

AMSTERDAM PAPERS IN FORMAL GRAMMAR VOL. I



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AMSTERDAM PAPERS IN FORMAL GRAMMAR

VOL. I

PROCEEDINGS OF THE AMSTERDAM COLLOQUIUM ON

MONTAGUE GRAMMAR AND RELATED TOPICS

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PREFACE

This is the first volume of the series "Amsterdam Papers in Formal Grammar", issued by the Centrale Interfaculteit of the University of Amsterdam. It comprises almost all papers presented at the symposium 'Montague Grammar and Related Topics', held in Amsterdam on January 12-16, 1976. The papers missing are the papers by Guenther, ter Meulen and von Stechow. They shall appear in the following issue of this series.

Although most of the papers do not discuss or extend Montague's grammar directly, they are more or less related to it. The relation lies in the formal logical approach of natural language in the fields of semantics and pragmatics. They thus give an impression of the conception of this whole series. Its purpose is to serve as a medium for quick publication of discussions and results in that branch of formal grammar that is associated with the name of Richard Montague and his students. The papers are reproduced exactly as they are received. Therefore, only the authors are responsible for the form and content.

TABLE OF CONTENTS

Renate BARTSCH, Syntax and Semantics of Relative Clauses	page 1
Jerry EDMONSON, Semantics, Games and Anaphoric Chains	page 25
Michael GRABSKI, Zur Semantik von 'Meinen' und 'Bedeuten'	page 41
Jeroen GROENENDIJK & Martin STOKHOF, Some Aspects of the Semantics and Pragmatics of Performative Sentences	page 61
Roland HAUSSER, Scope Ambiguity and Scope Restrictions in Montague Grammar	page 95
Jaap HOEPELMAN, Mass-Nouns and Aspects, or: Why We Can't Eat Gingercake in an Hour	page 132
Theo JANSSEN, A Computer Program for Montague Grammar: Theoretical Aspects and Proofs for the Reduction Rules	page 154
Peter LUTZEIER, The Counterfactual Reading of 'Before'	page 170
Frans PLANK, Misunderstanding Understood Subjects: The Minimal Distance Principle in Montague Grammar	page 194
Helmut SCHNELLE, Circumstances and Circumstantial Expressions	page 217
Frank VELTMAN, Prejudices, Presuppositions and the Theory of Conditionals	page 248
Ryszard ZUBER, Operators and Arguments in Natural Language	page 282

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SYNTAX AND SEMANTICS OF RELATIVE CLAUSES

Renate Bartsch

It is a widely accepted assumption that the difference between restrictive and non-restrictive^{relative} clause constructions should be expressed in their syntactic categorial structure as well as in their semantics. This view is held, e.g., by Rodman 1972. There, a syntactic function combines a common noun and a sentence to form a complex common noun in the case of restrictive relative clauses, and, in the case of the non-restrictive relative clause construction, a syntactic function combines a term (noun phrase with determiner or a proper name) with a sentence to form a complex term. Rodman formulates this assumption in a Montague grammar in a way that rests on the transformational approaches to relative clause constructions. He, thus, has to formulate conditions that say under which circumstances which elements of a sentence can be relativized, namely, within a relative clause no other element can be relativized, and in the case of non-restrictive constructions, a further restriction has to be imposed to the effect that coreference between the governing term and the relativized element has to be assumed. The formulation of restrictions like these can be avoided, if we do not assume that relative clauses are constructed from sentences by relativizing one of their elements and moving it towards the front of the sentence, but rather make quite a different assumption to begin with, namely: relative clauses are not built from sentences but from predicates. With this assumption we follow Frege's (1892) analysis of restrictive relative clauses and not the tradition of transformational grammar.

In what follows, this approach shall be elaborated for restrictive as well as for non-restrictive relative clauses. It then will be discussed whether it is really wise to give two relative clause constructions in syntax, namely as noun modifiers and as term modifiers for restrictive and non-restrictive interpretations, respectively, or whether we should not rather follow Thompson (1971) in just

assuming one syntactic construction, but different strategies of interpretation, depending on certain pragmatic factors present in the context. If we follow that line the term-modifying construction is the only candidate for a single syntactic structure of relative clause constructions, because the construction "proper name + relative clause" can never be incorporated in a noun modifying construction. This is not possible, because a proper name is a primitive term that cannot be analyzed into a "Determiner + Common noun"-construction. Although the rules of semantic interpretation of the term-modifying construction have some drawbacks with regard to the elegance of their form, there is further evidence for the assumption of this syntactic construction, also for restrictive relative clauses, by the problem of interpretation of the so-called Bach-Peters sentences. This problem can be solved in the proposed framework.

Proposal I

In proposal I I assume that the relative pronoun is the morphological realization of two different operators, REL_n and REL_t . REL_n maps a pair consisting of a noun and a one-place predicate onto a noun. - Of course, the noun and the one-place predicate can be complex, i.e. the result of a syntactic construction, - In this way we have the noun-modifying construction, generally assumed as the restrictive relative clause construction. REL_t maps a pair consisting of a term and a one-place predicate onto a term. This is the term-modifying construction, which is widely assumed as the non-restrictive clause construction.

We have the following syntactical and semantical rules:

Syntactical rules:

S1: Adnominal relative clause

If α is a noun, β the relative operator REL_n and γ a one-place predicate, then $\beta(\alpha, \gamma)$ is a noun; $\beta(\gamma)$ is an adnominal relative clause, and $\beta(\alpha, \gamma) = (\beta(\alpha))(\gamma)$.

S2: Adterminal relative clause

If α is a term, β the relative operator REL_t and γ a one-place predicate, then $\beta(\alpha, \gamma)$ is a term; $\beta(\gamma)$ is an adterminal relative clause, and $\beta(\alpha, \gamma) = (\beta(\gamma))(\alpha)$.

Remark: By S1 and S2 we receive the categorial structures of relative clause constructions. To get the surface clauses, β_{REL} has to be realized as a relative pronoun in congruence with the gender and number of the governing noun or term, respectively, and according to the morphological case realization of the λ -bound position of the one-place verb γ . The serialization of the relative clause $\beta(\gamma)$ is according to the general rules of subordinate clause serialization, i.e. in German the natural "Operater (Operand) $\rightarrow$ Operater + Operand"-serialization of the hierarchies represented in the constructions of categorial syntax. The constructions of categorial syntax, by convention, are such that an operator stands in front of his operand. They are thus not to be understood as linearly ordered but rather as hierarchically ordered, with a unidirectional representation of the hierarchies when we write them down on paper (compare Bartsch 1976).

Semantical rules:

T1: Adnominal relative clauses (restrictive)

If $\lambda x\alpha'(x)$ and $\lambda x\gamma'(x)$ are the translations of α and γ from S1, then the translation β' of β is a mapping with the following characterization:

$$\beta'(\lambda x\alpha'(x), \lambda x\gamma'(x)) = \lambda x(\alpha'(x) \& \gamma'(x)).$$

The translation of the adnominal relative clause $\beta(\gamma)$ then is $(\beta'(\lambda x\gamma'(x)))$ with: $(\beta'(\lambda x\gamma'(x)))(\lambda x\alpha'(x)) = \lambda x(\alpha'(x) \& \gamma'(x))$.

T2.1: Adterminal relative clauses (non-restrictive)

If $\lambda PP(a)$ is the translation of the proper name α and $\lambda x\gamma'(x)$ the translation of γ from S2, then the translation β' of β is a mapping with the following characterization: $\beta'(\lambda PP(a), \lambda x\gamma'(x)) = \lambda P(\gamma'(a) \& P(a))$.

The translation of the adterminal relative clause $\beta(\gamma)$ then is

$$(\beta'(\lambda x\gamma'(x))) \text{ with: } (\beta'(\lambda x\gamma'(x)))(\lambda PP(a)) = \lambda P(\gamma'(a) \& P(a)).$$

Since we also have non-restrictive constructions with the specific indefinite article and the specific definite article, T2 needs to be extended to cover these cases. But before doing so we need to describe how definite descriptions are interpreted. As long as we simply adhere to the Russelian analysis of definite descriptions and translate, basically following Montague's "Proper Treatment" and Thomason 1974 and Ballmer 1975, the by $\lambda Q\lambda P(\exists x)(Q(x) \& (\forall y)(Q(y) \rightarrow x = y) \& P(x))$, we could incorporate into T2 the following extension:

T2.2: If $\alpha = (\mu_{D<def>}(\kappa_N)T_{<def>})$, then $\beta'(\lambda P(\exists x)(\kappa'(x) \& (\forall y)(\kappa'(y) \rightarrow x = y) \&$

$P(x)), \lambda x \gamma'(x)) = \lambda P(\exists x)(\kappa'(x) \ \& \ (\forall y)(\kappa'(y) \rightarrow x = y) \ \& \ \gamma'(x) \ \& \ P(x)).$

But even this is unnecessary. We could just treat the non-restrictive relative clauses with definite terms by S1 and T1. No mistake can arise this way: if $\kappa'(x)$ is satisfied for exactly one individual then, if also $\gamma'(x)$ is satisfied for the same individual following T2', then the definite description with $\lambda x(\kappa'(x) \ \& \ \gamma'(x))$, constructed according to S1/T1, is satisfied. The difference between restrictive and non-restrictive would be recognizable by the context, but would have no effect on the semantics. That an analysis, solely based on Russell's theory of definite descriptions, is inadequate as an analysis of the use of the definite article in natural language has long been recognized and, actually, never was intended by Russell to be adequate in this way. Russell's theory does not cover contextual use of the definite article and has to be modified quite a bit to be applicable even for the semantics of the definite article in contextual use. We want to be able to give the semantics of examples like the following:

A man and a woman sat at a table in a restaurant, having a drink.

Suddenly, a man appeared at the entrance. The man, who had a short glimpse over the scene, took his gun and shot the woman.

We want to interpret the sentence such, that the man refers back to the man who entered and not to the man mentioned first. On the other hand, in the following text, we want to refer to the man mentioned first:

A man and a woman sat at a table in a restaurant, having a drink.

Suddenly, a man appeared at the entrance. The man who sat at the table, took his gun and shot at the stranger.

Obviously, in the second example, the relative clause plays a role in identifying the man meant out of the two mentioned, and in the first example it does not. We, therefore, need an analysis of definite terms that allows us to account for these facts. To do this, we need a theory of interpretation that, among other things, provides the connection between a definite term and a previously used indefinite term. The interpretation is based on two kinds of reference acts formulated by means of reference instructions. This concept of reference instruction was introduced in Ballmer 1972. The interpretation of an indefinite term "a(n) α " in a non-negative context is accompanied by an instruction to perform an act of referent-introduction and the interpretation of a definite term "the α " relies on a reference act performed according to an instruction to search for a suitable referent. The referent-introduction and the referent search is done in an univers of discourse constructed in the course of interpretation of a text (compare also Ballmer 1975). This univers consists partly out of representations of entities

which the speaker assumes to be commonly known to the partners of the discourse, and partly out of representations of entities introduced by the discourse. This realm of entity-representations is structured for each partner according to his knowledge about the entities represented and gets further changed by the discourse. We can look at this realm of entity-representations with its structure as a model for the set of propositions assumed to be true by the discourse partners. The discourse partners deviate from each other in their models but in order for the discourse to be happy, a correspondence of parts of the realm of entities and their structural properties (i.e. properties and relations satisfied by them and represented in the models) is necessary. For the purpose of reference introduction we need to narrow down the concept of a discourse universe to the concept of a relevant universe of discourse.

A relevant universe of discourse (for referent-introduction) is determined as follows: if there is an intensional verb to which "a(n) α " is applied

1. the relevant universe of discourse is the universe of those worlds that are specified by the intensional verb and its subject term, if the term "a(n) α " is applied with regard to a place of the verb marked as intensional.

Otherwise (i.e. in all de re constructions) we have (2).

2. the relevant universe of discourse is the univers of the speaker-hearer discourse, i.e. the basic universe of discourse of assumed common speaker-hearer knowledge, including information from the previous text.

The indefinite article can be interpreted in a specific or non-specific reading with regard to the speaker's way of referring (cf. Bartsch 1976). The non-specific reading is primary. The specific reading is only possible if indicated by the context.

The indefinite article:

specific: a(n) translates into $\lambda Q\lambda P(Q(v) \ \& \ P(v))$, with v being a newly introduced constant.

non-specific: a(n) translates into $\lambda Q\lambda P(\exists x)(Q(x) \ \& \ P(x))$.

Referent-introduction:

RI: If a(n) is not in the scopus of a negation or preceded by a term of the form "every ..." or "no ..." then add, after the translation that specifies the variables Q and P , a new individual name with the specifications of Q and P to the relevant universe of discourse.

Remark: If the new name is v then we have to add v to the relevant universe of

discourse with $\text{Spec}[Q](v)$ & $\text{Spec}[P](v)$, where $\text{Spec}[Q]$ and $\text{Spec}[P]$ are the specifications of Q and P , respectively.

The definite article (specific):

the translates into $\lambda Q \lambda P (Q(v) \& P(v))$ with v determined according to the following reference instruction:

Reference instruction:

for: the α .

1. Take the last individual name introduced or used with the interpretation of the last sentence such that of its referent the property α' , i.e. the predicate specifying Q , is true. If there is no such name, do (2).
2. Take the second last individual name introduced or used with the interpretation of the second last sentence such that of its referent the property α' is true. If there is no such name, do (3).¹⁾
3. Control whether it holds in the knowledge induced by previous text information and presupposed speaker-hearer knowledge that: $(\exists x)(\alpha'(x) \& (\forall y)(\alpha'(y) \rightarrow x=y))$. If that is the case use the introduced individual name v with $\alpha'(v)$, or, if there is no such name, introduce a new name v with $\alpha'(v)$. If it is not the case, do (4).
4. Control whether in the presupposed speaker-hearer knowledge that does not belong to the previous text information it holds that $(\exists x)(\alpha'(x) \& (\forall y)(\alpha'(y) \rightarrow x=y))$. If that is the case use the introduced individual name v with $\alpha'(v)$, or, if there is no such name, introduce a new name v with $\alpha'(v)$.

There exists the following restriction of use for definite articles. The α can only be used if $(\exists x)(\alpha'(x) \& (\forall y)(\alpha'(y) \rightarrow x=y))$ holds in one of the realms of information described in the strategy (1)-(4) above. The restriction gives rise to the assumption of $(\exists x)(\alpha'(x) \& (\forall y)(\alpha'(y) \rightarrow x=y))$ for one of the realms of information described in the strategy (1)-(4).

After this excursus on indefinite and definite articles we are able to formulate the interpretation of non-restrictive relative clause constructions for definite terms and specific indefinite terms in the same way as for proper names. We add to T2:

T2.2: If the α or a α translates into $\lambda P(\alpha'(v) \& P(v))$ and γ into $\lambda x \gamma'(x)$, then β translates into the mapping β' with: $\beta'(\lambda P(\alpha'(v) \& P(v)), \lambda x \gamma'(x)) =$

$\lambda P(\alpha'(\nu) \ \& \ \gamma'(\nu) \ \& \ P(\nu))$. And, accordingly, the relative clause $\beta(\gamma)$ translates into $(\beta'(\lambda x \gamma'(x)))$ with: $(\beta'(\lambda x \gamma'(x)))(\lambda P(\alpha'(\nu) \ \& \ P(\nu))) = \lambda P(\alpha'(\nu) \ \& \ \gamma'(\nu) \ \& \ P(\nu))$.

The restrictive relative clauses are taken care of by S_T/T_T, by which a complex $\lambda x \beta'(x)$ is constructed that goes into the syntax and semantics of term constructions, following rules S_T and T_T.

S_T: If α is a determiner and β is a noun, then $\alpha(\beta)$ is a term.

T_T: If α' is the translation of α and β' the translation of β from S_T, then the translation of $\alpha(\beta)$ is: $\alpha'(\beta')$.

The translations of non-specific determiners, this far, are formulated, following Montague 1974 and Ballmer 1975:

a : $\lambda Q \lambda P (\exists x)(Q(x) \ \& \ P(x))$

every: $\lambda Q \lambda P (\forall x)(Q(x) \rightarrow P(x))$

no : $\lambda Q \lambda P (\forall x)(Q(x) \rightarrow \neg P(x))$

and, according to the Russellian analysis:

the : $\lambda Q \lambda P (\exists x)(Q(x) \ \& \ (\forall y)(Q(y) \rightarrow x = y) \ \& \ P(x))$.

This treatment of determiners will be revised in the course of this paper.

To be able to handle some interesting examples of relative clause constructions we need to incorporate an interpretation strategy for pronouns. The interesting cases are constructions that cannot be handled in a Montague Grammar so far. For example, the sentence (1)

(1) Every man who buys a car insures it.

cannot be handled in Montague's PTQ with coreference for a car and it, because it remains unbound by the quantifier introduced with the translation of a car.

Another interesting group of constructions that have not been handled successfully in a Montague Grammar are the so-called Bach-Peters-sentences. The solution by introduction of double term constructions, as proposed by Rohrer (1975), has as a drawback that the method needs to be generalized if we want to have a unified way of interpreting terms. It is fairly ad hoc if we treat term interpretation in sentences that are not Bach-Peters-sentences differently than in Bach-Peters-sentences. And since problems are imaginable where we need triple term introduction or even n-tupel term introduction, we end up at a generalization of

Rohrer's method that is very costly to handle, if at all. Furthermore, not all the interesting types of Bach-Peters-sentences have been analyzed in Rohrer's framework. Before getting into details of the problem of Bach-Peters-sentences a treatment of pronouns has to be sketched that makes possible pronominal coreference with terms outside and inside a sentence, and that, specifically, serves to handle the interpretation of sentences like sentence (1) and the so-called Bach-Peters-sentences. Like the interpretation strategy for definite terms the interpretation strategy for pronouns has the status of a tentative proposal and certainly needs revision in the light of special empirical studies on the subject matter. But this provisional account of pronouns should at least be sufficient to handle the following illuminating linguistic facts.

A provisional treatment of pronouns.

The sketch of pronominal reference given in this paper will at least take care of the following linguistic facts, which are contextual properties of pronouns.

(A) Within relative clause constructions, for every term there can occur a pronoun in the following text that is coreferential with it.

- (1) A man who loves the woman who loves him ...
 No man who loves the woman who loves him ...
 Every man who loves the woman who loves him ...
 The man who loves the woman who loves him ...
 John who loves the woman who loves him ...

But it seems doubtful whether terms "every ..." or "no ..." in subordinate relative clauses can have a coreferential pronoun in superordinate clauses, e.g.,

- (2) A man who loves every woman who loves him dates her.

(B) Within conditional and adverbial clause constructions coreference between a term in the subordinate clause and a pronoun in the main clause is possible only for terms with the indefinite or definite article and proper names in preceding subordinate clauses, and the indefinite term may not be in the scope of a negation operator or follow a term of the form "every ..." or "no ...".

- (2) * If every participant is invited to the party he has to buy some liquor.
 * Because every participant is invited to the party he has to buy some liquor.

- * Although every participant is invited to the party he has to buy some liquor.
- * If no participant is invited to the party he has to buy some liquor.
- * Because it is not the case that a participant is invited to the party he has to buy some liquor.
- * If every man dates a woman, she is happy.

But: If a participant is invited to the party he has to buy some liquor.
 If a participant is not invited to the party he may come nevertheless.
 Because John is invited to the party he has to buy some liquor.

(C) If the full term is in the main clause and the pronoun in the subordinate clause in conditional or adverbial clause construction coreference is possible for all terms, regardless whether the subordinate clause precedes or follows the main clause

- (3) Every participant has to buy some liquor if he is invited.
 No participant needs to buy liquor if he is invited.
 No participant needs to buy liquor because he is invited.
 Every participant has to buy liquor although he is invited.
 Although he is invited every participant has to buy liquor.

(D) Coreference extending over the sentence boundary is possible in parallel situations with those described under (B): Coreference is possible between pronouns and proper names, pronouns and definite terms, and between pronouns and indefinite terms if these are not in the scope of a negation operator.

- (4) * Every participant is invited. He has to buy some liquor.
 * No participant is invited. He has to buy some liquor.
 * It is not the case that a professor is invited to the party. He has to buy the liquor.
A professor is invited to the party. He has to buy the liquor.
A professor is not invited to the party. Therefore, he does not need to buy liquor.
The professor is invited to the party. He has to buy some liquor.
John is invited to the party. He has to buy some liquor.
 * Every man loves a woman. Therefore she is happy.

But specific:

Every man loves a woman. She is mother Mary.

(E) If the preceding indefinite term appears under the scope of an intensional operator or fills in an intensional position of a verb coreference is restricted to extensional readings if the pronoun is not under the scope of the same intensional operator or another intensional operator such that the set of possible worlds specified by the first is included in those of the second.

(5) John seeks a ball. It is red. (extensional reading)

*John seeks a wife. She is tall. (intensional reading)

But:

John seeks a wife. She must be tall.

John believes there is a red-eyed unicorn. He seeks it.

(F) Furthermore a theory of pronominal reference must be such that the so-called Bach-Peters-sentences can be handled.

(6) Every man who finds a car that he likes buys it.

A man who finds the woman who loves him dates her.

The man who loves her dates the woman who loves him.

The pronouns in the sentences under (6) have to be interpreted in such a way that they are coreferential with the corresponding term. But, furthermore, the interpretation procedure must also permit the interpretation with no coreference within the sentence, but with coreference with a term outside the sentence as is required in the texts under (7).

(7) John has a fine old car. Every man who wants the car he likes will buy it.

John has a nice girlfriend. Every man who chases a woman who he likes dates her.

To account for the linguistic facts (A)-(F), as far as pronominal reference is concerned, we develop an interpretation procedure that does the following: Pronouns in subordinate clauses get translated by means of variables that have to be bound by the same quantifier that is used in the translation of corresponding terms in the main clause. If the term is a proper name the pronoun is translated by means of a constant. With specific indefinite and definite terms both procedures are possible, the procedure via a variable or via a constant.

Pronouns in main clauses behave differently as to whether they are in relative

clause constructions or in adverbial and conditional clause constructions. In relative clause constructions they may be coreferential with an indefinite term in a relative clause, and, then translate via the variable or constant used with the translation of that term. In adverbial and conditional clause constructions they can only be translated by a constant used in the translation of the preceding term. In texts, pronouns with coreference that extends over the sentence boundary can only be translated by means of constants used or introduced with the translation of the preceding term.

To be able to formulate a translation procedure, which is taken to be the interpretation procedure of natural language sentences as far as the translation into an interpreted logical language goes, we first have to modify our previous procedure of translation for terms. This is done by using the method used in logical deductions, which is known as existential instantiation, universal instantiation, existential generalization and universal generalization. To avoid troubles, we introduce a method of blockade of variables which says that a variable blocked with the translation of a term may not be used in the translation of other terms in the course of interpretation of a sentence (clause construction), except in the translation of those pronouns that are coreferential with the term for which the variable was blocked.

The general interpretation procedure, or more precisely "translation procedure", IN, for terms that translate with a quantifier consists out of two parts: an instantiating translation and a generalization. Pronominal reference, as far as it happens via variables, occurs within the instantiating procedure and then takes part in the generalization and thus is captured inside the quantifier scope. This way, the problem of dangling variables in Montague grammar is avoided.

IN: In translating non-specific terms of the form "a(n)...", "every ...", "no ...", "the ..." block a new variable v with the translation (instantiating translation):

"a(n) ..." : $\lambda Q \lambda P (Q(v) \ \& \ P(v))$

"every ..." : $\lambda Q \lambda P (Q(v) \rightarrow P(v))$

"no ..." : $\lambda Q \lambda P (Q(v) \rightarrow \neg P(v))$

"the ..." ²: $\lambda Q \lambda P (Q(v) \ \& \ (\forall y)(Q(y) \rightarrow y = v) \ \& \ P(v))$

After finishing the translation of a sentence on the basis of this preliminary translation of terms the final translation is received by existential generalization and universal generalization according to the following rule. The order in which these operations are applied follows the order of the terms within the

sentence beginning from the inside, i.e. first we have generalization regarding the innermost term (i.e. the last term) and last we have generalization regarding the outermost term (i.e. the first term).

Generalizing interpretation:

(1)

Rule of order of application:

The order of application of quantifiers reflects the linear order of the terms in the sentence translated.

(2.1)

If a term A is preceded by an uneven number of head terms of the form "every ..." or "no ..." in embeddings of relative clause constructions of which the instantiating translation has been given, we get for A the following generalization:³⁾

If A = "a(n) ..." or A = "the ..." its generalization is achieved by binding the respective variables used in the instantiating translation of the term A by the universal quantifier ($\forall$).

If A = "every ..." or A = "no ..." its generalization is achieved by binding the respective variables used in the instantiating translation of the terms A by the existential quantifier ($\exists$).

(2.2)

Otherwise, we get the following generalization:

If A = "a(n) ..." or A = "the ..." its generalization is achieved by binding the respective variables used in the instantiating translation of the term A by the existential quantifier ($\exists$).

If A = "every ..." or A = "no ..." its generalization is achieved by binding the respective variables used in the instantiating translation of the term A by the universal quantifier ($\forall$).

