\forall x[A(x) \rightarrow Human(x)]] \rightarrow \exists B([\forall y[B(y) \rightarrow Table(y)] \ \& \ |B| = 3] \ \& \ \forall x[A(x) \rightarrow \exists y[B(y) \ \& \ Lift_*(x,y)]]))$$

This says that all sets A containing persons can be related to a set B such that all members of A are involved in a $Lift_*$-relation to members of B. Note that (39) is derived from a representation of the form $\sim\exists A(\alpha \ \& \ {\sim}\exists B\beta)$ which is logically equivalent to $\forall A(\alpha \rightarrow \exists B\beta)$ on the basis of quantifier exchange ($\sim\exists x\alpha \leftrightarrow \forall x{\sim}\beta$) and a law of propositional logic saying $\alpha \rightarrow \beta$ is equivalent to $\sim(\alpha \ \& \ {\sim}\beta)$.

It is of importance to see that sentence (40) - however hard to interpret - appears to be at least non-stative.

(40) Nobody did not lift three tables for hours

I doubt whether this sentence should be called terminative, because contrary to cases like (22), (39) contains a universal quantifier over sets A, whereas the terminative functions p operate on just one domain. Thus it appears as if (39) requires that the terminative machinery operates on all domains A in the range of the universal quantifier. Actually, this seems to be exactly what is expressed by (40), but on this interpretation one cannot speak of terminativity.

Finally I would like to discuss (32) **The two men did not lift three tables, but four.** Jacobs(1982:269-360) analyses sentences like (31) in terms of contrastive negation. The negation element **not** does not affect the verb **lift** in so far as as it blocks only the reference to the lifting of a certain number of tables (viz. three) by the two men. Rather it affects the direct object NP, its effect being that (31) expresses a terminative event because the information about three tables is corrected into the information that the two men lifted four tables. In terms of the sets A and B, contrastive negation denies the existence of B clearing the way for the introduction of the existence of a proper B', which serves as the supplier for a finite amount of its partitioned subsets mapped into the temporal structure induced by **lift**, so that p obtains a proper terminative co-domain.

To account for contrastive negation, Jacobs (1982) introduces two predicates of type <t,t>, namely a correctness predicate CORR and an adequacy predicate AD, which are defined informally here, but formally in Jacobs:

(41) CORRa is true iff α is true and ADα is true.
ADα is true iff is α has a (sufficient) adequacy value ad

What is sufficiently adequate is, of course, determined by standards holding in the domain of discourse (Jacobs introduces an adequacy value assignment).

The introduction of CORR can be made plausible by comparing the two sentences in (42).

(42) a. Mary did not lift three tables but two
b. Mary did not lift three tables but four

Suppose that (42a) is true. In that case Mary lifted two tables. Thus it is not true that she lifted three tables, so in terms of (41) ~α would turn CORRα into ~CORRα. If Mary lifted four tables in (42b), then is it also true that she lifted three tables, so on the basis of this fact alone we would obtain CORRα. However, because it is not adequate to evaluate with respect to just a part of Mary's lifting ADα is not true, so we obtain ~CORRα. Applied to (31) this analysis of contrastive negation yields the following representation:

(43) The two men did not lift three tables, but four ~>
$\theta A([\forall x[A(x) \rightarrow Man(x)] \& |A| = 2] \& \sim CORR\exists B([\forall y[B(y) \rightarrow Table(y)] \& |B| = 3] \& \forall x[A(x) \rightarrow \exists y[B(y) \& Lift_*(x,y)]]) \& CORR\exists B'([\forall y[B(y) \rightarrow Table(y)] \& |B'| = 4] \& \forall x[A(x) \rightarrow \exists y[B'(y) \& Lift_*(x,y)]]))$

This analysis explains why (32) is terminative. It affirms the existence of the set A and a set B', whose members are involved in a $Lift_*$-relation. This concludes our account of (29) - (31).

Returning now to (2a) in its contrastive reading (1j), one can easily see that this can be represented by (43) the only difference being that $|B'| = n$.

6. **Conclusion.** In section 1, two problems concerning sentences like (1) were given and the prospect of one, unified account was held out. The first problem - how to account for the neutralization of terminative aspect in (1) - has been solved on the basis of an aspectual theory which explains terminative aspect in terms of a number of functions. Terminativity is neutralized as soon as these functions cannot be defined, their definition being dependent on the nature of the verb (it should induce temporal structure) and the NPs occurring as its argument (they should pertain to specified quantities).

The second problem has disappeared by appealing to the same formal machinery. Distributivity and collectivity can be defined in terms of the same functions p_d and p_c in which sentential aspect has been defined. Negation in two-place predicates eliminates the domain and the co-domain of these functions. This explains why the D/C-distinction breaks down under non-contrastive negation.[8)]

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Footnotes

1. Kempson & Cormack(1981) is at the parsimonious end of the scale, Scha (1981) at the exuberant other side. Link (1984) represents an intermediate position. My position is at the K&C-side of Link's position.

2. Any member $i_t \in I_T$ which consists of more than one pair, is construed such that the intervals which are induced by the verb occur as its second member such that for all i, $i_1 \subseteq i_2 \subseteq \ldots \subseteq i_n$, where $\subseteq$ is interpreted temporally (cf. Van Benthem 1983).

3. Arguments for type-lifting in the analysis of NPs can be found in Scha (1981), Hoeksema (1983), Van Eijck(1983;1985). My own 1981-argument was based upon my wish to interpret generative X-bar structures semantically. A second argument is added in this paper: by simply following my 1981-track I found that the negation operator is being attached at a type-level that turns out to be the domain or co-domain of certain functions.

4. E.g. Partee (1975), Dowty, Wall and Peters (1981).

5. Many verbs pertaining to abstract states of mind or to mental processes, can often be interpreted as pertaining to utterances. Thus a sentence like **The whole morning Mary hoped that you would come** can report about a state of mind, but it may also apply to several utterances by which Mary expressed her hope repeatedly. In this latter interpretation the intensional verb **hope** becomes extensional resulting in a terminative aspect.

6. For a critical overview of attempts to derive an ontology from Vendler-classes, see Verkuyl (to appear b). The idea of a "representational ontology" rather than a "real physical" ontology is winning ground, cf. Kamp 1981, Landman 1986

7. I am not sure whether I am so happy with the derivation of the form $\exists A(\ldots \lambda Q(\sim(\lambda P \ldots . P))\ (Q)(A))$. But it may be expected that if this iterated application is meets "lambda-mechanical" opposition, one can find a technical way out.

8. I would like to thank Johan van Benthem, Joyce Bommer, Jeroen Groenendijk, Lyn Frazier, Manfred Krifka, Godehard Link, and Johan Kerstens, without holding them responsible for any errors.

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