(3)

After the generalization is completed, variable blockade is cancelled.

The procedure IN is based on the idea that surface order reflects the hierarchical order of deeper structures. It is a kind of reverse "global constraint", but in a more severe form than known from Lakoff 1971. It rules out that the sentence Every man loves a woman is interpreted as being ambiguous between "For every man there is a woman such that he loves her" and "There is a woman such that every man loves her". Only the first interpretation is a direct interpretation of the

sentence discussed. The second interpretation is stronger than the first. It can be inferred from the first in conjunction with sufficient contextual information as in "Every man loves a woman. She is mother Mary." Here we need to assume the specific interpretation for "a woman", because otherwise we would not have an antecedent term for the pronoun she. From the translation of this text we can infer the translation of "There is a woman such that every man loves her". But this does not mean that "Every man loves a woman" is ambiguous in the direct way assumed by Lakoff 1971 and, even, Montague 1974.⁴⁾ If we want to express the second reading, assumed by these authors, without a specifying context we have to use passive voice: "A woman is loved by every man" or the rather clumsy sentence "There is a woman such that every man loves her". Note, that in using the described translation procedure we avoid the undesirable multiplicity of readings, that arises by Montague's rule S14/T14 in Montague 1974.

Restriction on IN:

In the translation of subordinate clauses other than relative clauses, generalization has to be completed for all non-pronominal terms before the clauses get combined with their main clauses.

The restriction excludes the unacceptable cases under B and D. The acceptable ones, like If a man buys a car he insures it, are taken care of by using the new constant introduced with the translation of a car in the translation of the pronoun. The rules of pronominal reference are formulated such, that they permit that.⁵⁾ Of course, a satisfactory theory of interpretation can only be achieved if the study of the interpretation of subordinate clause constructions is completed. So long, the restriction on (IN) is just an ad hoc measure to avoid obvious mistakes.

These preliminaries suffice to establish a theory of pronominal reference that can account for the linguistic facts mentioned above. We restrict ourselves to non-reflexive pronouns.

The interpretation of non-reflexive pronouns: he, she, it (him, her are related to he, she, respectively, by a morphological rule)

IP:

Reference-Instruction:

1. (a) Search within the clause construction for the nearest preceding term with gender-number agreement with the pronoun such that term and the pronoun do not bind places of the same verb.⁶⁾
- (b) If there is no such term search for the nearest following term with gender-number agreement in the superordinate clause within the clause construction

such that that term and the pronoun do not bind places of the same verb.

(c) If there is no such term search for the second nearest preceding term with gender-number agreement, and so on.

(d) If there is no such term in the clause construction search for the next preceding term with gender-number agreement in the preceding text.

2. Has a term been found according to (1) then translate the pronoun by $\lambda PP(v)$ with v being the variable blocked in the course of translation of the term or with v being the constant used or being introduced with the translation of the term.⁷⁾ If there is no such variable or constant follow procedure (1) for the next subroutine among (a), (b), (c), (d).
3. If the interpretation achieved via the translation according to (1) and (2) is improbable or destroys text coherence - then follow procedure (1) and (2) for next subroutine among (a), (b), (c), (d).

The procedure formulated in IP very likely will turn out to be deficient in a further study of pronominal patterns. But it seems to suffice for the present purpose. We need two other syntactic rules to be able to construct sentences, term construction (S3) and sentence construction (S4). The surface structures are related to the categorial structures, constructed according to S3 and S4, by realization rules, including: serialization rules, lexicalization rules and morphological and morphophonemic rules. These will be neglected in the present fragment.

S3: If α is a D (determiner) and β is an N (noun), then $\alpha(\beta)$ is a T (term).

T3: If α' is the translation of α as a D and β' is the translation of β as an N, then $\alpha'(\beta')$ is the translation of $\alpha(\beta)$.

Pronouns are a subcategory of the category of terms. Their syntactic role is therefore described by the syntactic rules for terms. In our present fragment we shall use rule S3/T3 only.⁸⁾

S4: If β is a V^n (n -place verb) with the set of term-places K , $i \in K$, and α a T (term) then $(\alpha, i)(\beta)$ is a V^{n-1} with the set of term-places $K - \{i\}$. For this we write $(\alpha_{T< i >}(\beta_{Vn})_{Vn-1})$.

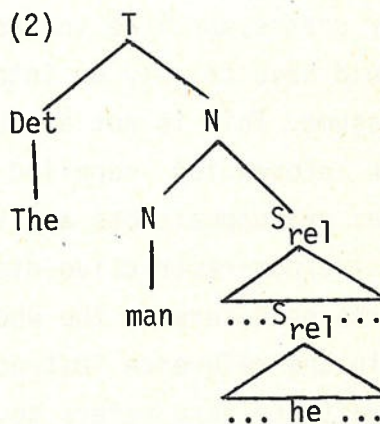
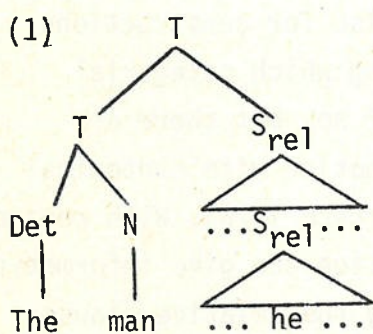
The corresponding translation rule is:

T4: If α' is the translation of α as a T and $\lambda x_1, \dots, x_n \beta'(x_1, \dots, x_n)$ is the translation of β as a V^n , then the translation of $(\alpha, i)(\beta)$ is:

$$\lambda x_1, \dots, x_{i-1} x_{i+1}, \dots, x_n (\alpha' (\lambda x_i (\beta' (x_1, \dots, x_n))))).$$

Note that this rule corresponds to rule S14/T14 in Montague 1974c, which is the basis of construction for de re readings. In the fragment presented in this paper we only get de re readings; but there exists a modification of this fragment with regard to S4 and T4 in part III of Bartsch/Ehrich/Finke 1976, which accounts for de dicto readings, too.

Before discussing Bach-Peters-sentences in detail, we should be aware of the following property of the procedure for pronominal interpretation presented here: This procedure relies on the analysis of the head term of a relative clause construction as a single constituent. That is, it assumes that analysis (1) is taken and not (2) as is usually done for restrictive clauses.



The reason for this is that a pronoun in a relative clause that is embedded in a higher relative clause may be translated by means of the variable used in the translation of the determiner of the head noun (of the higher relative clause) which by number and gender agreement establishes that the head term is a candidate for a preceding coreferential term. If we assume The man not to be a constituent, like in (2), we need to define a special surface structure relation between the determiner and the head noun that has no other function than serving as a link between the establishment of number-gender agreement between head noun and pronoun on the one handside; and the variable blocked in the translation of the determiner that goes with the head noun and that is needed for the translation of the pronoun on the other. Since it does not seem advisable to define, in grammar, two different kinds of constituents, those according to categorial structure and those according to the needs of establishing agreement and coreference, we suggest to use structure (1), i.e. term-modification, as a single syntactic structure for all relative

clause constructions, whether restrictive or non-restrictive.

There are also independent reasons for assuming a single categorial structure for all relative clause constructions, as also suggested by Thompson (1971):

- 1) There is only one surface structure for relative clause construction, as far as wordorder and morphology is concerned.
- 2) Because of (1) the question arises by means of what information one could decide, before entering the interpretation process, which categorial structure to take, the term-modifying one or the noun-modifying one.
- 3) The problem mentioned in (2) can be decided for head determiners a, every, no in favor of always taking the noun-modifying construction; and, for proper names as head term the only possible one is the term-modifying construction. But for head terms with a this would not be quite correct because non-restrictive relative clause constructions are possible, e.g., "a priest, who of course never cheats, shall be the accountant". And also for constructions with the, we would have to rely on intonation in deciding which categorial structure to assume. This is not a counter argument per se, but there are reasons to link information supplied by sentence intonation with contextual features such as presuppositions and focus (compare Bartsch 1976). With regard to the restrictive/non-restrictive distinction, intonation can give information about whether the head term or the whole term including the relative clause shall be used in the reference instruction that has to be followed to find the individual a definite term refers to. This means that a minor modification of our rule of reference instruction for definite terms is in order.
- 4) If we decide to favor a single syntactic relative clause construction for all relative clauses we cannot do with the one in which the relative clause is a noun-modifier, i.e. according to structure (2), because relative clauses may occur with proper names or pronouns as head terms. Thus, only structure (1), i.e. the relative clause as a term-modifier, can be a candidate for a single syntactic relative clause construction.

Although our treatment of Bach-Peters-sentences can also be used with regard to structures with relative clauses as noun-modifiers⁹⁾ we decide to abandon this construction in favor of the term-modifier construction as the only syntactic relative clause construction. This decision is based, first, on the desirability to have a head term as a constituent for our retrieval of the variable or constant to be used in the translation of pronouns, and, second, on the independent considerations mentioned under (1)-(4). The treatment of all relative clause constructions as term modifying ones amounts to cancel S1/T1 and to supply a new formulation of T2.2.

T2.2: If $(\delta_D(\alpha_N)_T)$ translates into $\lambda P(\dots \alpha'(v) \dots)$, with v as a variable or constant and γ translates into $\lambda x \gamma'(x)$, then the relative clause $\beta(\gamma)$ translates into a mapping to the effect that $\alpha'(\cdot)$ is replaced by $\alpha'(\cdot) \& \gamma'(\cdot)$ in all its occurrences. I.e. $\beta'(\lambda P(\dots \alpha'(v) \dots), \lambda x \gamma'(x)) = \lambda P(\dots \alpha'(v) \& \gamma'(v) \dots)$ and, accordingly, $(\beta'(\lambda x \gamma'(x)))(\lambda P(\dots \alpha'(v) \dots)) = \lambda P(\dots \alpha'(v) \& \gamma'(v) \dots)$.

Note, that if v is a constant the reading is in fact the non-restrictive one; if v is a variable the reading may be restrictive, depending on whether there are, in fact, more individuals with the property α' than with the properties α' and γ' . If δ is the definite determiner then it may be that the uniqueness condition is not fulfilled with α' but rather with α' and γ' in conjunction. Note, that $\alpha(\cdot)$ has also to be replaced by $\alpha(\cdot) \& \gamma(\cdot)$ in the uniqueness condition. It is possible that the translation of "the α " has no designation, namely if the uniqueness condition $(\forall y)(\alpha'(y) \rightarrow v = y)$ is not fulfilled, but "the α that γ " has a designation, if the definite description with a restrictive relative clause is used correctly.

EXAMPLES

(1) Every man who buys a car insures it.

This sentence cannot be interpreted in Montague's (1974) fragment with coreference between it and a car. In the present fragment both interpretations are possible, with and without coreference within the sentence. In this example the interpretation with coreference is the most probable.

A: Instantiating translation:

<u>every man</u> :	$\lambda P(\text{man}'(x) \rightarrow P(x)); x \text{ blocked!}$	[T3, IN]
<u>a car</u> :	$\lambda P(\text{car}'(y) \& P(y)); y \text{ blocked!}$	[T3, IN]
<u>it</u> :	$\lambda PP(y)$	[IP]
<u>buys a car</u> :	$\lambda v(\text{car}'(y) \& \text{buy}'(v, y))$	[T4, lexicon]
<u>every man who</u> <u>buys a car</u> :	$\lambda P(\text{man}'(x) \& \text{car}'(y) \& \text{buy}'(x, y) \rightarrow P(x))$	[T2.2]
<u>insures it</u> :	$\lambda v \text{ insure}'(v, y)$	[T4]
<u>every man who buys</u> <u>a car insures it</u> :	$\text{man}'(x) \& \text{car}'(y) \& \text{buy}'(x, y) \rightarrow \text{insure}'(x, y)$	

B: Generalizing translation (complete translation):

$(\forall x)(\forall y)(\text{man}'(x) \& \text{car}'(y) \& \text{buy}'(x, y) \rightarrow \text{insure}'(x, y))$

Note that a car was preceded by one head term of the form "every ..." and thus got generalizaed by (Ψ).

(2) Every man who finds a woman who loves him dates her.

A: Instantiating translation:

<u>every man:</u>	$\lambda P(\text{man}'(x) \rightarrow P(x)); x \text{ blocked!}$	[T3, IN]
<u>a woman:</u>	$\lambda P(\text{woman}'(y) \& P(y)); y \text{ blocked!}$	[T3, IN]
<u>him:</u>	$\lambda PP(x)$	[IP]
<u>her:</u>	$\lambda PP(y)$	[IP]
<u>love(s):</u>	$\lambda v z \text{ love}'(v, z)$	[lexicon]
<u>love(s) him:</u>	$\lambda v(\lambda PP(x))(\lambda z \text{ love}'(v, z))$ $= \lambda v(\lambda z \text{ love}'(v, z))(x)$ $= \lambda v \text{ love}'(v, x)$	[T4]
<u>a woman who loves him:</u>	$(\text{REL}(\lambda v \text{ love}'(v, x)))(\lambda P(\text{woman}'(y) \& P(y)))$ $= \lambda P(\text{woman}'(y) \& \text{love}'(y, x) \& P(y))$	[T2.2]
<u>find(s):</u>	$\lambda v z \text{ find}'(v, z)$	[lexicon]
<u>finds a woman who loves him:</u>	$\lambda v((\lambda P(\text{woman}'(y) \& \text{loves}'(y, x) \& P(y)))(\lambda z \text{ find}'(v, z))) = \lambda v((\text{woman}'(y) \& \text{love}'(y, x) \& \text{find}'(v, y)))$	[T4]
<u>every man who finds a woman who loves him:</u>	$(\text{REL}(\lambda v(\text{woman}'(y) \& \text{love}'(y, x) \& \text{find}'(v, y)))(\lambda P(\text{man}'(x) \rightarrow P(x))))$ $= \lambda P(\text{man}'(x) \& \text{woman}'(y) \& \text{love}'(y, x) \& \text{find}'(x, y) \rightarrow P(x))$	[T2.2]
<u>date(s):</u>	$\lambda v z \text{ date}'(v, z)$	[lexicon]
<u>date(s) her:</u>	$\lambda v(\lambda PP(y))(\lambda z \text{ date}'(v, z))$ $= \lambda v \text{ date}'(v, y)$	[T4]
<u>every man who finds a woman who loves him dates her:</u>	$(\lambda p(\text{man}'(x) \& \text{woman}'(y) \& \text{love}'(y, x) \& \text{find}'(x, y) \rightarrow P(x)))(\lambda v \text{ date}'(v, y))$ $= \text{man}'(x) \& \text{woman}'(y) \& \text{love}'(y, x) \& \text{find}'(x, y) \rightarrow \text{date}'(x, y)$	[T4]

B: Generalizing translation (complete translation):

1 regarding a woman (with preceding "every ..."):

$$(\forall y)(\text{man}'(x) \ \& \ \text{woman}'(y) \ \& \ \text{love}'(y, x) \ \& \ \text{find}'(x, y) \rightarrow \text{date}'(x, y))$$

2. regarding every man:

$$(\forall x)(\forall y)(\text{man}'(x) \ \& \ \text{woman}'(y) \ \& \ \text{love}'(y, x) \ \& \ \text{find}'(x, y) \rightarrow \text{date}'(x, y))$$

(IN, (1)-(3))

With this, the translation is completed and the interpretation can be provided according to model theory for predicate logic.

Compare the following text with the interpretation of (2).

(3) Johns knows a nice girl. Every man who loves every woman that pays attention to him dates her.

Here her is not interpreted as coreferential within the sentence but rather as coreferential with a nice girl from the preceding text. Otherwise we would get an incoherent text. We receive as the translation of the first sentence

$(\exists x)(\text{know}'(h, x) \ \& \ \text{girl}'(x) \ \& \ \text{nice}'(x))$ with referent introduction: a with $\text{know}'(h, a) \ \& \ \text{girl}'(a) \ \& \ \text{nice}'(a)$. Then the pronoun her of the second sentence can be translated by $\lambda PP(a)$. Thus we get as the appropriate interpretation:

$(\forall x)(\exists y)(\text{man}'(x) \ \& \ (\text{woman}'(y) \ \& \ \text{pays attention to}'(y, x) \rightarrow \text{love}'(x, y)) \rightarrow \text{date}(x, a))$. This is equivalent to $(\forall x)((\forall y)(\text{man}'(x) \ \& \ (\text{woman}'(y) \ \& \ \text{pays attention to}'(y, x) \rightarrow \text{love}'(x, y)) \rightarrow \text{date}'(x, a))$ and to $(\forall x)((\text{man}'(x) \ \& \ (\forall y)(\text{woman}'(y) \ \& \ \text{pays attention to}'(y, x) \rightarrow \text{love}'(x, y))) \rightarrow \text{date}'(x, a))$

The following example has a pronoun preceding its coreferring term in the main clause. Rule (IP) takes care of this.

(4) A man who finds her dates a woman who loves him.

Following the rules of our fragment we get the translation:

$$(\exists x)(\exists y)(\text{man}'(x) \ \& \ \text{woman}'(y) \ \& \ \text{love}'(y, x) \ \& \ \text{find}'(x, y) \ \& \ \text{date}'(x, y))$$

Compare the following text with the interpretation of (4):

(5) Kathrin is a well-known psychologist. A man who listens to her dates a woman who loves him.

Because of text coherence we have to follow the procedure (IP) until we get Kathrin as the coreferring term with the pronoun her. If $\lambda PP(k)$ is the translation of

Kathrin we get $\lambda PP(k)$ as the translation of the pronoun her.

In the following example we get the particular interpretation and not the universal interpretation, which would be more probable.

(6) The man who finds a woman who loves him dates her.

$(\exists x)(\exists y)(\text{man}'(x) \ \& \ \text{woman}'(y) \ \& \ \text{love}'(y, x) \ \& \ \text{find}'(x, y) \ \& \ (\forall z)(\text{man}'(z) \ \& \ \text{woman}'(y) \ \& \ \text{love}'(y, z) \ \& \ \text{find}'(z, y) \rightarrow z = x) \ \& \ \text{date}'(x, y))$

The general interpretation that takes the man as a term denoting an universal concept cannot be derived in this fragment.

But we get another particular interpretation which is the non-restrictive interpretation of

(7) The man, who finds a woman who loves him, dates her.

This interpretation is based on the translation of the man which refers to a contextually introduced referent; let it be b. Then we get:

$(\exists x)(\text{man}'(b) \ \& \ \text{woman}'(x) \ \& \ \text{love}'(x, b) \ \& \ \text{find}'(b, x) \ \& \ \text{date}'(b, x))$.

Note that our fragment permits the translation of sentences like

(8) Every man who loves every woman is happy.

It is $(\forall x)(\exists y)(\text{man}'(x) \ \& \ (\text{woman}'(y) \rightarrow \text{love}'(x, y)) \rightarrow \text{happy}'(x))$. This is equivalent to $(\forall x)(\text{man}'(x) \ \& \ (\forall y)(\text{woman}'(y) \rightarrow \text{love}'(x, y)) \rightarrow \text{happy}'(x))$.

But it also admits to derive a translation with coreference between the underlined terms for sentences as

(9) Every man who finds every woman who loves him dates her.
and

(10) A man who finds every woman who loves him dates her.

The translations received are:

(9') $(\forall x)(\exists y)(\text{man}(x) \ \& \ (\text{woman}(y) \ \& \ \text{love}(y, x) \rightarrow \text{find}(x, y)) \rightarrow \text{date}(x, y))$
and

(10') $(\exists x)(\forall y)(\text{man}(x) \ \& \ (\text{woman}(y) \ \& \ \text{love}(y, x) \rightarrow \text{find}(x, y)) \ \& \ \text{date}(x, y))$,

respectively.

This might not be desirable because sentences (9) and (10) seem, at least to me, unacceptable with coreference between the underlined terms. If we have a close look at the truth conditions of these translations we realize that (9) would be true if for every man there is at least one woman who loves him but he would not find her (this makes the second part of the conjunction in the antecedence of the main conditional false and therefore the whole conditional true). Sentence (10) would be true if there would be a man, but no y would be a woman [or no y would love this man] and, he would date y.

We might want to block the interpretation of these sentences as Bach-Peters-sentences, because of their likely unacceptability in the coreference reading. The blockade of the translation of these sentences could be achieved by placing a restriction on (IP) to the effect that in a subordinate clause, i.e. including relative clauses, no term of the form "every . . ." or "no . . ." can be the coreferential term for a pronoun in the main clause. - This was already excluded for subordinate clauses other than relative clauses by a restriction on (IN). The restriction on (IP) would make sentences (9) and (10) only have the interpretation in which every man and her are not coreferential.

The treatment of Bach-Peters-sentences given in this paper suffers under the fact that some rules and restrictions show features that make an ad hoc appearance. This is true about the restrictions on referent introduction, the restriction placed on the rule (IN) and the restriction on (IP) mentioned above, and the generalization procedure for instantiating translations that made the choice of the quantifier dependent in whether there is an uneven number of preceding head terms (of relative clause constructions) of the form "every . . ." or "no . . .". It seems to me that in the course of the development of a more comprising theory of pronouns and subordinate clause constructions some of these features could be covered by rules that are more general.

Pragmatic features of relative clause construction are treated in a separate paper (Bartsch (ms)).

NOTES

- (1) This can be continued for the third last sentence and possibly further backwards. Further empirical studies are necessary to decide about factors determining the limit of searching backwards. It should be noticed that the procedure has to be extended: if according to the procedure formulated here, no individual name can be found then the procedure has to be repeated with the weaker requirement "the predicate specifying Q may be true about the individual" instead of "is true".
- (2) Note that "the ..." can also be translated by means of a constant by the procedure introduced previously. This translation is appropriate for non-restrictive relative clauses.
- (3) The necessity of formulating the disjunction that complicates part (2) of this rule has been brought to my attention by Zeno Swijtink and Theo Janssen. Without this complication a sentence like "Every man who finds a woman who loves him is happy" would receive the wrong interpretation according to $(\forall x)(\exists y)(\text{man}(x) \ \& \ \text{woman}(y) \ \& \ \text{love}(y, x) \ \& \ \text{find}(x, y) \rightarrow \text{happy}(x))$ instead of the right interpretation according to $(\forall x)((\exists y)(\text{man}(x) \ \& \ \text{woman}(y) \ \& \ \text{love}(y, x) \ \& \ \text{find}(x, y)) \rightarrow \text{happy}(x))$ which is equivalent to the one we get in the present paper, namely $(\forall x)(\forall y)(\text{man}(x) \ \& \ \text{woman}(y) \ \& \ \text{love}(y, x) \ \& \ \text{find}(x, y) \rightarrow \text{happy}(x))$ (compare note 5). Note further, that a coordination of head terms will count as one head term; but the treatment of constructions with coordinated terms goes above the present treatment.
- (4) The assumption of the specific reading for "a woman" by the hearer is a matter of cooperation with the speaker by the hearer. The speaker uses the pronoun in an, to the hearer, unexpected way. Therefore the hearer has to reconsider his interpretation of the preceding sentence and to assume that the speaker has somebody in mind he is referring to by the term "a woman". The specific readings are always only secondary readings the hearer can get at by context or situational information, as, for example, with: "Look a boat is capsizing", where the hearer might answer: "No, it is just heeling over." Certain verbs, especially verba sentiendi, e.g. see, hear, are an indicator that the hearer might assume a specific reading with regard to the speaker's universe of discourse. These are the only situations when a hearer may interpret a relative clause with "a(n) ..." as head term as non-restrictive.
- (5) Note, that for conditional sentences the restriction on IN corresponds nicely with the fact that $(\forall x)(\dots x \dots) \rightarrow p$ is not equivalent to $(\forall x)((\dots x \dots) \rightarrow p)$ and that $(\exists x)(\dots x \dots) \rightarrow p$ is not equivalent to $(\exists x)((\dots x \dots) \rightarrow p)$. For a sentence

like "If every man buys a car industry flourishes" we have to receive the translation $((\forall y)((\exists x)(\text{man}'(y) \rightarrow \text{car}'(x) \ \& \ \text{buys}'(y, x)))) \rightarrow \text{flourish}(i)$. The scope of the universal quantifier may not be extended beyond the main conditional without changing truth conditions. Therefore, we are not able to provide a translation for the following sentence with every man and he being coreferential:

If every man buys a car he profits from it.

And, luckily, we do not need to supply a translation for this sentence because it is unacceptable with coreference.

(6) Otherwise the pronoun would have to be a reflexive pronoun. It was brought to my attention by Martin Stokhof that it is not possible to establish on the surface level that this restriction holds for examples like: Every man who beats him, where every man should not be selected as a coreferential preceding term for him. The information whether two terms are binding places of a single verb has to be formulated on the level of the translation of the sentence. On the surface level we might do with the following restriction:

A pronoun occurring in a relative clause as binding one of the places of the verb of that relative clause cannot have the head term of the relative clause construction as its preceding term with coreferentiality.

(7) According to the restriction placed on IN, the terms "every ...", "no ...", and "a(n) ..." under negation or preceded by a term of the form "every ..." or "no ...", are excluded as preceding coreferential terms in subordinate clauses other than relative clauses. They are **excluded** because the blocked variable is no more retrievable since the translation of those subordinated clauses has been completed before they got interpreted into the translation of the clause construction. Thus we prevent the non-acceptable examples under (B) and (D). By way of cooperation, the hearer might assume "a(n)..." to be intended in a specific use, if he does not find another term that fits to be coreferential with the pronoun to be interpreted.

(8) This rule and others are motivated for languages with a morphological case system and fairly free order of terms, like German, in Bartsch 1976. In English restrictions are placed on the order of application of terms in the different case-positions, if we assume that linear word order reflects the hierarchy of structures formulated according to rules of categorial syntax.

(9) This stand was taken by Theo Janssen in a criticism of this paper.

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SEMANTICS, GAMES AND ANAPHORIC CHAINS

Jerold A. Edmondson

In "The proper treatment of quantification in ordinary English", Montague (1974) illustrates the power and elegance of his theory of syntax and semantics by providing an account of indefinite NP's in the environment of intensional verbs. This tour de force rests, I think, on a number of assumptions and strategies, three of which might be characterized as follows:

I. The translation targets in intensional logic of natural language indefinite NP's involve variable binding with an existential quantifier, i.e.

$$(1) \quad \underline{a}/\underline{an}(\zeta) \Rightarrow \lambda P \exists x (\zeta'(x) \wedge P(x)).$$

I have slightly simplified Montague here and throughout by having the quantification be over individuals and not over individual concepts, taking my lead from Bartsch (1975) and Bennett (1975).

II. Montague provides for dual derivations of NP's in the syntax. On the one hand, a full noun phrase (term) begins in the derivation outside the core of the sentence and then replaces the first occurrence in a series of variables, the remaining variables becoming he, she or it according to the gender of the term. Or secondly, a full noun phrase can originate as a nuclear constituent in the analysis tree.

Following Gabbay-Kasher (1975), I call these two strategies external and internal derivations respectively. The sentence John seeks a unicorn thus can come from either 2a or 2b.

- (2) a. ((a unicorn) (John (seek him₀)))
 b. (John (seek (a unicorn)))

When translated into intensional logic a unicorn in 2a winds up outside the scope of the translation of the verb seek, while in 2b the rendering of a unicorn remains inside the scope of seek. The verb seek in the two forms 2 turns out to have a different translation in intensional logic, translations that are, however, systematically related by meaning postulate for extensional verbs.¹

III. Montague semantics employs a strong version of the principle that the meaning of complex expressions is constructable from the meaning of the parts, Frege's Principle. Specifically,

Thomason (1974:28) says:

The strategy that Montague inherited from metamathematical semantics or model theory, consists in assigning semantic values to linguistic expressions by means of semantic rules. These rules are formulated in a recursive definition that retraces the syntactic construction of expressions. (my underlining).

The meaning of complexes ensues not only from the meaning of the parts but from a step by step build-up of the whole, where only derivationally adjacent material may combine.

In this paper I will argue that in seeking to expand Montague's fragment to include an account of complexer cases of anaphoric chaining intrasententially and across sentence boundaries there is reason to challenge all of these assumptions. The kind of empirical evidence that leads me to this conclusion comes primarily from the capacity of an indefinite NP to introduce a discourse referent. So that it is clear what kinds of empirical phenomena are at issue, I offer this summary of the assumptions and conclusions found in Karttunen's "Discourse referents" (1971).

IV. In general, indefinite noun phrases have both a specific and a nonspecific interpretation except for nonreferring instances, as for example in the case of predicate nominatives, idioms and generics.

V. Specific indefinite interpretations are associated with the capacity to introduce a discourse referent, nonspecific indefinites do not introduce them. Consider:

- (3) a. John has a girlfriend. She is a real fox.
 b. John doesn't have a girlfriend. *She is a real fox.

A pronoun or definite NP can take up an individual only if the introducing indefinite is specific.

VI. Modal verbs, opaque verbs and "other world" verbs in the environment of indefinites prevent or alter the introduction of a discourse referent.

- (4) a. John needs a drink. *It is cold. (opaque verb)
 b. John must find a lavatory. *It is dirty. (modal)
 c. Mary wants to find a cure for cancer. *It is with drugs. (opaque verb)
 d. John believes Mary sleeps in a hammock. *It has

yellow fringe. (belief context)

VII. If the pronoun or definite NP is itself in the scope of a nontransparent verb, then a continuous text may occur.

- (5) a. John needs a drink. He needs it bad.
 b. John must find a lavatory. He wants it to be clean.
 c. Mary wants to find a cure for cancer. It will be with drugs.

In the case of 4d an acceptable reading is present if one assumes that a hammock is a description of something in the speaker's world, but unacceptable if it is supposed to introduce something in John's belief world.

VIII. The kind of environments that can influence the introduction of discourse referents include not only the intensional verbs but also negations, some extensional verbs, questions and imperatives.

My assumption in the following remarks will be that it is desirable to find an adequate account of when and how an indefinite NP can introduce a discourse referent in one of the several worlds that are pointed at or created by the verbs types described above.

Let us first consider Montague's use of the existentially quantified sentence as a translation of the specific indefinite NP. It seems to me that a number of objections to this treatment can be raised. The first reservation I have taken in its entirety from Gabbay-Kasher (1975), though I disagree that this weakness speaks against the translation of the nonspecific indefinite with an existentially quantified sentence. Assume a sentence of the type:

- (6) Johnny planted an appletree.

which according to PTQ would have a translation like 7, making the simplifications I have discussed at the beginning.

- (7) $\exists x(\text{appletree}'(x) \wedge \text{planted}'(j, x))$

Now, 6 can certainly introduce a discourse referent as in 8.

- (8) It bore fruit the first year.

However, a natural language paraphrase of the logically equivalent form of the translation 7, namely 9, cannot.

- (9) Not every appletree is such that it is not the case that Johnny planted.it. *It bore fruit the first year.

Thus, we see that the existentially quantified sentence cannot be an adequate rendering of one of the crucial properties of natural

language indefinite NP's in its specific interpretation. They do not have the capacity to introduce a discourse referent. Identical semantics (truth conditions) does not suffice to describe this property.

A second objection comes from what we know about anaphoric chains from our experience as speakers and hearers. A quantifier-variable-binding hypothesis of anaphoric chains would have to include a variable for each succeeding occurrence of a pronoun in a text sequence. The entire structure would then presumably be in the scope of a single prenex quantifier as in Montague's PTQ. But, in natural languages, when we speak or write, the first pronouns may be in the next sentence or in the next paragraph. Furthermore, a series of pronouns can extend the length of an entire book. Yet, the quantifier-scope theory would be tantamount to claiming that the translation of natural language is such that a truth value for a series of propositions is adducible only after the last variable (i.e. pronoun) had been uttered, assuming that the hearer constructs the interpretation during the time of utterance. Simply put, the first sentence can be understood only when the last pronoun of a series has fallen. Such a claim is, of course, absurdly counter-intuitive and such a theory could no longer assert that it wants to do justice to both the psychological and the logical sides of language.

Thirdly, there are anaphoric chains between an indefinite and following definite NP's in which the terms obviously refer to different things and still an anaphoric link is involved, cf. Karttunen (1968) and Harweg (1968). Harweg has worked out an elaborate typology of such chains, showing that they depend upon such tertia comparationis as part-whole, whole-part, culture specific or object specific associations and other links.

- (10) a. A face appeared in front of my front door peep hole.
She was blonde and very attractive. (whole-part)
 b. A book fell over. The silver bookend had just been
removed for polishing. (object association)
 c. A new Mercedes 280SEL with the right front fender
damaged pulled around the corner. (part-whole)

What this kind of example shows is that variable binding can capture only particular subcases of anaphoric chaining, those where a

certain object is repeatedly referred to. Montague's rules S14, S15 and S16 bind all occurrences of a variable simultaneously, whereas our natural language facility seems to demand a step by step process that can involve speaker specific knowledge. Notice further that for a fragment of English incorporating the plural, variable binding would have to be enriched very considerably to include instances where two or more indefinites that appear at different places in the sentence bind a single set variable. And conversely, there are cases in which a collective indefinite NP is capable of binding pronouns that represent subsets of the collection, where these pronouns may appear at nonadjacent places in the succeeding discourse.

- (11) a. A man met a woman on the corner. They went into the nearest bar.
 b. A married couple was walking in the park. She had on a blue dress, he a grey suit.

Providing for every eventuality in advance, as would be done in the variable binding hypothesis, would lead to very complicated rules indeed. As Quine is supposed to have said, the variables of logical languages are like the natural language pronouns and not the reverse, cf. Partee (1972:441).

These arguments militate quite strongly, it seems to me, against a theory in which indefinites in natural language are treated as in Montague (1974) and for a theory in which they are viewed as reference instructions to introduce individuals into a particular discourse world, cf. Ballmer (1972) and Bartsch (1975).

Now, if it can be said that variable binding encounters difficulty in the above type sentences, then the following case is even more perplexing. The verbs be missing, lack, go wanting and be absent are not thought to be "other world" verbs though all have a certain negative "flavor". Nevertheless, if one would wish to attempt a solution with decomposition, then one would still need to explain that the subject term and not the object term is potentially ambiguous. In the sentence 12:

- (12) A twenty-dollar bill is missing from the cash drawer.

I, like Gabbay-Kasher (1975), detect the same ambiguity as in the sentences with negative environment. Usually, a twenty-dollar bill is regarded to be nonspecific since such objects are not easily individualizable. However, one can certainly get a specific reading

as soon as we are talking about a collection of marked notes or evidence at a trial. The difference between the specific and non-specific readings of 12 is not in the sense of twenty-dollar bill but in the way in which the speaker is using the description. We can convince ourselves of this fact by asking how the speaker might choose to prove the truth of each reading in 12. He might show the person who challenged him a list of serial numbers and say "see, it's gone." Where the reading "twenty dollars has been stolen" is meant, the speaker is reduced to counting the money. It is perhaps now clear why this group of verbs can be used with a specific or non-specific indefinite subject. The property be missing from cannot be used to identify an object out of a population of bills because the individual is no longer in the field of search. A specific interpretation depends on the speaker having sufficient information external to the utterance of the sentence in question that allows him, when challenged, to clarify by ostension or other means who or what is meant, otherwise only indirect verification is possible.

The second keystone of PTQ was the method of internal and external derivations. Actually, the constructional duality of sentences with indefinite NP's has been generalized for all sentences. Subsequently, these dual forms have been exploited to account for a number of syntactic ambiguities: strict/sloppy identity, focusing and topic-comment distinctions. While this evidence is not without its appeal there does remain an infinitely large group of sentences with two or more structurally different analysis trees where speakers sense no structural ambiguity. For this reason, I have chosen to be even more "surfacy" than Montague and to develop a syntactic model for analyzing English that doesn't allow dual derivations. Such a step will obviously mean a somewhat more complex semantics, but this price seems justified if the result accords with our intuitive understanding, especially if some of the intuitively nonexistent scope ambiguities predicted by variable binding can be eliminated.

Since I haven't much time to talk about syntax here, I am going to hope that the following fragmentary rules suffice to give a provisional though certainly still inadequate sketch of the syntax of verbs and NP's, cf. Bartsch (1975).

(13) Sketch of a categorial syntax

Basis categories: The n-place verb categories, V^n and

the common noun phrase category, N.

Derived or functor categories: Terms (including proper names, definite and indefinite NP's, pronouns) $T = V^{n-1}/V^n$. Determiners (including the articles) $D = T/N$.

Formation rules: If $\rho \in T$ and $\beta \in V^n$, then by applying ρ in the i -th place of β a V^{n-1} ensues, i.e.

$(\rho_{\langle i \rangle T} (\beta_{V^n})_{V^{n-1}}) \dots V^0 = S$. If $\sigma \in N$ and $\beta \in D$, then $(\beta(\sigma)) \in T$, i.e. $(\beta_D(\sigma_N)_T)$.

A sentence like 6

(6) Johnny planted an appletree.

thus has a syntactic representation

(14) $\{\text{Johnny}_{\langle 1 \rangle T} \{\text{an appletree}_{\langle 2 \rangle T} \{\text{planted}_{V^2}\}_{V^1}\}_S\}$

where the indices $\langle 1 \rangle$ and $\langle 2 \rangle$ indicate the argument places of plant to which the terms apply.

The third of Montague's hypotheses was that the semantics recapitulates the syntax and works from the inside of complex expressions to the outside. This is in essence also the position that Karttunen (1971:11) takes, "a text interpreting device apparently has to process complex sentences starting from the inside". He is led to this conclusion because of short term reference as in

(15) Mary had a baby and named her Sue.

If, then, 15 falls in the scope of I don't believe that, then the discourse referent is erased. Yet, all that is really demanded is that a baby and her be interpreted together since there are natural language sentences in which a discourse referent is introduced by such a constellation as in 16.

(16) I don't believe that Mary had a baby and I can't imagine that she called her Sue.

Karttunen is forced to conclude that the semantics operates from the inside out because the context I don't believe that is supposed to cancel a specific reading. But, 16 shows that the verbal environment relegates the individuals in the chain to certain worlds.

Implicative verbs are another instance in which the derivationally nonadjacent context can influence the interpretation of indefinites. Consider the sentences:

- (17) a. John filled a tank.
 b. John forgot to fill a tank.
 c. John didn't forget to fill a tank.

- d. John managed to find an apartment.
- e. John didn't manage to find an apartment.

Whereas Karttunen assumes two readings for each of the indefinites in underlying structure and a subsequent alteration by the context, all of the speakers I have consulted find that 17a, c and d are unambiguously specific and that 17b and e have both specific and nonspecific readings. It appears that the contexts creates readings and not the reverse. The example 17c is especially instructive. A negated negative implicative verb like forget, just like 17a, is unambiguously specific. Once again, Montague's approach was to provide for all the possible readings an indefinite might have in any context and allow the context to eliminate the incorrect ones or to declare readings to be equivalent in the presence of certain verbs. The exact opposite approach is also possible and is perhaps needed if we are to account for sentence like 16. In the following I intend to propose a solution to the semantics of sentences containing anaphoric chains that operates from the outside in. In many ways it is identical with the suggestions made in Hintikka (1973, 1974a, 1974b) and Hintikka-Saarinen (1975).

The core of Hintikka's suggestion rests on verifying that a sentence is compatible with a certain given state of affairs that it is supposed to describe. This occurs by means of a game between two mythological players called MYSELF and NATURE, who pick individuals from a domain D and substitute them into the sentence in question. All of the predicates and relations are defined on the domain D, which means that each atomic sentence has a determinate truth value, i.e. a set of ordered n-tuples assembled from D that make the relation true. Both of the players are taken to know all of these sets in advance. MYSELF is trying to pick individuals to make a true sentence, which means that he is trying to construct an ordered set that is an element of the extension set of the predicate or relation involved. NATURE is trying to construct a false sentence, i.e. force in a nonelement. The rules of the game determine whose turn it is and what moves are allowed. The game is a zero-sum game with a definite winner, no draws.

My approach differs from Hintikka's because the game rules do more than merely pick individuals. They also give instructions

about how to unpack nonatomic sentences into their atomic parts and most importantly how to translate the signs of the natural language syntax. I now list some of the most important rules of the game.

- (18) a. Indefinite NP's. If play lands on a/an(ζ) in the structure $(\dots(\underline{a\zeta}_T(\dots))\dots_S)$, then MYSELF picks an individual from D, say b, and play continues with respect to $(\dots(\lambda QQ(b)(\dots))\dots_S) \wedge \lambda x\zeta(x)(b)$.
- b. Proper names. If play lands on John in the structure $(\dots(\underline{John}_T(\dots))\dots_S)$, then MYSELF or NATURE selects an individual from D, say j, and play continues with respect to $(\dots(\lambda QQ(j)(\dots))\dots_S)$.
- c. Verbs. If play lands on $\beta_V n$ in the structure $(\dots(\beta_V n)_S)$, then play continues with respect to the structure $(\dots(\lambda x_1 \dots x_n \beta(x_1 \dots x_n))_S)$.
- d. Negated verbs. If play lands on not $\beta_V n$ in the structure $(\dots(\underline{not} \beta_V n)_S)$, then roles reverse and play continues with respect to $(\dots(\lambda x_1 \dots x_n \beta(x_1 \dots x_n)))$. MYSELF is now looking for a false sentence and NATURE for a true one.
- e. Δ . If play lands on Δ in the structure $(S \wedge S')$, then NATURE picks one of the two conjuncts and play continues with respect to it.

One final point is necessary before we can illustrate a game. A win occurs when all the symbols of natural language have been played. The original sentence is verified iff MYSELF has a strategy of constructing a true atomic sentence (or false one if roles have been switched) regardless of what NATURE does. With the general ideas somewhat clarified though certainly not yet sufficiently restricted, I turn to an example, the sentence 14.

- (19) a. $\{\underline{Johnny} \{\underline{an\ appletree} \ \{\underline{planted}\}\}\}$
- b. MYSELF begins by selecting an individual from D for Johnny, translating and substituting in the formula. $\{\lambda PP(j) \ \{\underline{an\ appletree} \ \{\underline{planted}\}\}\}$
- c. MYSELF picks an individual for an appletree, translates and substitutes. $\{\lambda PP(j) \ \{\lambda QQ(b) \ \{\underline{planted}\}\} \wedge \lambda x\underline{appletree} \ x(b)\}$
- d. MYSELF translates planted. $\{\lambda PP(j) \ \{\lambda QQ(b) \ \{\lambda xy \ \underline{planted} \ xy\}\} \wedge \lambda x\underline{appletree} \ x(b)\}$

- e. NATURE must now pick one of the two conjuncts and the game ends. NATURE will lose every time iff both $\langle j, b \rangle \in |\underline{\text{planted}}|$ and $b \in |\underline{\text{appletree}}|$. If this is the case, then MYSELF, having picked j and b , has a winning strategy for any move NATURE can make.

In order to see how this kind of game semantics will yield the specific and nonspecific interpretations in the case of negated verbs, consider the game for the sentence Johnny didn't plant an appletree.

- (20) a. $\{\underline{\text{Johnny}} \quad \underline{\{\text{an appletree} \quad \{\text{not planted}\}}\}$
 b. MYSELF chooses an individual for Johnny, say j , translates and substitutes.
 $\{\lambda PP(j) \quad \underline{\{\text{an appletree} \quad \{\text{not planted}\}}\}$
 c. MYSELF chooses an individual for an appletree, translates and substitutes.
 $\{\lambda PP(j) \quad \{\lambda QQ(b) \quad \underline{\{\text{not planted}\}}\} \quad \wedge \quad \lambda x \underline{\text{appletree}}x(b)\}$
 d. MYSELF translates not planted, roles switch.
 $\{\lambda PP(j) \quad \{\lambda QQ(b) \quad \underline{\{\lambda xy \text{ planted } xy\}}\} \quad \wedge \quad \lambda x \underline{\text{appletree}}x(b)\}$
 e. MYSELF, who is now looking for a false, can choose one of the two conjuncts. Obviously, he can always win if $\langle j, b \rangle \notin |\underline{\text{planted}}|$ even if $b \in |\underline{\text{appletree}}|$ by picking the first conjunct.

Game 20 corresponds to the specific reading since MYSELF has the freedom of selecting the individual and not simply reacting to choices made by NATURE.

- (21) a. $\{\underline{\text{Johnny}} \quad \underline{\{\text{an appletree} \quad \{\text{not planted}\}}\}$
 b. MYSELF begins by choosing an individual for Johnny as before.
 $\{\lambda PP(j) \quad \underline{\{\text{an appletree} \quad \{\text{not planted}\}}\}$
 c. MYSELF translates the negated verb not planted. Roles reverse.
 $\{\lambda PP(j) \quad \underline{\{\text{an appletree} \quad \{\lambda xy \text{ planted } xy\}}\}$
 d. NATURE must now pick an individual for an appletree, say b , translate and substitute.
 $\{\lambda PP(j) \quad \{\lambda QQ(b) \quad \underline{\{\lambda xy \text{ planted } xy\}}\} \quad \wedge \quad \lambda x \underline{\text{appletree}}x(b)\}$
 e. MYSELF can now pick one of the two conjuncts and will always win iff for whatever individual NATURE has chosen for an appletree, either $\langle j, b \rangle \notin |\underline{\text{planted}}|$ or $b \notin |\underline{\text{appletree}}|$

Game 21 corresponds to the nonspecific reading of an appletree because MYSELF can always respond without knowing in advance which individual NATURE will pick.

If game semantics is to be a viable alternative to other kinds of interpretation schemes, then it must also provide for ways of handling not only scope ambiguity, as in 20 and 21, but also cases of use ambiguity, cf. 12. As was shown earlier, the use of the description instead of considerations of scope was the source of the specific/nonspecific ambiguity. I have also indicated how one intuitively would attempt to verify the truth of the two readings, by referring to an identifying property external to the sentence or by being forced to count the members in a population with one element missing. The game semantics approach to the problem will be a formalized version of the intuitive approach.

Up to now the players, MYSELF and NATURE, have had perfect information in the game. Each has known all the choices open to him and what choices have been made on previous moves. As Hintikka (1974a:162) has pointed out, laxing this condition will lead to logical systems of higher order than first order predicate logic. Such extensions may be necessary to treat problems in natural language and game semantics can easily be extended to encompass situations without perfect information. This may be a decided advantage over other interpretation schemes. On the concept of perfect information and particularly on restricting the domain of choices I will follow the description in Luce-Raiffa (1957:43).

In a game of verification for sentences containing verbs of the type be missing from, one can insist that when play lands on the verb, the domain of choices of individuals for translating the subject NP, if it is indefinite, is reduced by one. This could be formalized by a rule like 22:

- (22) be missing from. If play in G stops on be missing from in the structure $\{g_D(\beta_N)_{<1>T} \{ \dots \{ \text{be missing from} \} \}$ (and no individual has, of course, already been chosen for $<1>T$), then roles switch and the domain of choices for NATURE is reduced by one element. The new extension set $|\beta_N^*|$ results by removing a member from the set $|\beta_N| \cap |\text{not missing from}|$. NATURE no longer has perfect information about the choices at the start of the game.

The nonspecific reading for sentence 12 then comes about by means of the following game.

- (23) a. $\{a \$20 \text{ bill} \quad \{the \text{ cash drawer} \quad \{is \text{ missing from}\}\}\}$
 b. MYSELF chooses b for cash drawer and translates.²
 $\{a \$20 \text{ bill} \quad \{\lambda QQ(b) \quad \{is \text{ missing from}\}\}\}$
 c. Play falls on be missing from. Roles reverse and MYSELF translates. The extension set of \$20 bill is reduced by one.
 $\{a \$20 \text{ bill} \quad \{\lambda QQ(b) \quad \{\lambda xy \text{ is missing from } xy\}\}\}$
 d. NATURE must now pick an individual for a \$20 bill, say c, translate and substitute.
 $\{\lambda RR(c) \quad \{\lambda QQ(b) \quad \{\lambda xy \text{ is missing from } xy\}\} \wedge \lambda x \$20 \text{ bill } x(c)\}$
 e. MYSELF, who is now looking for a false, can pick one of the two conjuncts and win every time iff for any choice of an individual for a \$20 bill, either
 $\langle c, b \rangle \not\models | \text{is missing from} |$ or $c \not\models | \$20 \text{ bill} |$.
 This would be the case if the missing bill has been removed from the domain of choices open to NATURE.

Many difficulties for a game semantics of the type I have been speculating about in the last few pages would have to be solved before anything approximating observational adequacy could be obtained. Most verbs are not like be missing from and permit only specific interpretations of indefinite NP's in subject position. For these there must be the requirement that the choice of individuals for a subject NP not be influenced by the verb.

A game semantics of anaphoric chains must, of course, have some proposal to make about pronominalization. As I have argued here, a variable binding theory does not seem very promising as a general strategy. In the theory I am about to propose, the sentence 24 would have an underlying representation without variables, pronouns would be treated like any other term.

- (24) Mary had a baby and named it Sue.

- (25) $\{Mary_{\langle 1 \rangle T} \quad \{a \text{ baby}_{\langle 2 \rangle T} \quad \{had\}\} \quad \text{and} \quad \{it_{\langle 2 \rangle T} \quad \{Sue_{\langle 3 \rangle T} \quad \{named\}\}\}\}$

Following the suggestions in Hintikka (1974a) and Hintikka-Saarinen (1975), I will assume that a rule for "depronominalization" must apply as soon as an individual has been chosen for an indefinite or proper name if there is a pronoun in the same sentence. This rule requires that the same individual be chosen as for the pronominal

antecedent. Either MYSELF or NATURE can depronominize as is seen from the nonspecific reading of the sentence:

- (26) John didn't steal a car and sell it at auction.

Hintikka (1974a:159) has also noticed a crucial property of anaphoric chains between sentence parts.

Sentential game rules for conjunction, disjunction, conditional sentences are normally inapplicable in the presence of pronominal crossreference between conjuncts, disjuncts, etc. They may be applied, however, in the special case in which the depronominizing NP is a proper name.

In the sentence 25, for example, this will mean that the rule for and cannot disconnect one of the two conjuncts until after the pronoun has been played upon.

Before the sentence 25 can be further commented upon, however, there must be a suggestion for the game rule of and.

- (27) and. If play in the game G land on and in the structure $\{\omega_{<1>T} \{ \dots \{ \tau_{Vn} \} \text{ and } \{ \beta_{Vm} \} \}_S \}$, then NATURE chooses either $\{\omega_{<1>T} \{ \dots \{ \tau_{Vn} \} \}$ or $\{\omega_{<1>T} \{ \beta_{Vm} \} \}$ and play continues with respect to it.

Since this rule is identical to a kind of reverse conjunction reduction transformation, I pass over it without further comment.

The game for sentence 25 proceeds as follows.

- (28) a. Mary {a baby {had} and {it {Sue {named}}}}
 b. The presence of it prevents the rule for and from applying. MYSELF chooses an individual for Mary, Sue and translations for the verbs.
 $\{\lambda_{PP}(m) \{ \{ \lambda_{QQ}(b) \{ \lambda_{xy} \text{ had } xy \} \text{ and } \{ \text{it } \{ \lambda_{RR}(s) \{ \lambda_{xyz} \text{ named } xyz \} \} \} \}$
 c. MYSELF chooses b for a baby translates and substitutes.
 $\{\lambda_{PP}(m) \{ \{ \lambda_{QQ}(b) \{ \lambda_{xy} \text{ had } xy \} \text{ and } \{ \text{it } \{ \lambda_{RR}(s) \{ \lambda_{xyz} \text{ named } xyz \} \} \} \}$
 $\wedge \lambda x \text{ baby } x(b)$
 d. Obligatorily, MYSELF must now choose the same individual for it as was chosen for a baby.
 $\{\lambda_{PP}(m) \{ \{ \lambda_{QQ}(b) \{ \lambda_{xy} \text{ had } xy \} \text{ and } \{ \lambda_{QQ}(b) \{ \lambda_{RR}(s) \{ \lambda_{xyz} \text{ named } xyz \} \} \} \}$
 $\wedge \lambda x \text{ baby } x(b)$
 e. NATURE now has the choice between two of the conjuncts joined by and and the sentence $\lambda x \text{ baby } x(b)$.
 f. MYSELF always has a winning strategy iff all of the following conditions are met.

$\langle m, b \rangle \in |\text{had}|$ and $\langle m, b, s \rangle \in |\text{named}|$ and
 $b \in |\text{baby}|$.

The final problem I wish to discuss here is how a game semantics might treat cases of depronominization across the sentence boundary. This issue is especially important if variable binding is to be rejected. Short term reference demands immediate application of the depronominization rule as was seen in 28. In cases of longer term reference an independent rule is needed. Some of the crucial sentences are those found in 5. Any influence that the verb might have on the selection of an individual for a pronoun must be activated before the choice of an individual is made for such a pronoun. That's why 29a is an acceptable discourse and 29b is not.

- (29) a. Mary wants to have a baby. *Her name is Sue.
 b. Mary wants to have a baby. She wants her name to be Sue.

These are cases in which the rules must operate from the outside in.

- (30) Intersentential pronouns. If play lands on he, she or it in the structure $(\dots(\text{he}_{<1>T}(\dots))_S)$ and all other signs have been played upon, then MYSELF (and only MYSELF) picks an individual q from the set of those individuals already introduced in the preceding contexts, translates and substitutes. Play continues, in the case the game ends, with respect to the structure $(\dots(\lambda TT(q)(\dots))_S)$.

For a discourse like:

- (31) Mary had a baby. She named her Sue.

we have the game for the last sentence.

- (32) a. $\{\text{She}_{<1>T} \{\text{it}_{<2>T} \{\text{Sue}_{<3>T} \{\text{named}\}\}\}$
 b. MYSELF picks an individual for Sue and a translation for named.
 $\{\text{She} \quad \{\text{it} \quad \{\lambda RR(s) \quad \{\lambda xyz \text{ named } xyz\}\}\}$
 c. All signs except for the pronouns have now been played upon and MYSELF can pick individuals for she and it.
 $\{\lambda PP(m) \{\lambda SS(b) \{\lambda RR(s) \{\lambda xyz \text{ named } xyz\}\}\}$
 MYSELF always has a winning strategy iff $\langle m, b, s \rangle \in |\text{named}|$.

In conclusion, the game semantics approach to anaphoric chains offers some advantages over truth in a model interpretational schemes, where variable binding has the function of expanding the influence of a binder to elements that are not derivational adjacent to it. First of all, who chooses an individual, MYSELF or NATURE, has been shown to correspond to the introduction or nonintroduction of a discourse referent. Furthermore, whether an expression introduces a discourse referent or not is not dependent on truth conditions alone since logically equivalent forms do not necessarily share the capacity to introduce such a discourse referent. Game semantics, secondly, allows the translation of an expression to depend on the context in which the expression appears. This property seems to be unavoidable for discourse situations. Lastly, game semantics can be rather easily and naturally extended to cover discourse situations without falling victim to the dilemma of being forced to wait for the last variable in a potentially infinitely long string of variables to appear before a truth assignment can be made to any part of the sentence.

FOOTNOTES

¹I have ignored throughout Montague's rules of quantification over things other than sentences, i.e. rules S15 and S16.

²The definite NP has been treated here as if it were a proper name. Hintikka-Saarinen (1975) discuss the proper treatment of definite NP's in game semantics.

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ZUR SEMANTIK VON MEINEN UND BEDEUTEN *

Michael Grabski

o. Vorbemerkungen

In "Contexts and possible worlds" hat R. Stalnaker gezeigt, wie der begriff des what was said in den rahmen der modelltheoretischen semantik eingeführt und in ihm präzisiert werden kann; dies geschieht im wesentlichen dadurch, daß zunächst die verschiedenen rollen, die mögliche welten einerseits und kontexte andererseits bei der zuordnung von wahrheitswerten zu sätzen spielen, beachtet werden, zugleich aber die kontexte nicht ohne beziehungen zu den welten gelassen werden, sondern der tatsache rechnung getragen wird, daß sie immer auf gewisse weise ein teil einer möglichen welt sind.

Mögliche welten und gleichzeitig teile von ihnen bestimmen also die extension von ausdrücken; dieses konzept findet, so zeigt Stalnaker, eine entsprechung in dem prinzip des double indexing, d.h. der bewertung von ausdrücken an zwei welten gleichzeitig, wie es von Kamp, Vlach, Åqvist u.a. entwickelt worden ist.

Sei ein paar aus einer welt und einem kontext ein index genannt; in ähnlichen überlegungen hat R. Thomason 1973 dahingehend argumentiert, daß mit nutzen mögliche welten als ein aspekt des kontextes aufgefaßt werden können - und damit welten an zwei stellen in einem index auftreten -, um die ähnlichkeit zu erklären, die zwischen der interpretation lexikalischer einheiten und dem einfluß des kontextes in bezug auf die interpretation eines satzes bestehen. Obwohl sie für einen gegebenen satz festgelegt sind, sind sie nicht notwendigerweise so festgelegt, wie sie es sind.

Das wird deutlich in kontrafaktischen sätzen, deren vordersatz eine andere als die aktuelle festlegung ins auge faßt:

- (1) (a) If you were speaking, I would listen to you.
- (b) If "and" meant what "or" means, then Albuquerque would be in New Mexico and would not be in New Mexico.¹

In beiden vordersätzen werden welten betrachtet, in denen die aktuellen verhältnisse explizit anders sind: in (1a) ist im vordersatz wahr, daß der aktuelle hörer der sprecher ist, in (1b) ist dort die interpretation der lexikoneinheiten "and" und "or" anders, als sie es aktual ist; trotzdem referieren in (1a) die wörter you und I wie am aktuellen kontext, d.h. sie bezeichnen den aktuellen sprecher und hörer.

Auf entsprechende verhältnisse deutet die falschheit von (1b): trotz der im vordersatz ausgedrückten proposition wird im nachsatz and nach wie vor so wie am aktuellen kontext interpretiert, nämlich so, daß insgesamt ein widersprüchlicher satz entsteht.²

Das vorliegende papier soll, unter ausnutzung von erwähnten gedankengängen, eine semantik der beiden wörter meinen und bedeuten erarbeiten, indem beide wörter in eine sprache der intensionalen logik übersetzt werden, ähnlich wie in Montagues "Proper Treatment" (PTQ).³ Entsprechend werden die beiden wörter selbst kategorien eines kategorial aufgebauten fragmentes einer natürlichen sprache zugeordnet und in ausdrücke entsprechender kategorien der logik übersetzt.

Die beiden wörter haben insofern etwas mit zusammenhängen zwischen kontexten und welten zu tun, als mit ihnen sätze gebildet werden, in denen bestimmte elemente von kontexten mit propositionen in verbindung gebracht werden.

Satz (1b) oben ist ein beispiel dafür, wie mithilfe des (englischen) wortes (für) bedeuten über in einer welt geltende interpretationen von einheiten der syntax geredet werden kann.

Meinen bezieht sich darüber hinaus noch ausdrücklich auf eine person, für die die betreffende sprachverwendung gilt, vgl. (2):

(2) Mit "Du idiot" meint Fritz, daß er hunger hat.

Die personenbezogene interpretationszuordnung mit meinen muß nicht die eher allgemein geltende mit bedeuten sein, vgl.

(3) "Du idiot" bedeutet nicht, daß der sprecher hunger hat, aber Fritz meint damit, daß er hunger hat.

Verschiedene personen brauchen in ihren interpretationszuordnungen nicht übereinzustimmen, vgl. (4):

(4) Mit "Du idiot" meint Fritz, daß er hunger hat, und Hans meint damit, daß er durst hat.

Im folgenden sollen letzten endes zwei fragen verfolgt werden:

1. Wenn sätze mit meinen und bedeuten kontingent sind, gibt es dann irgendwelche einschränkungen für die mit ihnen ausgedrückte bedeutungszuordnung? Anscheinend lassen sich für A, x und B in die schemata

(5) (a) Mit "A" meint x daß B

(b) "A" bedeutet daß B

beliebige ausdrücke einsetzen (bei x und B sind allerdings bestimmte kategorien zu wählen), ohne daß eine notwendigerweise falscher satz entsteht.

2. Gibt es semantische beziehungen zwischen meinen und bedeuten? Von Grice ist das insofern prinzipiell bejaht worden, als er in Grice (1968) die "bedeutung eines äußerungstyps x für eine gruppe G" - also das was ein "A" bedeutet - definiert mithilfe von

(6) "a notion of meaning which I want to regard as basic, viz. that notion which is involved in saying of someone that by (when) doing such-and-such he meant that so-and-so..."⁴

Letzteren begriff identifizieren wir mit dem, etwas zu meinen, damit daß man etwas tut, oder mit: mit ...meinen, daß etwas der fall ist.

In Lewis (1968) wird ein umgekehrter weg beschritten, indem zunächst ein unpersönliches means (d.h. bedeutet) definiert wird und dann gezeigt wird, daß in normalen fällen der sprecher eines bestimmten satzes mit ihm meint, was der satz bedeutet.⁵

Im folgenden soll untersucht werden, welche zusammenhänge sich allein aus der bedeutung von sätzen mit meinen und bedeuten konstruieren lassen.

1. Syntax

Folgende sätze sind beispiele für konstruktionen mit meinen und bedeuten:

(7) (a) Mit "Du idiot" meint Fritz, daß er hunger hat.

(b) Damit daß er sagt: "Du idiot" meint Fritz, daß er hunger hat.

(c) Mit dem apfel meint Paris, daß Aphrodite die schönste ist.

(d) Damit daß er ihr den apfel gibt, meint Paris, daß Aphrodite die schönste ist.

(8) (a) Mit "Du idiot" meint Fritz Egon zu beleidigen.

(b) Fritz meint, mit "Du idiot" Egon zu beleidigen.

(c) Fritz meint zu fliegen.

(9) Mit "Du idiot" meint Fritz "Verschwinde".

(10) "Der hund ist bissig" bedeutet, daß ein bestimmtes tier gefährlich ist.

(9) steht für die vielen interessanten, d.h. bedeutungen bezeichnenden konstruktionen mit meinen, die hier aus raumgründen nicht behandelt werden sollen; aus einem anderen grund sollen fälle wie die sätze in (8) ausgeschlossen werden; hier hat meint insgesamt eine bedeutung wie sie in (8c) deutlich wird: es drückt eine relation zwischen einer person und einer proposition aus, die nicht von einer äusserung dieser person begleitet ist.

In (8a) und (8b) modifiziert die phrase mit "Du idiot" den infinitiv Egon zu beleidigen bzw. die verbalphrase Egon beleidigt. Dies wird deutlich anhand von sätzen wie (11), die seltsam sind und zeigen, daß es sich nicht um das meinen wie in (7a) handelt, welches nicht derartige einschränkungen in bezug auf die gemeinte proposition aufweist:

(11) (a) Mit "Du idiot" meint Fritz hungrig zu sein.

(b) Fritz meint, mit "Du idiot" hungrig zu sein.

(11b) dürfte aus dem gleichen grund seltsam sein. Der unterschied zwischen den beiden wörtern meinen wird auch deutlich an der erfüllbarkeit von (12):

(12) Mit "Du idiot" meint Fritz, daß er hunger hat, aber er meint nicht, daß er hunger hat.

Dies ist wahr in einer situation, wo Fritz eine bestimmte äusserung als etwas verstanden haben will, an das er selbst nicht glaubt. Auch das mit daß-satz konstruierte meint in (8b) ist ein anderes wort als das meint in (7a), vgl. das seltsame

(13) Fritz meint, daß er mit "Du idiot" hunger hat.

Die seltsamkeit von (13) läßt sich so erklären, daß, anders als in (8b), die verbalphrasen des daß-satzes nicht durch das komplexe

adverb mit "Du idiot" modifiziert werden kann.

Welche rolle spielt das entsprechende stück syntax in (7a)? Da es anscheinend keine opaken kontexte in bezug auf das subjekt des satzes schafft, kann es kein satzoperator sein⁶, vgl. (14), wo aus (14a) immer (14b) folgt.

- (14) (a) Mit "Du idiot" meint ein student, daß er hunger hat.
 (b) Für einen studenten gilt, daß er mit "Du idiot" meint, daß er hunger hat.

Am ehesten kommt ein die VP modifizierendes adverb in frage. Für die deutung dieses adverbs bestehen aber dadurch bestimmte einschränkungen, daß das dativ-objekt von mit immer als durch das subjekt des meinen-satzes hervorgebracht zu verstehen ist; d.h. (7a) ist immer durch einen satz der art (7b) paraphrasierbar, also einen, in dem das mit ...-stück ersetzt ist durch einen damit-daß-satz mit bestimmten eigenschaften; ein allgemeinerer fall ist (7c,d), wo das produzierte individuum nicht eine äußerung ist. Für (7a) läßt sich das durch die seltsamkeit von sätzen (15) zeigen:

- (15) Mit "Du idiot" meint Fritz, daß er hunger hat, aber er äußert nicht "Du idiot".

(äußern ist hier in einem allgemeinen sinn zu verstehen, der auch z.b. hinschreiben etc. umfaßt)

Am einfachsten ist es, das mit in (7) als zum wort gehörig zu betrachten und die vorkommen von meinen dort zwei kategorien zuzuordnen:

In (7a) und (7c) ist mit...meinen daß ein wort, das zunächst mit einem daß-satz, dann mit einem term für ein produziertes individuum, dann mit einem term für dassubjekt verknüpft wird, und ist gemäß der PTQ-notation ein element von $B_{TV/t}$.

In (7b) und (7d) wird meinen zunächst mit einem daß-satz, dann mit einem intransitiven verb (für die VP des damit daß-satzes), dann mit einem term, dem subjekt beider sätze, verknüpft, d.h. mit...meinen daß ist auch in $B_{(IV/IV)/t}$.

Bedeutend in (10) ist in $B_{IV/t}$.

Die formulierung syntaktischer regeln erscheint mir nicht problematisch, weswegen ich sie unterlasse.

2. Vorüberlegungen zu semantik

Mit der zuordnung der untersuchten wörtern zu grundlegenden kategorien stehen auch die λ -präfixe ihrer übersetzungen fest. Beschäftigen wir uns jetzt für eine weile mit mit... meinen daß. Wie satz (15) oben gezeigt hat, wird mit den sätzen (7a,b) oben explizit (wenn im fall von (7a) auch nicht "vollständig") auf einen äußerungsakt von Fritz referiert. Es läßt sich zeigen, daß dieser äußerungsakt sogar präsupponiert wird, vgl. das seltsame (16) Es ist nicht der fall, daß Fritz mit "Du idiot" meint, daß er hunger hat, aber er äußert nicht "Du idiot".

In der welt des sprechers von (7a) oder (7b) ist also wahr:

(17) Fritz äußert "Du idiot".

Wie ist diese tatsache mit der proposition, daß Fritz hunger hat, in verbindung zu bringen? Es bieten sich zwei möglichkeiten an: Entweder wird (17) in der übersetzung von (7a,b) durch einen satz repräsentiert, der in der aktuellen welt wahr ist und auf angemessene weise mit einem satz verknüpft wird, der die proposition, daß Fritz hunger hat, ausdrückt, oder der term "Du idiot" wird aufgefaßt als eine angabe, die eine modifikation des kontextes bezeichnet.

Letzteres kann geschehen, indem man, etwa wie auch in Åqvist (1972), an jedem kontext eine aktuelle äußerung definiert und die syntax einen operator enthält, der die kontextstelle auf eine bestimmte weise modifiziert. Wenn AUS_{α} ein solcher mit der äußerung α indizierter operator ist, und angenommen, der kontext (unterer index) würde nur aus äußerungen bestehen, ließe sich für die wahrheit eines ausdrucks $AUS_{\alpha} \phi$ an einer welt i (oberer index) definieren:

$$(18) [AUS_{\alpha} \phi]_i^i \text{ gdw. } [\phi]_{[\alpha]}_i^i$$

(Normalerweise ist α von der art " β ", d.h. ein in anführungszeichen eingeschlossener ausdrück β ⁸⁾)

Daß wie in (7a,b) ja ausgedrückt, ein bestimmter sprecher, und möglicherweise ein bestimmter hörer, involviert sind, wäre dann am besten durch weitere, analoge operatoren auszudrücken, und die übersetzung von mit...meinen daß aus $B_{TV/t}$ bekäme dann, unter

verwendung der in PTQ eingeführten zeichen, folgende struktur (die sogleich erläutert wird):

$$(19) \lambda p \lambda z \lambda x [\Box_{x,H} \text{Äus}_{v_z} \boxed{J^x} v_p]$$

Die art des λ -präfixes ist aus dem vorigen abschnitt klar. $\Box_{x,H}$ ist ein komplex von möglicherweise mehreren operatoren, die den äußernden, der gleich dem subjekt von meinen sein muß, und den hörer präzisieren.

Es folgt der in (18) skizzierte operator für die äußerung, in diesem fall gebunden durch λz , dann, wie noch zu diskutieren ist, ein komplex von operatoren $\boxed{J^x}$, die u.a. dem rechner tragen, daß die gemeinte proposition p weder für den sprecher des gesamt-satzes, noch für den äußernden (in (7a) Fritz), noch für seinen hörer wahr sein muß, vgl. die erfüllbarkeit von (20a-c), jedoch, wie ja auch schon längst z.B. bei Grice festgestellt, mit bestimmten intentionen des äußernden zu tun hat, vgl. die seltsamkeit von (20d).

(20) Mit "Du idiot" meint Fritz, daß er hunger hat, aber

- (a) Fritz hat keinen hunger.
- (b) Fritz findet nicht, daß er hunger hat.
- (c) niemand glaubt, daß er hunger hat.
- (d) er will nicht, daß jemand glaubt, daß er hunger hat.

(Das genauere aussehen dieses teils der übersetzung wird im nächsten Abschnitt diskutiert)

Vorteile dieser übersetzung wären:

Die tatsache, daß (17) präsupponiert wird, ist direkt in die übersetzung eingebracht. Unter den umständen, die durch ausgesondert werden, gilt für p etwas bestimmtes. Negiert man diesen ausdruck, negiert man noch nicht, daß die umstände betrachtet werden, die durch $\Box_{x,H} \text{Äus}_{v_z}$ ausgesondert werden.

Die deutung der operatoren $\Box_{x,H} \text{Äus}_x$ ist ferner nicht so, daß in der welt des gesamt-satz-sprechers der so modifizierte satz notwendigerweise falsch wäre; die operatoren deuten nur den kontext um.

Die tatsache, daß die sätze in (21) sämtlich seltsam sind, ist kein gegenargument für diese übersetzung; daß die in ihnen vorkommenden indexikalischen ausdrücke sich sämtlich auf den kontext

des gesamtsatzes beziehen, beruht für die mit-phrase und das sub-
jekt darauf, daß sie mithilfe des λ -operators "von außen" in den
satz hineingenommen und dort transparent konstruiert werden (vgl.
(21 a-c).

- (21) (a) Mit $\left\{ \begin{array}{l} \text{meinem apfel} \\ \text{deinem apfel} \\ \text{dem apfel hier} \end{array} \right\}$ meint Fritz, daß Aphrodite die schön-
te ist, aber $\left\{ \begin{array}{l} \text{ich habe keinen} \\ \text{du hast} \\ \text{hier ist kein} \end{array} \right\}$ apfel.
- (b) Mit "Du idiot", meinem dümmsten spruch, meint Fritz, daß
er hunger hat, aber "Du idiot" ist nicht mein dümmster
spruch.
- (c) Mit "Du idiot" meint mein freund, daß er hunger hat, aber
ich habe keinen freund.
- (d) Mit "Rom ist schön" meint Fritz, daß $\left\{ \begin{array}{l} \text{ich} \\ \text{du} \end{array} \right\}$ hunger $\left\{ \begin{array}{l} \text{habe} \\ \text{hast} \end{array} \right\}$,
aber er äußert nichts über $\left\{ \begin{array}{l} \text{mich} \\ \text{dich} \end{array} \right\}$.

Für den satz, der die gemeinte proposition ausdrückt, scheint
ebenfalls der kontext des gesamtsatz-sprechers zuständig zu sein,
vgl. (21d), aber aufgrund dessen, daß der operatorenkomplex vor
p in (19) noch ununtersucht ist, sagt das einstweilen noch gar
nichts.

Sei zunächst noch die andere möglichkeit kurz betrachtet, nämlich
daß die tatsache, daß (17) wahr ist, durch einen satz ausgedrückt
wird, der mit dem satz, der die gemeinte proposition ausdrückt,
irgendwie verknüpft wird.

Es ergibt sich dann eine übersetzung der struktur

$$(22) \lambda_p \lambda_z \lambda_x [A'(\nu_x, \nu_z) \circ \boxed{J^{\nu_x}} \nu_p]$$

bei der $\underline{A}$ eine prädikatskonstante (zulesen "äußern"), $\circ$ eine
zweistellige verknüpfung und der rest wie oben ist. $\circ$ bestimmt
dann die beziehung der beiden propositionen zueinander. Eine
natürliche lesart für $\circ$ wäre die materiale implikation. Wird
ein satz wie (7a) negiert,:

- (23) Es ist nicht der fall, daß Fritz mit "Du idiot" meint,
daß er hunger hat.

wird, wie (16) zeigt, nicht der erste der beiden sätze negiert.
Wird $\circ$ als materiale implikation aufgefaßt, läßt sich, bei

gleichzeitiger präsupposition des vordersatzes, aus der negation des gesamtausdruckes dies negation des nachsatzes ableiten.

(Gegen die plausibilität dieser übersetzung werden sich jedoch im folgenden noch gründe ergeben)

3. Struktur der sprecher-intentionen

Für die präzisierung des ausdrucks hinter ○ in (22) sind durch die beispiele in (20) schon bestimmte umrisse gegeben.

(20c,d) machen deutlich, daß eine weitere instanz, der hörer der äusserung, eine rolle spielt.

Für weitere intuitionen zu den beziehungen zwischen welten und kontexten sei ein beispiel aus Stalnaker (unveröff.) zitiert:

(24) I said "You are a fool" to O'Leary. O'Leary is a fool, so what I said was true, although O'Leary doesn't think so. Now Daniels, who is no fool and who knows it, was standing nearby, and he thought I was talking to him. So both O'Leary and Daniels thought I said something false: O'Leary understood what I said, but disagrees about the facts; Daniels, on the other hand, agrees with me about the facts (he knows that O'Leary is a fool), but misunderstood what I said. Just to fill out the example, let me add that O'Leary believes falsely that Daniels is a fool. Now compare the possible worlds i, j and k: i is the world as it is, the world we are in; j is the world that O'Leary thinks we are in, and k is the world Daniels thinks we are in. The diagram below represents the proposition concept (with respect to these three worlds) expressed by the utterance.

(24a) i j k

i	T	F	T
j	T	F	T
k	F	T	F

The vertical axis represents contexts, or possible worlds in their role as context. The horizontal axis represents possible worlds in their role as arguments of the functions which are the propositionsexpressed. Thus the horizontal lines represent what is said by the utterance in various different possible contexts.

In a sense, I said something true in i and false in j and k even though in none of these worlds did I express the proposition that is true in i and false in j and k. Although not expressed in any of the contexts, this proposition is represented in the proposition concept. I will call it the diagonal proposition since it is the function from possible worlds into truth values whose values are read along the diagonal of the matrix from upper left to lower right. This is the proposition that is true in i for any i just in case the proposition expressed by the sentence in i is true at i.

Intuitiv repräsentiert die diagonale proposition "das, was unter You are a fool verstanden wurde", nämlich was sich für jeden der beteiligten der äusserung unter einbeziehung sowohl des für ihn aktuellen kontextes wie der für ihn aktuellen welt ergab: das wahre für Stalnaker, das falsche für O'Leary und Daniels.

Wie aus der anfänglichen beschreibung der situation in (24) hervorgeht, ist zum zeitpunkt der beschriebenen äusserung wahr:

(25) Mit "You are a fool" meint Stalnaker, daß O'Leary ein idiot ist.

Wo auf dem diagramm (24a) ist die gemeinte proposition wahr? (24a) beschränkt sich auf drei aktuelle indizes; um auch die wunschwelten des sprechers darstellen zu können, sind auch die welten zu berücksichtigen, in denen z.b. O'Leary den satz You are a fool, gesagt zu ihm, für wahr hält; überhaupt sind die welten von den personen, die an sie glauben, zu lösen.

Daß ein satz an einer welt wahr ist, die für eine person die aktuelle ist, läßt sich durch einen operator $\Box^\alpha$ ausdrücken, mit:

(26) $[\Box^\alpha \phi]_i^i$ gdw. $[\phi]_i^{i'}$ mit $i' \in f_\alpha([\alpha]_i^i)(i)$

Propositionen lassen sich dann wieder, wie im allgemeinen fall, als mengen von welten auffassen, ebenso läßt sich auch ausdrücken, was für jemanden aktual wahr ist. Was kontexte betrifft, sind in (24a) gleichfalls nur zwei (aktuelle) berücksichtigt. Eine erweiterte matrix gibt (27):

(27)

Welten:

Kontexte:

	1	2	3	4	6	8	9		30	52	64	
1. <St.,O'L.>	T	T	T	T	F	F	F	T	...etc.	F	T	F
2. <St.,Dan.>	T	T	F	F	T	F	T	F	...	T	F	F
3. <O'L.,St.>	T	F	T	F	T	F	T	F	...	F	F	F
4. <O'L.,Dan.>	T	T	T	T	T	T	T	T	...	T	F	F
5. <Dan.,St.>	T	T	T	T	T	T	T	T	...	F	F	F
6. <Dan.,O'L.>	T	T	T	T	T	T	T	F	...	F	T	F

Von den 64 die sechs kontexte unterscheidenden welten sind nur einige interessante aufgeführt. Zunächst wäre welt 4 ein kandidat für die für Stalnaker und Daniels aktuelle welt, 6 für die von O'Leary. Zu fragen ist aber, ob die beiden ersteren nicht

eher an welt 52 glauben, letzterer nicht eher an 30.

In den kontexten 4 bis 6 treten die angesprochenen nochmals auf, und, eine gewisse rationalität vorausgesetzt, glaubt z.b. Stalnaker, daß O'Leary ein idiot ist, egal ob er selbst es sagt oder Daniels (kontext 1 bzw. 6).

In den bei der wahrheit von (25) von Stalnaker intendierten welten glaubt O'Leary, daß You are a fool, zu ihm gesagt, wahr ist.

Welt 64 gehört sicher nicht zu diesen fällen, wohl aber 1 bis 4, wo für beide verschiedenen sprecher sich der wert T ergibt. Die welten 8 und 9 sind jedoch fälle, wo dies nur jeweils für einen kontext gilt.

Problematisch ist besonders 8. In 8 ist für einen hörer O'Leary die äußerung nur deswegen wahr, weil sie von Daniels gemacht wird, d.h. wahr wahr nur aufgrund einer misinterpretation des kontextes. Intuitiv würde man eine solche welt aus den intendierten ausschließen, aber es ist schwer, hierfür legitimation durch beispiele zu bekommen. (28a) ist nur schwer nachvollziehbar, der spezielle sachverhalt wird mühsam von außen nachkonstruiert. (28b) scheint zwar erfüllbar, es ist aber unklar, welche rolle das dabei dabei spielt.

- (28) Mit "You are a fool" meint St., daß O'Leary ein idiot ist,
 (a) und er intendiert, daß der, zu dem er spricht, glaubt,
 daß dies jetzt nicht von ihm selbst geäußert wird.
 (b) und er tut dabei so, als sei er nicht er selbst.

Mir scheint es trotz allem gerechtfertigt, welten wie 8 auszuschließen, aus dem grund, weil eine einzelne welt, über die matrix in (27) hinaus, sehr viele nichtaktualisierte kontexte zuläßt; kaum eine welt wird so sein, daß sich nicht ein kontext in ihr findenläßt, der möglicherweise nicht aktual ist, aber, läßt man welt 8 zu, gleichfalls zugelassen werden müßte und derart wäre, daß für ihn sich für die betreffende äußerung "T" ergäbe. Damit würde die proposition an information relativ wertlos, indem die menge der vom sprecher mit seiner äußerung intendierten welten unzulässig groß werden würde.

Um 8 auszuschließen, wird daher gefordert, daß zu den intendierten welten nur solche zugelassen werden, in denen nicht nur bestimmte propositionen für den hörer wahr sind, sondern diese am aktuellen kontext für ihn wahr sind.¹⁰

Ein weiterer interessanter fall ist welt 9. Wie ist sie zu bewerten etwa im verlgeich zu welt 52? Letztere zeichnet sich gerade durch eine bestimmte rationalität aus, die welt 9 nicht besitzt: zwar ist am sprecher-aktualen kontext die äußerung wahr, aber nur an diesem. Solche welten zuzulassen, heißt, dem sprecher eine bestimmte autorität über das von ihm gemeinte zuzubilligen, indem eine solche welt gezählt wird, in der er und nur er die betreffende äußerung tut.

Solche welten scheinen jedoch gerade von interesse für die entstehung von bedeutungen zu sein; angenommen, jede äußerung ist irgendwann zum ersten mal mit einer bestimmten intention gemacht worden; dann gibt es nur einen kontext in der betreffenden welt, für den die extension der äußerung definiert ist, darüber hinaus möglicherweise zukünftige kontexte, für die aber "noch nichts feststeht". Ich kümmere mich nicht weiter um diese interessante frage, schließe aber einstweilen welten wie 9 nicht aus.¹¹

Mit...meinen daß (aus $B_{TV/t}$) wäre dann auf folgende zwei arten übersetzbar:

$$(29) (a) \lambda_p \lambda_z \lambda_x \exists y [S_{\check{x}} H_{\check{y}} A'US_{\check{z}} J^{\check{x}} \Box^{\check{y}} \Box^{\check{p}}] \\ (b) \lambda_p \lambda_z \lambda_x \exists y [A'(\check{x}, \check{y}, \check{z}) \rightarrow J^{\check{x}} \Box^{\check{y}} \Box^{\check{p}}]$$

$\Box$ ist dabei ein operator, der die welt auf den kontext kopiert, also:¹²

$$(30) [\Box \phi]_j^i \quad \text{gdw.} \quad [\phi]_i^i$$

4. Verschiedene kontextaspekte

In Stalnakers beispiel, von dem aus wir jetzt generalisiert haben, bezog sich die differenz zwischen dem gemeinten und dem verstandenen auf nur einen aspekt des kontextes, den des hörers. Es wäre eine interessante aufgabe, hierzu die analogien für die anderen indexikalischen ausdrücke zu konstruieren; ein satz mit ich könnte, entsprechend zu Daniels' mißverständnis oben, mißverstanden werden weil man den sprecher nicht identifiziert hat oder weil man nicht bemerkt, daß der sprecher zitiert, etc.

Was in Stalnaker beispiel jedoch vorausgesetzt wird, ist das richtige verständnis desjenigen kontextaspekts, auf den, wie oben kurz dargestellt, Thomason hingewiesen hat, die interpretation

lexikalischer einheiten.

Es zeigt sich, daß das beispiel in allen einzelheiten für diesen kontextaspekt umkonstruiert werden kann. Die situation ist dann etwa die, daß wie bisher O'Leary nicht glaubt, daß er ein idiot ist, Daniels hält You are a fool jedoch für falsch, weil er unter fool das versteht, was St. und O'Leary unter book verstehen. Dazu kommt, daß O'Leary sich geschmeichelt vorkommt, wenn man ihn als "buch" bezeichnet, jedenfalls den satz unter Daniels' deutung lexikalischer einheiten für wahr hält.

Die matrix (24a) läßt sich dann wie folgt lesen (wobei diesmal die interpretation von you einheitlich ist: es bezieht sich auf O'Leary):

1. und 2. zeile:

(31) (a) Wenn "fool" bedeutet, was "fool" bedeutet,
glaubt Staln., daß You are a fool zu O'L. wahr ist
" O'L. , " " " falsch "
" Dan. , " " " wahr ".

3.zeile:

(b) Wenn "fool" bedeutet, was "book" bedeutet,
glaubt St., daß You are a fool zu O'L. falsch ist,
" O'L., " " " wahr "
" Dan., " " " falsch ".

Entsprechend zu (27) ergibt sich (32), wobei die aktuelle welt für St. und Dan. nr. 2, für O'L. nr. 3 ist. Bei seiner äußerung ist in St.s wunschwelten wahr, daß O'L. die welten 1 und 2 für aktual hält.

(32)

Kontexte:

Wortbedeutung: <Sprecher, Hörer> :

1. "fool" "fool" } <St., O'L.>
2. "fool" "book" }

Welten:

T	T	F	F
T	F	T	F

Ein satz wie (25) kann damit auch auf denjenigen kontextaspekt referieren, der in (32) angesprochen ist, darüber hinaus auch

auf eine kombination von gemeintem adressat und gemeinter wortbedeutung etc. Für eine solche allgemeinheit der betroffenen kontextaspekte ist jedoch das präfix von operatoren in der übersetzung (29a) zu speziell, da es nur auf sprecher, hörer und äußerung eingeht.

Es ist daher besser, einen operator zu definieren, der den kontext in bezug auf die syntaktisch auftauchenden aspekte sprecher und äußerung festlegt, ihn im übrigen nur dahingehend festlegt, daß er der nächstliegende kontext mit diesen eigenschaften ist. Alles andere, hörer, wortbedeutung etc., kann dann "indexikalisch" daraus bezogen werden.

Die übersetzung (29a) wird dann ersetzt durch

$$(33) \lambda p \lambda z \lambda x \boxed{d}_{v_x, v_z} J^{v_x} \square^h \square v_p$$

Die deutung für $\boxed{d}_{\alpha, \beta}$ ist:

$$(34) [\boxed{d}_{\alpha, \beta} \phi]_j^i \text{ gdw. } [\phi]_j^i \text{ für}$$

dasjenige j' in $f_s([\alpha]_j^i \chi_j) \cap f_a([\beta]_j^i \chi_j)$

das näher an j ist als alle j'' in "

Es entfällt dann auch die unnatürliche quantifizierung über hörer; letztere werden viel eleganter indexikalisch gegeben:

$$(35) [h]_j^i = f_h(j)$$

Diese möglichkeiten sprechen insgesamt dafür, (29a) fortzuentwickeln, (29b) dagegen nicht weiter zu verfolgen, da dort der rückbezug (z.b. wie der hörer festgelegt wird) immer syntaktisch zu leisten ist, was zu viel explizitheit verlangt.

5. Meinen und bedeuten

Die bisher vorgeschlagenen übersetzungen von mit...meinen daß betreffen die lesart, die mit Grice' occasional_meaning_for_a_speaker etwa gleichzusetzen ist, im gegensatz zu dessen timeless_meaning_for_a_speaker, dem gleichfalls eine lesart von mit ...meinen daß entspricht.¹³

Analog scheint bedeuten zwei lesarten zu haben; die vielleicht weniger einleuchtende okkasionele wird suggeriert durch sätze wie (36a):

- (36) "Der apfel ist rot" bedeutet, daß der sprecher hunger hat,
 (a) aber niemand glaubt, daß er hunger hat.
 (b) aber er glaubt nicht, daß er hunger hat.
 (c) aber er hat keinen hunger.
 (d) aber niemand soll glauben, daß er (der spr.) hunger hat
 (e) aber er meint damit nicht, daß er hunger hat.
 (f) aber er hat nicht geäußert: "Der apfel ist rot".

(36a) ist wahrscheinlich ein seltsamer satz, wenn bedeutet nicht-okkasionell verstanden wird. (Dieses bedeuten entspricht vielleicht Grice' applied timeless meaning for a group).

Es zeigt zusammen mit den anderen sätze in (36), daß auch die "bedeutete" proposition intentionaler art ist; weder der erwähnte sprecher (b), noch seine hörer (a), noch der sprecher von gesamt-(36 c) müssen glauben, daß die aktuelle welt zu dieser proposition gehört, dagegen ist die präsupponierte äüßerung (vgl. (f)) mit einer bestimmten intention gemacht, vgl. die seltsamkeit von (d).

(36e) scheint mir seltsam zu sein. Folgt daraus, das okkasionelles bedeuten äquivalent damit ist, daß der betreffende sprecher das entsprechende meint? Vgl. (37), das nicht notwendigerweise wahr zu sein scheint.

- (37) Wenn Fritz mit "Du idiot" meint, daß er hungrig ist, dann bedeutet "Du idio", daß er hungrig ist.

Anscheinend drückt bedeuten ein für sprecher und hörer der betreffenden äüßerung gemeinsames verständnis des geäußerten aus. Daraus ist für den sprecher ein satz mit mit...meinen daß folgerbar, jedoch gilt anscheinend nicht der umgekehrte schritt. Die frage ist nun, was es mit diesem "gemeinsamen v erständnis" auf sich hat. Es bedeutet nicht, daß auch der hörer mit der äüßerung meint, daß ..., vgl. (38) (u.a. deswegen, weil dann der hörer gleichfalls eine bestimmte äüßerung tun müßte).

- (38) Wenn "Du idiot" bedeutet, daß der sprecher hungrig ist, dann meint der hörer damit, daß er hungrig ist.

Ein besserer kandidat ist vielleicht eine kontrafaktische formulierung: wenn der hörer der sprecher wäre, würde auch er damit meinen, daß... Anscheinend ist jedoch auch ein satz wie (39a) erfüllbar:

- (39) "Du idiot" bedeutet, daß der sprecher hungrig ist,
 (a) aber wenn der sprecher der hörer wäre, würde er nicht damit meinen, daß er hungrig ist.
 (b) aber wenn der sprecher der hörer wäre, könnte er nicht damit meinen, daß er hungrig ist.

Ein fall, wo (39a) wahr ist, ist der daß der aktuelle sprecher eine spezielle sprachverwendung sozusagen anerkanntermaßen besitzt, und zwar ist das auch dadurch bedingt, daß der hörer derjenige ist, der er aktual ist; anders ausgedrückt: die situation ist eine solche, daß sich für den aktuellen hörer, wenn er der sprecher wäre, eine andere situation in bezug auf seinen hörer ergäbe.

Dagegen scheint (39b) nicht erfüllbar zu sein; daß jemand unter bestimmten umständen mit einer äusserung nicht etwas beliebiges meinen kann, scheint prinzipiell nicht ausgeschlossen.

Mir scheint es nicht sinnvoll, weiterhin das "gemeinsame verständnis" so zu explizieren, daß die hörer in bestimmten situationen mit der betreffenden äusserung das gleiche meinen würden; das problem ist, daß beim okkasionellen bedeuten gerade auch auf nicht konventionell regulierte beziehungen zwischen äusserung und proposition referiert wird. Sätze von der art (39a), die würde, einen notwendigkeitsoperator, gebrauchen, sind anscheinend zu stark; dagegen sind sätze mit könnte irgendwie zu "schwach"; sie drücken zwar, wie (39b) zeigt, eine notwendige bedingung aus, können aber nicht die für bedeuten irgendeine kennzeichnende notwendigkeit ausdrücken, daß nämlich, wenn etwas etwas bedeutet, der hörer das betreffende normalerweise verstehen sollte oder müßte.

Stattdessen schlage ich eine übersetzung vor, die die proposition, daß der sprecher die bedeutete proposition auch meint, ableiten läßt und weiter das "erfolgreiche meinen" so ausdrückt, daß für den hörer wahr ist, daß der sprecher mit dem meinen etwas bestimmtes intendiert; d.h. das okkasionelle bedeuten (aus $B_{IV/t}$) sei übersetzt als:

$$(40) \lambda p \lambda z \exists x [\Box_{v_x, v_z} [J^x \Box^h \Box v_p \wedge \Box^h J^x \Box^h \Box v_p]]$$

Auch (40) ist noch in bezug auf den sprecher zu "entsyntaktisieren", d.h. ein operator ist zu definieren, der den kontext zum

nächstgelegenen kontext mit einer expliziten äusserung ändert, also ein operator $\boxed{d}$ mit

$$(41) [d_\alpha \phi]_j^i \text{ gdw. } [\phi]_j^i \text{ an demjenigen } j' \text{ aus } \underbrace{f_\alpha([\alpha]_j)(j)}_{\text{aus "}}, \text{ das näher an } j \text{ ist als alle } j''$$

Auch der sprecher ergibt sich dann indexikalisch:

$$(42) [s]_j^i = f_s(j)$$

Bedeutung aus $B_{IV/t}$ sei also übersetzt als:

$$(43) \lambda p \lambda z \boxed{d}_{v_z} [j^s \square^h \otimes v_p \wedge \square^h j^s \square^h \otimes v_p]$$

6. Zusammenfassung des semantischen apparats

Vorausgesetzt wird ein rahmen wie in Montagues PTQ, mit dem unterschied, daß hier eine interpretation nicht eine geordnete menge von zeitpunkten vorgibt (was für nicht-okkasionale bedeutungen von meinen und bedeuten jedoch wichtig wäre).

Außerdem treten als kontexte wieder welten auf; die extension eines ausdrucks ist dann seine intension angewandt auf ein paar (von welten) aus $I \times I$, wobei die zweite stelle für welten in ihrer kontext-rolle steht.

Eine interpretation ist dann ein 8-tupel

$$(44) \langle A, I, <, f_a, f_\alpha, f_h, f_s, f_{int}, F \rangle,$$

wobei A eine menge von individuen, I eine menge von welten,

$<$ eine nähe-relation über I ist, f_a, f_α, f_{int} funktionen aus $\mathcal{P}(I)^{I^A}$ sind, die in abhängigkeit von einem individuum einer

welt eine (nicht-leere) menge von welten zuordnen, und zwar:

f_a für ein individuum einer welt die menge der von ihm für aktuell gehaltenen welten,

f_α für eine äusserung (äusserungen sind elemente von A) einer welt (kontext) die welten (kontexte), wo sie geäußert wird,

f_{int} für ein individuum einer welt die menge der von ihm bevorzugten welten.

f_s, f_h sind aus A^I und bestimmen für jede welt (kontext) den sprecher bzw. den hörer. F ist wie in PTQ, d.h. bildet die nicht-

logischen konstanten auf intensionen ab.

Die verwendung der in der syntax der intensionalen logik in PTQ vorkommenden zeichen ist wie dort, außerdem gilt:

$$(45) (a) F(s)(\langle i, j \rangle) = f_s(j)$$

$$(b) F(h)(\langle i, j \rangle) = f_h(j)$$

$$(c) [\Box \phi]_j^i \text{ gdw. } [\phi]_j^i$$

$$(d) [\Box^\alpha \phi]_j^i \text{ gdw. } [\phi]_j^{i'} \text{ mit } i' \in f_\alpha([\alpha]_j^i)(i)$$

$$(e) [J^\alpha \phi]_j^i \text{ gdw. } [\phi]_j^{i'} \text{ mit } i' \in f_{int}([\alpha]_j^i)(i)$$

$$(f) [\Box_{\alpha, \beta} \phi]_j^i \text{ gdw. } [\phi]_j^{i'} \text{ für dasjenige } j' \text{ aus } f_s([\alpha]_j^i)(j) \cap f_\beta([\beta]_j^i)(j), \text{ das näher an } j \text{ ist als alle anderen derartigen } j'.$$

$$(g) [\Box_\beta \phi]_j^i \text{ gdw. } [\phi]_j^{i'}, \text{ für dasjenige } j' \text{ aus } f_\beta([\beta]_j^i)(j), \text{ das näher an } j \text{ ist als alle anderen derartigen } j'.$$

Übersetzungen: siehe oben (33) und (43).

Anmerkungen:

- * Für hinweise und anregungen habe ich M.Cresswell, F.Guenthner und W.Sternefeld zu danken.
- 1 Vgl. Thomason (1973), p.2 f
- 2 dem als proposition die leere menge möglicher welten entspricht, womit fälschlicherweise die möglichkeit negiert wird, daß der vordersatz, der durchaus erfüllbar erscheint, irgendwo "ideal wahr" ist; vgl. z.b. die semantik für kontrafaktische sätze in Åqvist (1973)
- 3 Montague (1974)
- 4 Grice (1968) p. 54
- 5 Vgl. Lewis (1968) p. 155 ff
- 6 Dies ist eins der kriterien für satzoperatoren in Stalnaker-

Thomason (1973)

- 7 Ich kümmere mich im folgenden nur um dieses bedeuten und das mit...meinen daß aus $B_{TV/t}$. Weitere interessante fälle von bedeuten sind:
- (i) Zu sagen "Der hund ist bissig" bedeutet, daß man jemanden warnt (mit bedeuten aus $B_{(t/IV)/t}$)
 - (ii) Zu sagen "Der hund ist bissig" bedeutet, jemanden zu warnen (bedeuten aus $B_{(t/IV)/IV}$)
 - (iii) Daß Fritz sagt "Der hund ist bissig" bedeutet, daß alle gäste sich hüten müssen (bedeuten aus $B_{(t/t)/t}$)
 - (iv) "Der hund ist bissig" bedeutet nichts (bedeuten aus B_{TV})
- 8 Für fälle wie (7c) ist jedoch ein allgemeineres prinzip zu bedenken, vgl. hierzu Bigelow (1975).
- 9 Stalnaker (unveröff.) p. 5 f
- 10 Grice hat hier eine aufwendigere formulierung, dahingehend, daß der als aktual interpretierte kontext ein grund für den hörer sein soll, bestimmte dinge zu glauben. Dies ließe sich durch ein bedeutungspostulat einbringen.
- 11 Forderungen wie die, daß ein sprechakt nur dann als zu einem "Sprechaktmuster" gehörig gezählt werden kann, wenn er zu mindestens zwei gelegenheiten durchgeführt worden und verstanden worden ist, gehören hierher, vgl. Heringer (1974) p.43
- 12 Vgl. Åqvist (1973) p. 8 f
- 13 Mit dieser lesart ist der satz
- (i) Mit "Du idiot" meint Fritz, daß er hunger hat, aber er äußert gerade jetzt nicht "Du idiot"
- erfüllbar; er bezieht sich dann auf eine disposition von **Fritz**, für die jetzt nicht gerade eine manifestation vorliegt. Diese lesart von mit...meinen daß sei vorschlagsweise übersetzt als
- (ii) $\lambda p \lambda z \lambda x [T \Rightarrow \Box_{v_x, v_z} J^{v_x} \Box^h \Box v_p]$
- wobei $\Rightarrow$ die in Åqvist (1973) definierte verknüpfung für kontrafaktische bedingungssätze ist, T eine satzkonstante ist, die in allen welten wahr ist.

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SOME ASPECTS OF THE SEMANTICS AND PRAGMATICS OF PERFORMATIVE SENTENCES

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0. Introduction

In this paper we will discuss some aspects of the semantics and pragmatics of performative sentences. What we report here are results of research which is still in progress. Consequently, we sometimes abstract a little from the subtleties that characterize natural language, and the solutions and explanations we will propose will have a tentative character. They have to be elaborated and studied in more detail. However, we hope that our remarks will serve as an indication of the direction in which a more definitive solution can be found.

The aim of the research on which this paper is based is the incorporation of performative sentences in a Montague Grammar.⁽¹⁾ Here we will not deal with that task explicitly. The framework of Montague Grammar figures more or less as the background of our remarks. We will refer to it, now and then, and use notions which are defined in it, but we do not bother to define explicitly a fragment of some natural language and the corresponding grammar.

In this paper we will understand by a performative sentence an explicit performative sentence, such as:

- (1) I (hereby) promise to pay you £ 5
- (2) I (hereby) declare this meeting opened
- (3) I warn you, there is a bull in that field

The notion 'performative sentence' is fairly well understood, although many different definitions have been proposed over the years by philosophers, linguists and logicians.⁽²⁾ As a matter of fact, the main purpose of this paper is to add another one to this list. We hope that it will distinguish itself

from its predecessors by being fit to be incorporated into a logical grammar.

1. The syntactic status of performative sentences

Incorporating performative sentences in a grammar requires insight into their specific nature. One has to know what exactly distinguishes performative sentences from non-performative ones, and on what level or levels of linguistic description their characteristics should be accounted for.

We claim that the distinction between performative and non-performative sentences, and performative and non-performative verbs, cannot be made on a syntactic, nor on a semantic level, but lies on a pragmatic level.

Let us first, very briefly, consider the syntax⁽³⁾: categorial syntax is concerned only with the formal relations between linguistic expressions. It specifies with what kind of other expressions a certain expression can be combined to make up a more complex one; what the categorial status of the resulting expression is; and how exactly the expressions are to be combined. Performative verbs such as request, order, warn, ask behave syntactically just like non-performative verbs such as believe, think, want, expect. They all belong to the same category and combine in exactly the same way with expressions of other categories. The differences between performative and non-performative verbs are not of a syntactic nature.

Likewise, the sentential status of performative sentences does not differ from that of other indicative sentences. There are no syntactic differences between a performative sentence such as

(4) I request that you will be there

and non-performative ones such as

(5) I believe that you will be there

(6) John requests that you will be there

Within a categorial syntax all three sentences belong to the same category: that of a t-expression. Not only is there no syntactic reason whatsoever to assign a different categorial status to (4) on the one hand and (5) and (6) on the other hand, such a distinction would also violate the basic principles

of categorial syntax. Therefore, by the way, we prefer to interpret the category symbol t as indicating the set of indicative sentences and not of truth-value expressions or declarative sentences.⁽⁴⁾ Those are semantic and pragmatic terms which are simply out of place in the syntax. The distinction between indicative and non-indicative sentences is indeed of a syntactic nature. It can be characterized in terms of syntactic properties. Relevant features are: word order, presence or absence of a subject-term, intonation pattern, etc.

2. The semantic status of performative sentences

With respect to the semantic status of performative sentences two questions immediately arise. The first is: do performative sentences have truth-values? The debate on the truth status of performative sentences has been going on in the literature ever since Austin. The position that performative sentences do have truth values has been advocated by among others Hedenius (Hedenius 1963), David Lewis (Lewis 1972), Åqvist (Åqvist 1972) and Cresswell (Cresswell 1974). The opposite position has been taken by among others Austin (Austin 1962), Gale (Gale 1970), Sampson (Sampson 1971) and Searle (Searle 1969). We find ourselves in sympathy with those who advocate the first position, without adhering to all the arguments which are used to support it. We too see no reason why performative sentences should not have truth-values. Here we will give no arguments for our position. In Groenendijk & Stokhof 1975b we have discussed two arguments against the thesis that performative sentences have truth-values, one stemming from Austin and another put forward by Gale. There we have shown that these arguments do not force us to say that performative sentences do not have truth-values. However, we cannot go into this matter here-

The second question which arises is: do performative sentences have any special semantic property, and, if so, can this property be considered as a defining characteristic of performativity?

Sometimes it is said that there is indeed such a property, namely that of being pragmatically self-verifying, and that this property characterizes the special status of performative sentences.

We will now examine this claim in some detail.

Pragmatic selfverifiability⁽⁵⁾ can be defined as follows:

- (i) A sentence S is pragmatically selfverifying if and only if it is the case that if S is uttered then S is true

Considering this property to be a defining characteristic of performativity then leads to definition (ii):

- (ii) A sentence S is performative iff S is pragmatically selfverifying

But this certainly does not hold. Let us point out the most obvious counter-examples. First of all, not all pragmatically selfverifying sentences are to be calssified as performative. Normally one would not consider sentences such as (7) and (8) to be performative sentences:

- (7) I am the utterer of this sentence
(8) I exist

Secondly, there are many performative sentences which are not pragmatically selfverifying. To mention a few examples, consider:

- (9) I hereby sentence you to death
(10) I hereby declare this meeting opened
(11) I hereby pronounce you man and wife
(12) I hereby fire you

Consider (9) for example. If this sentence is uttered by someone who is not by some legal system endowed with the power to judge and sentence, then certainly (9) is not true. This means that it is not a pragmatically selfverifying sentence in the sense of definition (i). Only when it is uttered by someone with the proper authority in the appropriate circumstances it is true.

A third objection that can be raised against (ii) is that according to (i) all valid sentences (tautologies) are pragmatically selfverifying and consequently performative according to (ii). Valid sentences are always true, whether uttered or not, so they are pragmatically selfverifying and consequently performative.

We think that two of these three objections can be overcome. The last one can easily be remedied by adding an extra clause to (i) stating that a

pragmatically selfverifying sentence has to be false in at least one occasion in which it is not uttered. It is more difficult to deal with the second objection. Performative sentences are not in general pragmatically selfverifying because some of them are only true when uttered in the appropriate circumstances. These appropriate circumstances concern for instance the utterer of the sentence, the person addressed, time and place of the utterance. Conditions requiring that these appropriate circumstances obtain can, we think, certainly be formulated in a semantic framework. Given the possibility of a satisfactory interpretation of the notion of appropriate circumstances one might propose the following revised definition:

(iii) A sentence *S* is pragmatically selfverifying iff if *S* is uttered in the appropriate circumstances (for *S*) then *S* is true

Åqvist (in Åqvist 1972) has proposed a definition which, although more sophisticatedly formulated, has essentially the same character as (ii) in combination with (iii). But does this modified definition give a satisfactory account of the notion of performativity? I.e. does it serve as a criterion to distinguish performative sentences from non-performative ones? We do not think so. Although the second objection has been overcome and the third objection can easily be remedied, as is done by Åqvist, the first objection still holds. According to the definition (ii) and (iii) sentences such as

- (7) I am the utterer of this sentence
- (8) I exist
- (13) I am speaking

would still count as pragmatically selfverifying sentences and thus, according to (ii), as performative sentences. However, intuitively we do not classify these sentences as such.

Definition (iii) does not rule out these sentences. They are true whenever they are uttered, so they are certainly true whenever they are uttered in the appropriate circumstances.

The conclusion must be that this modified definition of pragmatic selfverifiability cannot serve simpliciter as a definition of performativity. It simply fails to distinguish performative from non-performative sentences. The specific character of performative sentences cannot be characterized completely

in semantic terms. Such a characterization has to be sought on the pragmatic and not on the semantic level. But of course a complete description of performative sentences will also have to account for their semantic properties in a satisfactory way. In fact, Åqvist has given the means with which such an account can be given.

With respect to the semantics two additional points should be made.

First of all, we assign truth-values to sentences in a model and not to utterances. If we would adopt the view that truth values are assigned to utterances, the properties of being pragmatically selfverifying and being a tautology would coincide. But surely this would be an unintuitive and undesirable result. We want our semantic theory to be at least sufficiently rich to enable us to distinguish between 'things' which are true no matter whether they are uttered and 'things' which are true whenever they are uttered. It will be clear that these things can only be sentences and not actual utterances of sentences.

Secondly, we must point out that we do not mean to imply that a specification of the truth conditions of a sentence is the same as a specification of its full meaning. Truth conditions are important, but they do not exhaust a theory of meaning. Besides knowing in which circumstances a sentence is true, one should also know for example what illocutionary act is typically performed in uttering that sentence, and what the conditions for its correct use are. In order to know the full meaning of a sentence only a specification of all these aspects suffices.

In this paper the term 'semantics' will be used to refer to the analysis of truth conditions of sentences and the term 'pragmatics' to indicate that part of the analysis which is concerned with the assignment of illocutionary forces to uttered sentences and the specification of their correctness conditions. A theory of meaning consists in our opinion of a semantic as well as a pragmatic analysis.

3. The pragmatic status of performative sentences

3.1. Correctness

In this section we will outline a theory of pragmatics the key notions of which are the notions conversational information and conversational correctness. These notions were first introduced and discussed in Groenendijk & Stokhof 1975a. The conversational information is the set of propositions which the speaker considers to be true propositions. Such a set will normally contain both propositions about the world in general as well as more specific ones about the speech situation, about the other speech participants, their information, etc. Such sets of conversational information play a crucial role in conversations. The mere possibility of informative discourse depends on the fact that there is an overlap in the information of the speech participants.

Furthermore, the set of conversational information determines whether or not a sentence is used correctly. If a sentence is to be used correctly it has to meet certain correctness conditions. These conditions require that certain propositions are, or conversely are not, part of the conversational information.

Our main hypothesis is that we need these pragmatic notions in order to account for a large class of linguistic phenomena.⁽⁶⁾ An example of such a phenomenon is the unacceptability of the following sentences:

(14)*I (hereby) promise to be there, but I do not intend to be there

(15)*I know that you are not able to do so, but I order you to open that window

(16)*I (hereby) assert that Mary will come, but I do not believe that she will

(17)*I warn you that there is a bull in that field, but there is no bull in that field

These sentences are unacceptable, but neither for syntactic, not for semantic reasons. The first and second conjuncts do not contradict each other. Although unacceptable, these sentences may very well be true. Take for example sentence (17). It may very well be the case that one warns someone that there is a bull, without there being a bull. No one can argue that he did not warn that there was a bull because there was no bull.

In other words, the unacceptability of these sentences cannot be explained in terms of a conflict between the truth-values of their conjuncts. But certainly, there is something wrong. What is wrong is that these sentences are, what we will call, structurally incorrect. By this we mean, that the conditions for their correct use are contradictory, which implies that they can never be used correctly. And structural incorrectness is a source of unacceptability of natural language sentences.

Why is sentence (17) structurally incorrect? Sentence (17) is a conjunction, and the correctness conditions of a conjunction are straightforward: a conjunction is correct iff both of its conjuncts are correct. So, if (17) is to be correct, both the sentence 'I warn you that there is a bull in that field' and the sentence 'There is no bull in that field' are to be correct. The first sentence expresses a warning. A generally accepted condition for correctly making a warning is that the speaker believes that what he is warning for is in fact the case. In terms of conversational information this means that if this warning is to be correct the proposition that there is a bull in the field is to be part of the conversational information. The second sentence is an assertion. A generally accepted condition for correctly making an assertion is that the speaker believes that what he asserts is in fact the case, i.e. the proposition that there is no bull in the field should be part of the conversational information. But this means that there is a conflict between the correctness conditions of the two conjuncts of (17). Both conjuncts cannot be correct in the same situation, this means that the conjunction as a whole can never be used correctly. In other words, sentence (17) is structurally incorrect, and hence unacceptable.

3.2. Forces

Of course, a very important question which has to be answered in our pragmatic theory is what determines the correctness conditions of a sentence.

In Groenendijk & Stokhof 1975b we have shown that it is impossible to connect all correctness conditions directly to elements of syntactic structure.⁽⁷⁾

Since correctness conditions belong to the realm of pragmatics, and since pragmatics deals with language use, it seems natural to connect them in some way with the specific ways in which sentences can be used. By the specific ways in which sentences can be used we understand the illocutionary acts

which can be performed by using these sentences.⁽⁸⁾ By an illocutionary force (henceforth: force) we understand an indication of an illocutionary act. Forces will be theoretical entities of the formal pragmatic theory to be presented below. This theory will assign a force to sentences uttered in a given situation which indicates what illocutionary act is performed by using that sentence in that situation. Sets of correctness conditions will be connected with pairs consisting of a sentence and a force. Depending on whether these conditions are fulfilled or not, a sentence is assigned the value correct or incorrect.

To make clear why we need forces as theoretical entities, consider the following sentences:

(18) I will come, but I don't feel obliged

(19) I will come, but I'm terribly busy

Both sentences are acceptable as such, but there is an important difference between them. Consider sentence (19): it is perfectly possible to interpret the first conjunct of this sentence as a correct promise. Quite often we make promises not by using explicit performative sentences, but by using non-performative indicative ones. In certain situations (19) can count as a correct promise followed by a correct assertion. On the other hand, sentence (18) can never be significantly interpreted in this way. It is not possible to interpret (18) as a correct promise followed by a correct assertion, since in the second conjunct it is asserted that a correctness condition for the promise in question is not fulfilled. If we would interpret the second conjunct of (18) as an assertion and the first conjunct as a promise, then the sentence as a whole would always be incorrect. Such an interpretation obviously makes no sense. Of course, there are interpretations in which (18) is correct, e.g. if we interpret both conjuncts as assertions.

Sentences such as (18) and (19) clearly show that correctness conditions are not connected with sentences as such, but depend at least in part on the illocutionary act(s) performed by using them. That is why we need forces as theoretical entities, to indicate these illocutionary acts. Correctness conditions can then be characterized as conditions which have to be fulfilled if a sentence with a given force is to be correct.

An analysis like the one proposed in this paper would be of little interest if there were no systematic relationships between (types of) sentences and forces. There has to be a systematic relationship between (types of) sentences and the forces they can possibly take, depending on their formal structure, their content or both. If it were possible to perform any arbitrary illocutionary act by using any arbitrary sentence, then the assignment of forces to sentences would be an arbitrary matter too, and therefore of little linguistic interest, for in that case it could not serve as the basis for the explanation of linguistic phenomena.

That such systematic relationships between (types of) sentences and forces exist can be seen by considering the following pair of sentences:

(20)*I promise that I will come, but I don't feel obliged

(21) I will come, but I don't feel obliged

Sentence (20) is unacceptable because it is structurally incorrect. Sentence (21) on the other hand is acceptable because we don't have to interpret the first conjunct as a promise. We can interpret both conjuncts of (21) as assertions, and in such an interpretation (21) can be correct. If there were no systematic relationships between (types of) sentences and forces, such an interpretation would also be possible with respect to (20). However, the fact that (20) is unacceptable shows that such an interpretation is not possible. Hence, we conclude that a systematic relationship between (types of) sentences and forces in fact exists. Roughly speaking, the highest verb (or verb phrase) in a performative sentence denotes the illocutionary act which is typically performed by using the sentence in question. So, there is a one-to-one correspondence between these verbs (or verb phrases) and the forces of the sentences in which they occur.

We claim that this property can be considered to be the defining characteristic of performative sentences. Examples like (21) show that such a one-to-one correspondence does not hold in general for all natural language sentences.

If it would hold for all natural language sentences, we would not need forces as a formal means to link sentences with sets of correctness conditions.

Sentences such as (21) show that forces are needed, sentences such as (20) show that they can be used to explain certain linguistic phenomena.

3.3. Standard forces

There is another kind of systematic relationship between (types of) sentences and forces. We have just said that the first conjunct of (21) can be assigned a different force than that of an assertion. But of course, it cannot be assigned any arbitrary force. It can never be interpreted as a request or as an order for example.⁽⁹⁾ The syntactic mood of a sentence limits the forces it can possibly be assigned. This does not only hold for indicative sentences, but also for interrogative and imperative sentences. A sentence such as (22):

(22) Are you coming tomorrow?

can be used to ask a question, or to make a request, but it can never be used to make a promise, a warning, or an assertion. Besides these relationships between the syntactic mood of a sentence and a certain class of forces, there are of course also relations between the propositional content of a sentence and its possible forces. E.g. only a non-performative sentence expressing a future act of the speaker can be assigned the force of a promise. Disregarding these relations between propositional content and forces, we can say that the standard force of non-performative indicative sentences is that of an assertion.

An interesting question is whether there is a relation between the standard force of non-performative sentences and the other forces they can have. Let us consider the case of indicative sentences. The correctness conditions for their standard force, assertion, include a condition to the effect that the speaker believes that what he asserts is true. A quite similar condition holds for promises and warnings. But of course there are other conditions which distinguish these forces from one another.

What seems to hold then, is that if a certain force is to count as a possible force for a certain type of sentence, it is to be compatible with the standard force of that type of sentence, in this sense, that the set of correctness conditions connected with the standard force must be a subset of the set of correctness conditions of the non-standard one.⁽¹⁰⁾

Take the non-performative sentence (23):

(23) I will be there too

Since this is an indicative sentence, its standard force is that of an assert-

ion. Therefore, one of its correctness conditions is that the speaker believes that it is true that he will be there too. Consider now a situation in which (23) is used as a promise. In what sense is the just mentioned correctness condition for (23) as an assertion part of the correctness condition for (23) as a promise? Normally, the condition in question would be formulated as: 'the speaker intends to be there too', rather than: 'the speaker believes that he will be there too'. But these formulations are in fact equivalent. Since promises always concern future acts which are under the control of the speaker, believing that such an act will be performed comes to the same as intending to perform that act. So in fact we are dealing with one and the same correctness condition.

The need for general formulations of correctness conditions becomes particular clear if we consider the following pair of sentences:

- (24) I assure you that I will be there tomorrow
- (25) I assure you that I was there yesterday

One might be inclined to formulate the following correctness condition for (24): 'the speaker intends to be there tomorrow'. On the other hand, the corresponding correctness condition for (25) would normally be formulated as: 'the speaker believes that he was there yesterday'. However, both sentences have the same force, therefore it is to be preferred to give a general formulation of the correctness condition in question.

This would also enable one to explain why non-performative indicative sentences, which have assertion as their standard force, cannot be used to ask questions or to make requests. For, a generally accepted condition for the correctness of a question is that the speaker does not know whether what he is asking is the case or not. The principle that the correctness conditions of a non-standard force must include those of the standard force, therefore prevents that an indicative sentence is interpreted as being used with the force of a question.

We have concentrated on indicative sentences, but the same point can be made with respect to non-indicative ones. Non-indicative sentences with an interrogative structure have as their standard force that of a question. One of the non-standard ones is that of a request. Non-indicative sentences with an imperative structure have as their standard force that of an exhortation. Non-standard ones include those of an order and an encouragement.

3.4. Force multiplicity

Some things remain to be said about force multiplicity. We have seen that non-performative indicative sentences may have different forces in different situations, but there are also sentences which may have more than one force in the same situation. This latter phenomenon we call 'force multiplicity'. We have already met such sentences, e.g. the structurally incorrect sentence (17):

- (17)*I warn you that there is a bull in that field, but there is no bull
in that field

Of course there are also sentences which have more than one force and which are acceptable:

- (26) John isn't there, but I authorize you to start anyway
(27) I admit that I was late and I promise to be on time from now on

These examples suggest that force multiplicity is a phenomenon restricted to compound sentences.⁽¹¹⁾

Force multiplicity is a phenomenon that has to be accounted for in the systematic assignment of forces to sentences. The examples given above suggest that force multiplicity is restricted to sentences the syntactic structure of which is that of a conjunction. This seems to be supported by the fact that sentences with the syntactic structure of a disjunction is general do not allow for force multiplicity.⁽¹²⁾ The following sentences are all unacceptable:

- (28)*I hereby ask you to come in person or I hereby ask you to send one of
your friends
(29)*I hereby promise to pay you £ 5 or I hereby promise you to go to Amsterdam
(30)*I hereby order you to go or I hereby warn you that I will beat you up
if you don't

There are, however, counterexamples to the claim that syntactic conjunction is the only source of force multiplicity. They concern sentences containing non-restrictive relative clauses, such as:

- (31) I admit that John, who is a very boring person, lives in London
(32) Mary, who I promise will not be invited, lives in London

These sentences do allow for force multiplicity. (31) contains both an admission and an assertion, (32) contains both an assertion and a promise. The syntactic structure of these sentences however is not that of a conjunction. Their semantic structure on the other hand is indeed that of a conjunction. In an Montague type grammar they are translated into formulas which are conjunctions. Since the other examples also translate into conjunctive formulas, this suggests that force multiplicity can be linked to an aspect of semantic structure. But such a conclusion is unwarranted there are sentences which translate into a conjunctive formula, but which in no way can be interpreted as having more than one force. Consider for example the following sentence:

(33) John walks and talks

The translation of (33) is a conjunction of two formulas. However, we do not want to say that (33) can have more than one force at the same time. So we can't say in general that every sentence which translates into a conjunctive formula allows for force multiplicity. The conclusion must be that in order to be able to decide whether or not a certain sentence allows for force multiplicity we need two kinds of information. First of all, we need syntactic information about the structure of the sentence. We need to know whether or not in the surface structure two syntactic strings which belong to the category sentence occur. But this is not enough, we also need information about the formula into which the sentence translates. We need to know whether it is a compound formula. Only on the basis of both kinds of information we can decide whether or not force multiplicity is possible.

Both conditions are intuitively quite reasonable. For what does force multiplicity in fact amount to? Saying that a sentence has two forces means that by uttering that sentence the speaker performs two illocutionary acts. An illocutionary act is an act performed by uttering a sentence, so if two acts have been performed two sentences must have been uttered. This explains the syntactic requirement. The reason why we need the semantic information is that not all sentences in which there are two occurrences of a syntactic string of the category sentence allow for force multiplicity. What we need to know is whether the sentence translates into a compound formula in which a connective occurs as the highest functor. If a sentence meets these two requirements it can have more than one force.⁽¹³⁾

4. Outlines of a formal semantics of performative sentences

In this section we will give the outlines of a theory in which we can describe some of the semantic phenomena concerning performative sentences.

For the moment we assume to have defined a categorial syntax of a fragment of English which includes performative sentences. Non-indicative sentences (interrogatives and imperatives) are not treated. Performative as well as non-performative sentences are translated into a language of intensional logic by means of the usual procedures. Performative verbs which take a sentential complement are translated into constants denoting a relation in intension between one or more individual concepts and a proposition. In this respect they do not differ from non-performative verbs which belong to the same syntactic category.⁽¹⁴⁾

What we want to be able to express in the semantics, is the property of pragmatic selfverifiability. The definitions we will propose are partially based on some notions defined by Åqvist. However, since here the purpose of defining a language of intensional logic is to obtain indirectly a semantics for natural language, we have to modify and complicate things a bit.

By a model we understand an 11-tuple

$$\langle A, P_t, I, J, j_0, \leq, F, s, h, ts, Cm \rangle$$

in which:

- (i) A, P_t, I, J are non-empty disjoint sets; (ii) $j_0 \in J$; (iii) $\leq$ is a linear ordering on J ; (iv) F is a function having as its domain the set of all constants such that whenever $a \in \text{Type}$ and $\alpha \in \text{Con}_a$, then $F(\alpha) \in S_{a,A,I,J}$. In particular: $F(i) = s$ and $F(y) = h$; (v) s and h are partial functions from $I \times J$ to $D_{e,A,I,J}$; (vi) ts is a partial function from $I \times J$ to P_t ; (vii) Cm is that partial function from $I \times J$ to $A \times A \times P_t$ such that $Cm(\langle i, j \rangle) = \langle s(\langle i, j \rangle), h(\langle i, j \rangle), ts(\langle i, j \rangle) \rangle$

A, I and J are the set of possible individuals, the set of possible worlds and the set of moments of time respectively. j_0 is the actual moment of time. P_t is a set of sentences of natural language, viz. those sentences which are generated by the syntax of the grammar. These sentences are translated into the language of intensional logic and thus are interpreted indirectly. F is

an interpretation function defined in the usual way. i and y are special constants occurring in the translation of first and second person pronouns. s and h are indices which determine for each point of reference who is the speaker and who is the hearer at that point of reference.⁽¹⁵⁾ ts is an index which determines for each point of reference which sentence is uttered at that point of reference by whoever is the speaker at that point of reference. Its range is the set P_t , for it are sentences of natural language and not formulas of intensional logic which are uttered. Notice that the fact that ts refers to natural language sentences implies that this notion of a model makes sense only for a language of intensional logic given a set of sentences of natural language which it translates. C_m is a function which determines for each point of reference between which possible individuals and sentence there exists a relation of communication.⁽¹⁶⁾ The requirement on C_m that $C_m(\langle i, j \rangle) = \langle s(\langle i, j \rangle), h(\langle i, j \rangle), ts(\langle i, j \rangle) \rangle$ expresses the assumption that there is only one medium in which sentences are communicated. s, h, ts and C_m are partial functions because we want to be able to evaluate sentences also with respect to situations in which there is no speaker, no hearer, no sentence, and consequently no relation of communication. Therefore, we also allow for models in which these functions do not have a value. Sentences containing no expressions referring to these elements can be assigned a truth-value irrespective of whether or not these functions have a value. However, sentences which do contain expressions which refer to these elements, i.e. indexical expressions such as first and second person pronouns, do depend on this. A sentence like:

(34) I love you

has a truth-value in a given model only if the functions s and h have a value in that model. If this is not the case, then the terms occurring in this sentence lack denotation, and consequently the sentence as a whole lacks a truth-value.

Let us now formulate what pragmatic selfverifiability comes to. Informally speaking, a sentence is pragmatically selfverifying if and only if it is true whenever it is uttered. To represent this property in a formal way, it is necessary to make reference to a natural language sentence as well as to its translation in the language of intensional logic. For the semantic notion of pragmatic selfverifiability can be defined only with respect to formulas of intensional logic. But we also need a sentence, since sentences are the things

which are uttered, and not formulas. We propose the following definition:

ϕ is pragmatically selfverifying iff

$$\Lambda M((\forall \psi: \psi \in P_t \ \& \ \text{Trans}(\psi, \phi) \ \& \ ts(\langle i, j_0 \rangle) = \psi) \rightarrow M \models \phi)$$

In this definition Trans is the translation relation as defined by the translation rules of the grammar. What the definition says is: a formula ϕ is pragmatically selfverifying iff it holds for all models M that if there is a natural language sentence ψ of which ϕ is the translation, and this sentence ψ is uttered in the situation described by M, then ϕ is true in M.

As a derivative, we can say that a sentence is pragmatically selfverifying iff it translates into a formula which is pragmatically selfverifying according to the definition given above.

There are some difficulties with this notion of a model, and consequently with this notion of pragmatic selfverifiability. First of all, it is not possible to express that in a sentence such as:

(35) I promise that I will be there tomorrow and I request that you see to it that Mary will be there too

the conjuncts are true because the conjuncts themselves are uttered and not because the conjunction as a whole is uttered. This fact cannot be formulated consistently within the framework developed so far. It is not possible to state of the first (or second) conjunct of the formula into which (35) translates that it is pragmatically selfverifying. The problem is that given the fact that in a model the timeindex consists of only one moment of time the function ts will always give the sentence as a whole as the sentence which is uttered at the moment which the time index of the model indicates.

Another problem is that some sentences which intuitively can count as being pragmatically selfverifying in one interpretation, can never count as such according to the definitions. An example of such a sentence is:

(36) I hereby utter a sentence, so therefore I have uttered a sentence

If (36) is to be pragmatically selfverifying, then the second conjunct would have to be evaluated with respect to a moment of time later than the moment of time with respect to which the first conjunct is evaluated. However, models have only one moment of time as their time index, and consequently each

compound of a compound formula is evaluated with respect to one and the same moment of time. Therefore, the utterance of the first conjunct of (36) can never count as a verifying instance of the second conjunct.

More generally, we can say that many so-called indexical expressions can have different denotations within the compounds of certain compound formulas. We call this phenomenon 'multiple reference'. Consider e.g. (37) (different subscripts indicate different denotation):

(37) You₁ will stay here, but you₂ will come with me

One might think that multiple reference is possible only in compound sentences. However, consider:

(38) I will take you₁ and you₂ with me

(39) I will kiss you₁ and beat you₂

On the other hand, multiple reference of you is not possible in any sentence:

(40)*You₁ love you₂

What (38) and (39) have in common with (37) and what distinguishes them from (40) is that (37)-(39) are translated into compound formulas whereas (40) is translated into a non-compound one. Indexical expressions are interpreted as functions from points of reference to suitable denotations. If multiple reference within a sentence is to be possible then a model should contain more than one moment of time. These moments of time are to be associated, as the examples just given show, with the compounds of a compound formula. However, the denotation of non-indexical expressions should not vary within these boundaries. The situation can be compared with a certain type of clock, the minute hand of which leaps only once a minute and the seconds hand of which leaps every second. The denotation of non-indexicals depends on the minute hand as the time index, the denotation of indexicals depends on the seconds hand. An additional argument for introducing more than one moment of time in a model stems from the pragmatics. In our pragmatic theory it will be necessary, e.g. when dealing with force multiplicity, to refer to the compounds of compound sentences. It would be natural to use the index ts for this purpose. However, the notion of a model as it stands would make this impossible.

In order to account for these facts we propose the following definition of a revised model.

A revised model M is an 11-tuple

$$\langle A, P_t, I, J, \langle j_0, \dots, j_n \rangle, \leq, F, s, h, ts, C_m \rangle$$

in which:

(i) $A, P_t, I, J, \leq, s, h, ts, C_m$ are as defined above; (ii) $\langle j_0, \dots, j_n \rangle$ is an ordered $n+1$ -tuple of elements of J ordered by $\leq$; (iii) F is as defined above with the additional requirement that $\wedge j, j' \in \langle j_0, \dots, j_n \rangle: F(\alpha)(\langle i, j \rangle) = F(\alpha)(\langle i, j' \rangle)$ for all constants α unless $F(\alpha) = h, ts$, or C_m

$\langle j_0, \dots, j_n \rangle$ is a series of moments of time. The compounds of a compound formula may be evaluated with respect to different moments of this series. It should be noted that it is in no way required that indexical expressions in fact do have multiple reference, it is only made possible. The additional requirement on F makes sure that within one and the same model non-indexical expressions do not have different denotations. This ensures that all contradictions in which no indexicals occur are still contradictions.

Let us now turn to a truth definition based upon this notion of a revised model. How are we to evaluate formulas with respect to a model which contains more than one moment of time?

Let us first introduce some auxiliary notions.

M^{sub} is a submodel of M iff M^{sub} is an 11-tuple

$$\langle A, P_t, I, J, \langle j_i, \dots, j_k \rangle, \leq, F, s, h, ts, C_m \rangle$$

in which: (i) $A, P_t, I, J, \leq, F, s, h, ts, C_m$ are as in M ; (ii) $\langle j_i, \dots, j_k \rangle$ is a subsequence of the sequence $\langle j_0, \dots, j_n \rangle$ in M

M_m^{atom} is the m -th atomic submodel of M iff M_m^{atom} is an 11-tuple

$$\langle A, P_t, I, J, \langle j_m \rangle, \leq, F, s, h, ts, C_m \rangle$$

in which: (i) $A, P_t, I, J, \leq, F, s, h, ts, C_m$ are as in M . (ii) j_m is the m -th member of the sequence $\langle j_0, \dots, j_n \rangle$ in M

A submodel M^{sub} is prior to a submodel $M^{\text{sub}'}$ iff

$$\wedge j, j': j \in \langle j_i, \dots, j_k \rangle \text{ in } M^{\text{sub}} \ \& \ j' \in \langle j_l, \dots, j_m \rangle \text{ in } M^{\text{sub}'} \rightarrow j \leq j'$$

The notion of an atomic submodel is needed to evaluate atomic formulas. Since the denotation of all expressions, whether indexical or not, is to remain constant within an atomic formula, such formulas are to be evaluated with respect to a single moment of time. The notion of a submodel is needed in order to state recursively the truth conditions of the connectives. A truth definition then has the following form:

- (i) If ϕ is an atomic formula, then $M \models \phi (g)$ iff $M_1^{\text{atom}} \models \phi (g)$
where g is an assignment of values to variables and $M_1^{\text{atom}} \models \phi (g)$
is defined as usual
- (ii) If ϕ is $\psi \& \chi$, then $M \models \psi \& \chi (g)$ iff there exist submodels M^{sub} and $M^{\text{sub}'}$
of M such that $M^{\text{sub}} \models \psi (g)$ and $M^{\text{sub}'} \models \chi (g)$ and $M^{\text{sub}'}$ is not prior to
 M^{sub}
- (iii) Similar for negation and the other connectives
- (iv) If ϕ is $\forall x \psi(x)$, then $M \models \forall x \psi(x) (g)$ iff there exists an a in A such that
 $M \models \psi(x) (g')$ where g' is like g except for the possible difference that
 $g'(x) = a$

As the reader can verify, introducing series of moments of time makes a difference only for the clauses of the connectives. The other clauses remain essentially the same.

Given this notion of a revised model indexical expressions may have multiple reference. This explains why a sentence such as (37) is not a contradiction, while a sentence such as (41) is:

(41) The king will stay, but the king will come with me

Furthermore, given the following accordingly revised definition of pragmatic selfverifiability:

ϕ is pragmatically selfverifying iff $\Lambda M((\forall \psi: \psi \in P_t \& \text{Trans}(\psi, \phi) \& \forall j_i: j_i \in \langle j_0, \dots, j_n \rangle \text{ in } M \& \text{ts}(\langle i, j_i \rangle) = \psi) \rightarrow M_i^{\text{atom}} \models \phi$

Sentence (36) can now be interpreted as being pragmatically selfverifying. Also ts can now be used to refer to compounds of a compound sentence.

Of course, what we have said here is sketchy and needs to be elaborated. However, we think that a theory along these lines is needed in order to account for some interesting phenomena in the semantics of natural language.

5. Outlines of a formal pragmatics of performative sentences

In this section we will give the outlines of how we plan to deal with the pragmatic phenomena concerning performative sentences. Let us summarize a few points. Correctness conditions of sentences depend on their force and on other linguistic elements such as connectives. Therefore we have to assign forces to sentences. As we have seen in section 3.4., the phenomenon of force multiplicity suggests that in order to do so we need syntactic as well as semantic information. Our semantic models provide us with the means to combine both kinds of information in an natural way. The syntactic information we need can be provided by means of the index ts. This allows us to formulate force assignment with respect to formulas of intensional logic.

Let us define a pragmatic model PM as any quintuple

$\langle M, \text{FORCE}, f, d, V \rangle$

in which: (i) M is a revised semantic model; (ii) FORCE is a finite set of forces, containing among others ASSERTION, PROMISE, WARNING, IMPERATIVE, QUESTION. With every force a set is associated. E.g. with ASSERTION we associate the set $\{ \langle x, p \rangle : \text{state}'(x, p) \} \cup \{ \langle x, p \rangle : \text{declare}'(x, p) \} \cup \{ \langle x, p \rangle : \text{assert}'(x, p) \}$; ⁽¹⁷⁾
 (iii) f is a partial function from ME_t to $\text{FORCE} \times \text{FORCE} \times \dots \times \text{FORCE}$; ⁽¹⁸⁾
 (iv) d is a consistent set of formulas; (v) V is a function from ordered tripels consisting of a formula, an ordered n -tuple of elements of FORCE, and d to $\{c, i\}$

A force as defined above thus serves as an indication of an illocutionary act. which is (partly) denoted by certain predicates translating certain verbs. It is in this sense that forces are entities which indicate illocutionary acts. This means that the exact formulation of the content of the set FORCE is language-dependent. And for that reason, the assignment of forces depends on the language in question as well. ⁽¹⁹⁾

f is a partial function assigning to elements of the set of formulas of intensional logic ordered n -tuples of elements of the set FORCE. Intuitively, f determines which force(s) a certain formula has in the situation defined by the semantic model M. f is not to be an arbitrary function, it has to be restricted by certain pragmatic postulates in which certain systematic relationships between (types of) sentences and forces are expressed.

The elements of the set d are the formulas considered to be true by the speaker in the situation defined by the model. It is his set of conversational information. By requiring d to be consistent we require it to have a model. This does not imply that d is closed under logical consequence. (20)

V is a valuation function assigning one of the values correct and incorrect to a formula given its force(s) and a set of conversational information d .

The class of acceptable pragmatic models will be defined as that class of pragmatic models which are in accordance with the pragmatic postulates. In these postulates the various relationships that exist between (types of) sentences and the forces they can be assigned will be explicated. We have to make sure for example that there is a one-to-one correspondence between (types of) performative sentences and forces. Also the relations between certain types of sentences and force multiplicity should be accounted for. But let us first turn to a pragmatic postulate which indicates in exactly what sense the function f is a partial function. The purpose of stating this postulate is to assure that forces are only assigned to those formulas which are the translations of sentences which are in fact uttered in the situation defined by the model in question. This postulate can be formulated as follows:

PP1: If $\phi \in ME_t$, then $f(\phi)$ is defined iff it holds for all parts ψ of ϕ that either (i) $\forall j: j \in \langle j_0, \dots, j_n \rangle$ in M & $\forall \chi: \chi \in P_t$ & $Trans(\chi, \psi) \text{ \& } ts(\langle i, j \rangle) = \chi$; or (ii) $\forall j: j \in \langle j_0, \dots, j_n \rangle$ in M & $\forall \xi: \psi$ is a part of ξ & $\forall \chi: \chi \in P_t$ & $Trans(\chi, \xi) \text{ \& } ts(\langle i, j \rangle) = \chi$

The relation part of is defined as follows: ψ is a part of ϕ iff either (i) $\psi = \phi$; or (ii) ϕ contains $\&\psi$ or $\vee\psi$ or $\rightarrow\psi$.

The content of PP1 can best be illustrated by considering the following example. Suppose we have a formula of the form

(42) $walk'(\wedge j) \text{ \& } talk'(\wedge j)$

The postulate says that this formula in a given situation is assigned a force by f if and only if either there are two sentences uttered in that situation which translate into $walk'(\wedge j)$ and $talk'(\wedge j)$ respectively, or there is one sentence uttered in that situation which translates into the formula as a whole. The first condition is met if e.g. the sentence

(43) John walks and John talks

is uttered, and the second condition if

(44) John walks and talks

is uttered in the situation in question.

The second pragmatic postulate expresses the one-to-one correspondence between (types of) performative sentences and forces.

PP2: If $\phi \in ME_t$ and ϕ is of the form $\Delta(x,p)$, where Δ , x , p are variables over two-place relations in intension, individual concepts and propositions respectively, and $F(\lambda x)(\langle i,j \rangle) = s(\langle i,j \rangle)$ and there exists a $\Gamma: \Gamma \in \text{FORCE}$ & $\{\langle x,p \rangle: \Delta(x,p)\}$ is a subset of the set associated with Γ , then $f(\phi) = \Gamma$

To illustrate the content of this postulate, consider the following example. Suppose the following formula is an element of ME_t :

(45) assert'($\wedge i, \wedge \text{come}'(\wedge j)$)

Since this formula is of the form $\Delta(x,p)$ PP2 applies to it. We also know that $F(\lambda i) = s$. Furthermore, there exist an element of FORCE, viz. ASSERTION, such that $\{\langle x,p \rangle: \text{assert}'(x,p)\}$ is a subset of the set associated with ASSERTION. According to PP2 therefore, f will always assign the force ASSERTION to (45) (if it assigns anything at all, i.e. if (45) is in accordance with PP1 as well). PP2 applies to all types of performative sentences, they will always be assigned the same force in all situations.

It should be noted that PP2 also formulates several other conditions with respect to the performativity of sentences. Requiring a formula to be of the form $\Delta(x,p)$ means that the highest predicate, Δ , does not occur under the scope of sentential operators such as negation, tense or modal operators, which have a performativity destroying character.

We are now able to define the notion of a performative verb:

A verb(phrase) ζ is a performative verb(phrase) iff there exists an expression Δ such that $\text{Trans}(\zeta, \Delta)$ and there exists a $\Gamma: \Gamma \in \text{FORCE}$ & $\{\langle x,p \rangle: \Delta(x,p)\}$ is a subset of the set associated with Γ

Based upon this definition we are now also able to define the notion of a performative sentence:

A sentence ϕ is a performative sentence relative to a pragmatic model PM iff there exists a ψ : $\psi \in ME_t$ & $Trans(\phi, \psi)$ & ψ is of the form $\Delta(x, p)$ and ϕ contains a performative verb(phrase) ζ & $Trans(\zeta, \Delta)$ & $F(x)(\langle i, j \rangle) = s(\langle i, j \rangle)$

This definition defines the notion performative sentence relative to a certain pragmatic model PM. A more general notion, that of a necessarily performative sentence, can be defined as follows:

A sentence ϕ is a necessarily performative sentence iff ϕ is a performative sentence relative to every pragmatic model PM

These two definitions make it possible to distinguish between the following two sentences:

(46) I promise that you will not be hurt

(47) The Court promises that you will not be hurt

Sentence (46) is a necessarily performative sentence, in every acceptable pragmatic model it will have the force of a promise. Sentence (47) on the other hand may fail to be performative in some models, viz. in those models in which the expression translating the subject term the Court fails to refer to the speaker.

The third pragmatic postulate will capture the observations made in section 3.3. with respect to the standard force of indicative non-performative sentences. Since in this paper we are only dealing with indicative sentences all elements of ME_t will be translations (if at all) of indicative sentences.

PP3: If $\phi \in ME_t$ & $(\Lambda \psi: Trans(\psi, \phi) \rightarrow \psi \text{ is not a performative sentence})$ & $f(\phi) = \langle \Gamma \rangle$, then $CC_{\Gamma}^{\phi} \supseteq CC_{\text{ASSERTION}}^{\phi}$

This pragmatic postulate expresses that the standard force of non-performative indicative sentences is that of an assertion, and that these sentences can only be assigned a force the correctness conditions of which include those of an assertion. The expression CC_{Γ}^{ϕ} stands for the set of correctness conditions of a sentence ϕ with a force Γ . A further explication will be given below.

The last postulate we will give concerns the assignment of forces to

compound formulas. In this postulate we must account for some of the regularities with respect to force multiplicity.

PP4: If ϕ is a compound formula of the form $\alpha \& \beta$, $\alpha \vee \beta$, or $\alpha \rightarrow \beta$, then $f(\phi) = \langle f(\alpha), f(\beta) \rangle$ iff $[\forall j, j': j, j' \in \langle j_0, \dots, j_n \rangle$ in M & $\forall \psi, \psi': ts(\langle i, j \rangle) = \psi$ & $ts(\langle i, j' \rangle) = \psi'$ & $Trans(\psi, \alpha)$ & $Trans(\psi', \beta)$] or $[\forall \chi: \chi$ is performative & $Trans(\chi, \alpha) \vee \forall \chi': \chi'$ is performative & $Trans(\chi', \beta)$]

This postulate expresses that compound formulas with a conjunctive, a disjunctive or implicational structure allow for force multiplicity only if their compounds each are the translation of a sentence which is uttered in the situation under consideration. It should be noted that this means that force multiplicity is possible only if the compounds of a compound formula are evaluated with respect to different moments of time.

To give an example, consider again (42):

(42) $walk'(\hat{j}) \& talk'(\hat{j})$

According to PP4 this formula allows for force multiplicity only if it is the translation of two sentences. If it translates sentence (43) or (48)

(48) John, who walks, talks

force multiplicity is possible. But if it translates (44) then only one force is possible.

One should bear in mind, though, that force multiplicity does not necessarily mean force diversity. Saying that a sentence has more than one force does not necessarily mean that it has different forces.

PP4 does not account for all phenomena with respect to force multiplicity.

E.g. it was observed in section 3.4. that disjunctions in general do not allow for force multiplicity. However, PP4 does not prevent the assignment of more than one force to formulas with a disjunctive structure. This is so, because we think that the regularities in question can be explained in a different, more illuminating way. We prefer the solution we will give for two reasons: (i) it relates the impossibility of force multiplicity in combination with disjunction to the specific character of disjunction; (ii) it allows in principle for the possibility that disjunctions containing non-indicative sentences do have more than one force. This possibility would be excluded if PP4 was restricted to conjunctions.

The impossibility of force multiplicity in combination with disjunctions will be explained in terms of structural incorrectness. E.g. we will show that due to the correctness conditions for disjunction, it is impossible to have a disjunction of indicative sentences with more than one force. Three facts can be accounted for: (i) disjunctions of explicit performative sentences are unacceptable; (ii) disjunctions of non-performative indicative sentences can only be interpreted as having one force; (iii) disjunctions of non-indicative sentences allow for force multiplicity.

Before going into this matter, we have to look a bit closer at the status of correctness conditions and the way in which they are handled in pragmatic models.

Within our framework correctness conditions are formulated by means of d and V as follows:

$$V(\langle \phi, \langle \Gamma \rangle, d \rangle) = c \leftrightarrow CC_{\Gamma}^{\phi} \subseteq d$$

Given a sequence and a (sequence of) force(s), and given a set of conversational information d , the function V assigns the value correct iff a particular set of formulas is a subset of the set of conversational information d . The precise content of the set indexed by ϕ and Γ depends on the values taken by ϕ and Γ . They are defined in a series of definitions in which the correctness conditions of the specific forces are spelled out. Since we are not concerned here with the exact content of the conditions for the various forces, we will illustrate by one simplified example. It should be noted that the set of correctness conditions of a certain force can be defined in general for all formulas. The only proviso we have to make concerns the distinction between formulas translating a performative sentence and those translating non-performative ones. The example illustrates this:

If ϕ is a performative formula of the form $\Delta(x,p)$, then

$$CC_{PROMISE}^{\phi} = \{\phi, \sim p, \text{prefer}'(\sim y, p, \sim p), \dots\}$$

If ϕ is otherwise, then

$$CC_{PROMISE}^{\phi} = \{\phi, \text{prefer}'(\sim y, \sim \phi, \sim \neg \phi), \dots\}$$

To give an example: the sentence I will be there is correctly used with the force of a promise by a speaker iff the speaker believes that he will be there and believes that the hearer prefers his being there to his not being there, etc. (21)

Besides definitions like these, we have to give (i) definitions of the correctness conditions of the connectives, and (ii) definitions of the correctness conditions of formulas with more than one force. In fact, the correctness conditions of the connectives should be stated with respect to standard forces. But since in this paper we are only dealing with indicative sentences there is only one relevant standard force, that of assertion. Therefore we do not have to refer to standard forces explicitly, this simplifies the formulation of the definitions. If we were to treat non-indicative sentences as well, we would use the notion standard force and formulate the definitions of compound formulas also with respect to them.

The correctness conditions for conjunction and disjunction can be defined as follows:

$$V(\langle \phi \& \psi, \langle \Gamma \rangle, d \rangle) = c \leftrightarrow \phi, \psi \in d \& CC_{\Gamma}^{\phi \& \psi} \subseteq d$$

$$V(\langle \phi \vee \psi, \langle \Gamma \rangle, d \rangle) = c \leftrightarrow \phi, \psi \notin d \& CC_{\Gamma}^{\phi \vee \psi} \subseteq d$$

The correctness conditions for compound formulas with more than one force can be defined along the following lines:

$$V(\langle \phi \& \psi, \langle \Gamma, \Delta \rangle, d \rangle) = c \leftrightarrow \phi, \psi \in d \& CC_{\Gamma}^{\phi} \subseteq d \& CC_{\Delta}^{\psi} \subseteq d$$

$$V(\langle \phi \vee \psi, \langle \Gamma, \Delta \rangle, d \rangle) = c \leftrightarrow \phi, \psi \notin d \& CC_{\Gamma}^{\phi} \subseteq d \& CC_{\Delta}^{\psi} \subseteq d$$

We are now able to explain the unacceptability of certain classes of sentences.

(i) Disjunctions of performative sentences. Disjunctions of performative sentences are structurally incorrect, and therefore unacceptable. An example of such a sentence is:

(49)* I promise to be there myself or I promise to send one of my friends

The structural incorrectness of this sentence follows from the definitions. Let ϕ be an abbreviation of the formula translating the sentence I promise to be there myself, and let ψ be an abbreviation of I promise to send one of my friends. Suppose that (49) is correct. According to PP2 and PP4 the formula $\phi \vee \psi$ is assigned the sequence of forces $\langle \text{PROMISE}, \text{PROMISE} \rangle$. The correctness conditions are then as follows:

$$V(\langle \phi \vee \psi, \langle \text{PROMISE}, \text{PROMISE} \rangle, d \rangle) = c \leftrightarrow \phi, \psi \notin d \& CC_{\text{PROMISE}}^{\phi} \subseteq d \& CC_{\text{PROMISE}}^{\psi} \subseteq d$$

According to the definition of $CC_{\text{PROMISE}}^{\phi}$, one of its elements ϕ itself.

Since $CC_{PROMISE}^{\phi} \subseteq d$, this implies $\phi \in d$. This contradicts $\phi \notin d$. The assumption that (49) is correct thus leads to a contradiction. This means that (49) is structurally incorrect. For this reason it is an unacceptable sentence.

(ii) Disjunctions of non-performative indicative sentences. These disjunctions cannot be interpreted as having more than one force. Consider for example:

(50) I will be there or I will send one of my friends

That this sentence can be assigned only one force is illustrated by the unacceptability of (49) and the acceptability of (51):

(51) I promise that I will be there myself or send one of my friends

The assumption that (50) has more than one force leads to a contradiction. Let $\phi \vee \psi$ be an abbreviation of the translation of (50). Suppose we assign a sequence of two forces to this formula. According to PP3 only those elements of FORCE can be assigned, the correctness conditions of which include those of ASSERTION. I.e. no matter what force we assign to a disjunct, say ϕ , one of the elements of its set of correctness conditions will be ϕ . This implies that if we assign two forces to $\phi \vee \psi$, ϕ as well as ψ are to be elements of d . But this contradicts the correctness conditions of disjunction which say that the disjuncts, in this case ϕ and ψ , are not to be elements of d . So, every interpretation which assigns more than one force to (50) implies that it cannot be used correctly. Evidently, such interpretations make no sense.

(iii) Conjunctions. Conjunctions such as:

(52)* I promise to give you a book though you prefer me not to

in which, loosely speaking, the second conjunct denies the fulfillment of a correctness condition of the first conjunct, are structurally incorrect and hence unacceptable. According to PP4, (52) is assigned a sequence of two forces. According to PP2, the first of these two is PROMISE. PP3 guarantees that whatever force is assigned to the second conjunct, its correctness conditions will include those of ASSERTION. So, it will be sufficient to show that the assignment of the force ASSERTION to the second conjunct of (52) renders it structurally incorrect. That this is so, can easily be seen. Let x be an abbreviation of I give you a book. If the first conjunct is to be correct, then

$\text{prefer}'(\sim y, \sim x, \sim \neg x)$ is to be an element of d . But for the correctness of the second conjunct with the force ASSERTION it is required that the negation of this formula is an element of d . By virtue of the fact that we assume d to be a consistent set of formulas, this situation can never arise.

6. Concluding remarks

We realize that the pragmatic theory developed so far is in need of further elaboration. The same holds for the semantic theory. An important test for the adequacy of the ideas we have put forward, would be to extend the grammar with non-indicative sentences.

Still, we are convinced that the theory outlined in this paper can be used successfully in the analysis of semantic and pragmatic phenomena of natural language. We think that this is shown in particular by the fact that using this theory some of these phenomena can be explained in a satisfactory way.

FOOTNOTES

- * The preparation of this paper was part of the research project 'Performatives and Pragmatics', supported by the Netherlands Organization for the Advancement of Pure Research (Z.W.O.). It is based upon an unpublished paper (Groenendijk & Stokhof 1975b) in which some of the topics dealt with here are discussed more extensively.

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1. Montague's works on natural language can be found in Thomason 1974.
2. See e.g. Austin 1962, Searle 1969, Hedenius 1963, Ross 1970, Åqvist 1972, and Cresswell 1973. A good survey is given in Danielsson 1973.
3. In Groenendijk & Stokhof 1975b the syntactic status of performative sentences is discussed in more detail. Also, syntactic definitions of performative sentences (as e.g. the one given by Ross in Ross 1970) are criticised and shown to be inadequate.
4. These are the interpretations which are commonly given, see among others Partee 1975, Montague 1970 and Montague 1973.
5. The inconsistency in the nomenclature is evident. Pragmatic selfverifiability is indeed to be sure a semantic notion. The adjective 'pragmatic' stems from the viewpoint that all properties which make reference to utterances are of a pragmatic nature. We do not adhere to this view but stick to the original name for historical reasons.
6. They concern e.g. modals (see Groenendijk & Stokhof 1975a) and epistemic expressions (see Groenendijk & Stokhof 1976b). In this latter paper the theory of pragmatics outlined here is given a more general and formally more satisfactory basis.
7. On these (and other) grounds we reject the so-called 'performative analysis' as proposed by Ross (Ross 1970) and Sadock (Sadock 1969). For details see Groenendijk & Stokhof 1975b.

8. For the notion 'illocutionary act' see Austin 1962 and Searle 1969.
9. We do not think that so-called 'indirect speech acts' are counterexamples to this thesis. The fact that an utterance of the indicative sentence It is cold in here sometimes has the effect that the addressee closes the window, is in our opinion a phenomenon of a totally different nature. To be sure, the indicative sentence has, in this situation too, the force of an assertion. It is only by way of a very complicated chain of reasoning, that the addressee reconstructs the intention with which this assertion was made. This is essentially different from taking the sentence I will be there as a promise when said e.g. as an answer to Do you promise to be there?
10. Given this formulation saying that the standard force of indicative sentences is ASSERTION might be too strong a claim. If one of the correctness conditions of ASSERTION is that the speaker believes that the hearer does not already know what he is going to assert, then not all correctness conditions of ASSERTION should be included in the sets of correctness conditions of the other possible forces. E.g. the just mentioned condition might fail if one uses I did it with the force of an admission. If this is true, then we should define a 'proto-force' of which assertion itself is an extension. This proto-force then, would be the standard force of indicative sentences.
11. By a compound sentence we understand a sentence which is formed from two or more other sentences and one or more connectives. By a complex sentence we understand a sentence in which another sentence is embedded. By a simple sentence we understand a non-complex and non-compound sentence. The same terminology will be applied with respect to formulas.
12. In Groenendijk & Stokhof 1975b we have discussed sentences which constitute apparent counterexamples to this claim. These sentences are also discussed in Kasher 1974.
13. In fact, only sentences which translate into conjunctions can be assigned more than one force without thereby becoming structurally incorrect.

Disjunctions which are assigned more than one force are structurally incorrect. This is caused by the special correctness conditions for disjunction.

14. In what follows we restrict ourselves to this class of performative verbs, although there are of course also other types of performative verbs. However, we see no fundamental problem in generalising our remarks.
15. A more detailed account can be found in Groenendijk & Stokhof 1976a. Notice that we make the simplifying assumption that in each possible world at each moment of time there is only one person speaking. This is of course not true. It is only in a very limited context, or speech situation, that there is a unique speaker. However, since the only contextual elements which are dealt with here are possible worlds and moments of time, the assumption we make is necessary. It is also quite harmless.
16. The idea of introducing the indices t_s and C_m stems from Åqvist.
17. The expressions x and p are metavariables ranging over expressions of type $\langle s, e \rangle$ and $\langle s, t \rangle$ respectively. I.e. expressions denoting individual concepts and propositions.
18. ME_t is the set of meaningful expressions of type t of the language of intensional logic, i.e. the set of formulas.
19. The assumption that FORCE is a finite set is, we think, warranted by the conventional character of illocutionary acts, and their specific language-dependency. It seems hard to imagine that the speakers of a certain language have managed to create by convention an infinite number of illocutionary acts.
20. The notion 'conversational information' is further elaborated in Groenendijk & Stokhof 1976b.
21. A precise description of these conditions can be found in Searle 1969.

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SCOPE AMBIGUITY AND SCOPE RESTRICTION IN MONTAGUE GRAMMAR

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The grammar described in Montague's "Proper Treatment of Quantification in Ordinary English" (PTQ) is equipped with a general syntactic mechanism for deriving scope ambiguities. The present paper will deal with the question of how to constrain this mechanism in order to implement restrictions of scope. The overall approach will be in line with some earlier work of mine (Hausser 1973, 1974b, 1976a) in that scope restrictions are analyzed in terms of particular properties of individual quantifiers.

In section 1 the linguistic nature of scope ambiguities and scope restrictions will be discussed. In section 2 the distinction between presupposing and assertive quantifiers (that is quantifiers which do and quantifiers which do not induce existential presuppositions, respectively) is introduced. The reason for mentioning presuppositions in the present context is that certain scope restrictions will turn out to depend on the distinction between presupposing and assertive quantifiers. In this sense the present paper will provide concrete surface syntactic evidence for the (semantically motivated) distinction between presupposing and assertive quantifiers, which I first argued for in Hausser (1973). In section 3 the role of pronouns in PTQ is discussed and my formal approach to implementing scope restrictions into an extended PTQ is outlined. In section 4, 5, and 6 different scope restrictions on presupposing quantifiers are presented and formally implemented. In section 7 the scope and occurrence restrictions of any and no are discussed. In section 8, finally, the restrictions of assertive quantifiers are formally implemented and the new rules are presented in their final form.

The rules defined in this paper, together with the rules and definitions retained from the original version of PTQ, constitute a complete grammar of English (complete in the sense that it has a rigorously defined syntax and semantics), generating a fragment of English in which the scope ambiguities as well as the scope restrictions of numerous quantifiers are accounted for.

1. The linguistic nature of scope ambiguities and scope restrictions
 Ambiguities are a matter of semantic intuition and the nature of some ambiguities is often subject to controversy. Let me therefore present the kind of data to be discussed as well as the kind of general analysis to be adopted.

This paper deals with three types of scope ambiguity arising with certain quantifiers of English. By "quantifiers of English" I mean such lexical items as every, some, the, both, a(n), any, no, one, two, three, etc. 'Relative' quantifiers like many, few, much will not be considered here, however, because they involve implicit standards of comparison and require a more complicated semantic analysis than the 'absolute' quantifiers listed above.¹

The three types of scope ambiguity we will be concerned with are exemplified in the sentences (1), (2), and (3) discussed below.

1) Every girl read some books.

Sentence (1) has two readings, which may be paraphrased as follows:

1a) Every girl read his own set of books.

1b) There is a given set of books which every girl read.

The logico-philosophical approach (e.g. Quine 1960) analyses the two readings of (1) in terms of different underlying orders of the logical representation of every and some. On the reading paraphrased in (1a) every has wider scope than some. That is, the logical formula representing the underlying structure of the first reading of (1) should look roughly like this:

1a') $\Lambda x \dots \text{girl}(x) \dots \text{Vy} \dots \text{book}(y) \dots \text{read}(x,y)$

On the reading paraphrased in (1b), on the other hand, some has wider scope than every. Here the logical formula representing the underlying structure should have roughly the form:

1b') $\text{Vy} \dots \text{book}(y) \dots \Lambda x \dots \text{girl}(x) \dots \text{read}(x,y)$.

Next consider sentence (2):

2) John didn't find a unicorn.

Again, (2) has two different readings, which may be paraphrased as:

2a) There is a unicorn which John didn't find.

2b) John found no (=not a) unicorn.

The different readings of sentence (2) correspond to different underlying orders of negation and the indefinite article (as reflected in the paraphrases).

The third type of scope ambiguity is exemplified in sentence (3):

3) John is looking for a unicorn.

Here the ambiguity arises because of the possible difference in the underlying order of the intensional verb look for and the indefinite term. The two readings of (3) may be paraphrased as follows:

- 3a) There is a certain unicorn John is looking for.
- 3b) John is looking for any old unicorn.

In our examples (1), (2), and (3) we established different readings in form of paraphrases and related the ambiguities observed to different underlying orders of a quantifier and another predicate. The reason is, of course, that the order of quantifiers and other operators in a logical formula has crucial truthfunctional consequences. For example, in our analysis of sentence (1) we exploited the truthfunctional difference between $\Lambda x V y [\phi]$ and $V y \Lambda x [\phi]$. Similarly, in our analysis of sentence (2) we aimed at the truthfunctional difference between $\sim V x [\phi]$ and $V x \sim [\phi]$. Can we show that the different readings in question are not merely a projection of logical distinctions into natural language? What kind of evidence can we adduce in support of our analysis (which represents the traditional logico-philosophical approach) beyond the correspondence in meaning of the postulated readings and the meaning of the corresponding logical formulas?

First, there is the comparison of different languages. For example, if we translate sentence (2) into German we do not obtain one ambiguous sentence. Instead, German disambiguates the two readings of (2) morphologically. The (2a) reading translates as

4a) Hans hat das Einhorn nicht gefunden.

while the (2b) reading translates as

4b) Hans hat kein Einhorn gefunden.

The fact that sentence (2) translates alternatively into two sentences of German shows that (2) is indeed ambiguous.

Secondly, there is the phenomenon of dominant versus non-dominant readings. Consider:

1) Every girl read some books.

The point is that the two readings of (1) are not equally strong. If we interpret (1) in isolation the reading paraphrased as (1a)

1a) Every girl read his own set of books.

is clearly the dominant one. And there is a reason for this: on the (1a)-reading the order of the quantifiers in the postulated underlying formula is the same as the order of the corresponding linguistic quantifiers in (1). And conversely, the reading paraphrased in (1b)

1b) There is a given set of books which every girl read.
is the non-dominant reading because here the underlying order of quantifiers does not agree with the surface order every...some. In other words, certain properties of the postulated underlying logical formula are (in certain instances) reflected on the surface. As another example consider (5):

5) John didn't kiss both girls.

On the dominant reading of (5) John kissed one, but not the other girl. This reading corresponds to the underlying order not...both, which is also the surface order of the quantifiers. On the non-dominant reading of (5), on the other hand, John kissed neither girl, which corresponds to the underlying order both...not. If we change the surface order, for example by passivizing the sentence, we obtain a different dominant reading:

6) Both girls weren't kissed by John.

(6) has the neither (i.e. both...not) reading as the dominant reading - in contrast to (5).²

Let us turn now to the main topic of this paper: the phenomenon of scope restrictions. Consider sentence (7):

7) John didn't find every unicorn.

Based on our previous observations in connection with sentence (2) we should expect that (7) is an ambiguous sentence. One reading should represent the underlying order

not...every

and the other reading the underlying order

every...not.

Upon inspection we realize, however, that (7) is in fact not ambiguous. (7) can intuitively only mean that John found some though not all unicorns. (7) cannot mean, however, that John found no unicorns at all. In other words, we can interpret (7) only in the sense that not has wider scope than the logical representation of every. This kind of phenomenon I want to call a scope restriction: the scope of the (logical representation of the) quantifier every is restricted to having more narrow scope than negation.

Are there instances in which scope restrictions are reflected on the surface? Consider:

8) *Every girl didn't kiss John.

(8) is unacceptable under normal intonation. The reason is that in

(8) the surface order does not correspond to the only possible underlying order not...every. Instead of (8) one would say (9):

9) Not every girl kissed John.

The fact that (8) may be acceptable if read with rising intonation on every girl does not diminish the significance of this example. Indeed, special intonation is also required to bring out non-dominant readings (c.f. example (5) and (6)). Syntactic relations expressed by word-order may often be alternatively expressed by special intonation. Therefore let us treat the fact that (8) requires special intonation in order to be acceptable (whereby it still has the same interpretation as (9)!) as a consequence of the disagreement between surface order and underlying order. Accordingly, no restriction of the surface syntax (in the sense that (8) should not be generated by the grammar) will be implemented.

Another quantifier of English which is subject to a scope restriction regarding negation is the definite article. Consider for example (10):

10) John didn't kiss the girls at the party.

(10) can only mean that John kissed none of a definite set of girls. It cannot mean, however, that John kissed some though not all girls in this definite set. Definiteness is assumed here to be an indexical property of certain quantifiers (for a detailed analysis of the definite article as a context dependent quantifier see Hausser (1974b), chapter V). Before we can decide whether the takes wider or more narrow scope than negation we have to determine whether the should be represented by an existential or a universal quantifier. Consider in this connection sentence (11):

11) John kissed the girls at the party.

(11) means that John kissed all of a certain definite set of girls and not just one or two of them. Therefore the plural of the should translate by means of a universal quantifier. Singular the may also translate by means of a universal quantifier - provided that the existential import of this quantifier is captured in some other way. This is taken care of in connection with the implementation of existential presuppositions into PTQ (c.f. section 2 below; c.f. also Hausser (1976a)). Assuming that the singular and the plural of the translate uniformly by means of a universal quantifier we conclude that the is restricted to having wider scope than negation.

A third example of a scope restriction with respect to negation is the quantifier some. Consider:

12) John didn't kiss some girls at the party.

(12) can only mean that John kissed some though not all girls; it can not mean that John kissed none of the girls. Assuming that some translates by means of an existential quantifier, we conclude that some is restricted to having wider scope than negation.³

Scope restrictions arise through the interaction of a quantifier and another operator, which we might call the 'trigger'. In our examples (7), (10), and (12) the trigger was negation. There are other operators, however, with respect to which every, some, and the are unrestricted. This is shown by the ambiguity of

1) Every girl read some books.

or

13) John is looking for the murderer of Smith.

On the other hand, negation is not the only trigger with respect to which every, some, and the are restricted (other types of scope restrictions will be presented below). Quantifiers which are not restricted with respect to negation are the indefinite article (as demonstrated by the examples (2) and (3)) and the natural numbers.

We characterized a sentence of natural language as ambiguous if it related to at least two (non-equivalent) logical formulas. In this connection it is important to keep in mind that scope ambiguities (and syntactic ambiguities in general) are a phenomenon which depends on the particular surface morphology of the natural language in question. This is demonstrated, for example, by the fact that sentence (2) has two different translations in German. The surface dependency of syntactic ambiguities is captured in Montague's PTQ in the following way: structural indeterminacies⁴ (i.e. when a sentence has more than one possible analysis - which is actually the normal case in PTQ) are generated within the categorial surface syntax in the most general fashion. Many of these structural indeterminacies are rendered semantically uninteresting on the level of intensional logic, however, in that the different analyses translate into equivalent formulas (for example because of a meaning postulate). In order to formally treat the phenomenon of scope restrictions there are two basic possibilities to constrain the generating of syntactic ambiguities in PTQ:

- i) a semantic approach (for example by defining additional meaning postulates which render the translation of different analyses equivalent, or by means of constraints which characterize certain types of translation formulas as linguistically unacceptable);
- ii) a syntactic approach (by excluding certain analyses from the output of the categorial surface syntax).

In order to choose between these alternative we must find out whether scope restrictions are a purely semantic phenomenon or not. This is an empirical question; it could be, for example that every quantifier in natural language which is semantically represented by a universal quantifier must take more narrow scope than negation. If this were true we would formulate scope restrictions on the level of translation formulas (i.e. on the level of semantic representation). Our present data, however, show already that this is not the case: both every and the translate by means of a universal quantifier, yet every takes narrow scope regarding negation, while the takes wider scope. A more straightforward example are the quantifiers any and no, which will be analyzed in section 7 below.

2. Presupposing versus assertive quantifiers

After presenting the general type of data we will be concerned with, let us turn to the specifics of a formal analysis of scope restrictions. Our goal is to find syntactic and semantic distinctions which would allow a preferably simple description of seemingly unpredictable scope restrictions (the really complex data will be presented in the following sections as we go on with our analysis). One promising way to find such distinctions is to develop reasonably realistic semantic representations of individual quantifiers of English.

Since we want to present our analysis of scope restrictions in form of an extension of PTQ, it will be helpful to improve the semantic representation of quantifiers in PTQ. One of the inadequacies of PTQ is that presuppositions are not implemented. Consider

14) John kissed every girl at the party.

(14) translates in PTQ as

14a) $\Lambda x[\text{girl a.t.p.}'(x) \rightarrow \text{kiss}'(^j, \hat{P}\{x\})]$

According to translation (14a) sentence (14) is true with respect to a situation where there are no girls at the party. This is intuitively unsatisfying, however. (14) presupposes the existence of girls and should therefore be truthvalueless under the indicated circumstances.

I cannot go here into the details of my formal treatment of presuppositions (c.f. Hausser 1976a). However, let me state briefly the main points. I assume that all relevant presuppositions of a sentence of natural language are induced by certain lexical items which I call P-inducers. For example, the verbs stop and regret are P-inducers. The presence of a P-inducer in a simple sentence guarantees the presence of a characteristic presupposition. In complex sentences, furthermore, we have to deal with phenomenon of presupposition canceling. Once we have established all P-inducers as well as all canceling contexts of a given natural language, we can systematically compute all presuppositions of any given sentence without depending on the intuition.

In the case of quantifiers it can be shown that every, some, the, and both are existential P-inducers, while the indefinite article, any, no and the natural numbers do not induce existential presuppositions. Let us call the P-inducing quantifiers "presupposing quantifiers", and the other quantifiers like the indefinite article, any, etc. "assertive quantifiers". It remains to implement the distinction between presupposing and assertive quantifiers formally into the grammar. This is done in Hausser (1973, 1974b, and

1976a) by translating presupposing quantifiers by means of newly defined restricted quantification, while assertive quantifiers translate by means of the usual non-restricted quantification. Restricted quantification has the form

15a) $\forall x \lambda [f(x)] \phi$

15b) $\lambda x \lambda [f(x)] \phi$

The truthdefinitions for restricted quantification say that a formula like (15a) or (15b) is without truthvalue ~~with respect to a given model~~ if $\lambda x \lambda [f(x)]$ denotes the empty set with respect to the point of reference in question. Otherwise the truthvalues of (15a) and (15b) are defined as in the case of non-restricted quantification. The translation of the various quantifiers is defined in our extension as indicated in (16) and (17):

16a) a(n) translates into $\hat{Q}\hat{P}\forall x [Q\{x\} \wedge P\{x\}]$

16b) any translates into $\hat{Q}\hat{P}\lambda x [Q\{x\} \rightarrow P\{x\}]$

16c) no translates into $\hat{Q}\hat{P}\sim \forall x [Q\{x\} \wedge P\{x\}]$

The P-inducers every, some, and the, on the other hand, translate as

17a) every translates into $\hat{Q}\hat{P}\lambda x \lambda [Q\{x\}] P\{x\}$

17b) some translates into $\hat{Q}\hat{P}\forall x \lambda [Q\{x\}] P\{x\}$

17c) the (singular) translates into $\hat{Q}\hat{P}\lambda x \lambda [\lambda y [Q\{y\} \leftrightarrow y=x]] P\{x\}$

According to (17a) sentence (14) translates in our extension as

14a') $\lambda x \lambda [girl \text{ a.t.p. } '(x)] \text{ kiss } (^j, \hat{P}P\{x\})$

(14a') is # (i.e. without truthvalue) with respect to a situation where there are no girls at the party, i.e. where the extension of $\lambda x \lambda [girl \text{ a.t.p. } '(x)]$ denotes the empty set.

The implementation of existential presuppositions just outlined improves the semantic adequacy of PTQ in an obvious way. For example, sentence (18)

18) John didn't kiss the girl

intuitively presupposes the existence of the 'the girl'. Yet one possible translation of (18) in PTQ is

18a) $\sim \forall x [\lambda y [girl'(y) \leftrightarrow y=x] \wedge \text{ kiss } (^j, \hat{P}P\{x\})]$

(18a) is inadequate in that it doesn't even entail the existence of the girl. In our extension, on the other hand, (18) translates as

18a') $\lambda x \lambda [\lambda y [girl'(y) \leftrightarrow y=x]] \sim \text{ kiss } (^j, \hat{P}P\{x\})$

(18a') presupposes the existence of the girl - as desired.

In what way does the implementation of existential presuppositions affect the semantic properties of the scope ambiguities handled in PTQ? As indicated in the beginning, we are here concerned

with three basic types of scope ambiguities, namely scope ambiguities

- 19a) arising over varying underlying order of two different quantifiers,
- 19b) arising over varying underlying order of a quantifier and negation,
- 19c) arising over varying underlying order of a quantifier and an intensional predicate.

As far as ambiguous sentences of type (19a) and (19b) are concerned, the implementation of existential presuppositions leads to the same kind of overall improvement as in unambiguous sentences. This kind of unproblematic carry over does not hold, however, in the case of the ambiguities of type (19c), which Montague calls the de dicto/de re ambiguity.

Of course, as long as the term involved in a de dicto/de re ambiguity is an assertive term there is no problem. Consider for example (20)

20) John seeks a unicorn.

The de dicto reading of (20) translates as

20a) $\text{seek}(\hat{j}, \hat{\text{PP}}\text{Vu}[\text{unicorn}_*(u) \wedge P\{\hat{u}\}])$

while the de re reading translates as

20b) $\text{Vu}[\text{unicorn}_*(u) \wedge \text{seek}'(\hat{j}, \hat{\text{PP}}\{\hat{u}\})]$

The de re reading (20b) entails the existence of a unicorn (via simplification of the conjunction). On the de dicto reading, (20a), on the other hand, simplification is not valid and thus the existence of a unicorn is not entailed on this reading. In short, the translation formulas representing the de dicto/de re readings are adequate in the original version of PTQ as long as the quantified term involved is an assertive term. But what about the de dicto/de re ambiguity if the term involved is a presupposing term? Consider as an example (21).

21) John wants to murder the man who lives in Apt. 3.⁵

It is clear that the de re reading of (21) presupposes the existence of a man in Apt. 3. This intuition is reflected in our extension, where the de re reading of (21) translates as

21a) $\text{Ax}\exists[\text{Ay}[\text{man}'(y) \leftrightarrow y=x]] \text{ want to}'(\hat{j}, \hat{2} \text{ murder}'(z, \hat{\text{PP}}\{x\}))$

The de dicto reading of (21), on the other hand, translates in our extension as (21b):

21b) $\text{want to}'(\hat{j}, \hat{2} \text{ Ax}\exists[\text{Ay}[\text{man}'(y) \leftrightarrow y=x]] \text{ murder}'(z, \hat{\text{PP}}\{x\}))$

The problem is: should (21b) be # if there doesn't exist a man in Apt. 3? In other words, now that we have implemented existential

presuppositions we have to decide whether de dicto readings cancel existential presuppositions induced by terms positioned in the opaque context.

According to my intuitions (21b) does not presuppose the existence of a man in Apt. 3 (though we might require that John must believe in the existence of such a man in order for (21b) to be bivalent). We implement this intuition by defining want to as an intensional predicate, that is a predicate the extension of which is defined even if the extension of its argument is undefined. For the exact definitions see Hausser (1976a).

It can be shown that other existential P-inducers, for example every and some, behave just like the definite article as far as de dicto readings are concerned. Consider (22):

22) John wants to talk to every boy who failed the examination. On the de dicto reading John wants to talk to whatever boys happen to fail the examination. John's wish may be reported before the results of the test are known, and it might very well turn out that in fact nobody failed the examination. Since (22) would intuitively be bivalent under such circumstances, the existence of boys who failed the examination is not presupposed on the de dicto reading of (22).

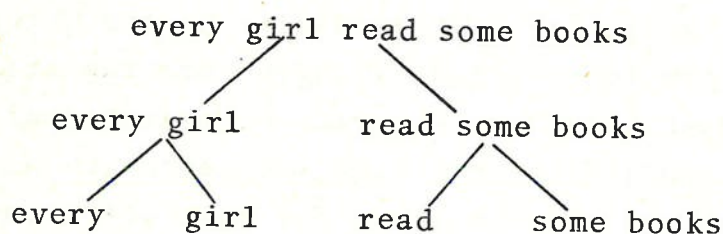
The just described implementation of presuppositions into PTQ is semantic in the linguistic sense insofar as the categorial syntax of PTQ remains untouched. All we change are the translation rules for presupposing quantifiers, the syntax of intensional logic (by adding restricted quantification), and the semantics of intensional logic (by adding the truthdefinitions for restricted quantification as well as for intensional versus extensional predicates). We have improved the fit between theory and data in that the translation formulas in our extension correspond closer to our intuition - at least in the case of sentences containing presupposing quantifiers. Furthermore, we have improved the semantic handling of the de dicto/de re ambiguity in our extension. The question is now: how can we further improve the descriptive adequacy of PTQ by implementing scope restrictions?

3. The role of pronouns in PTQ

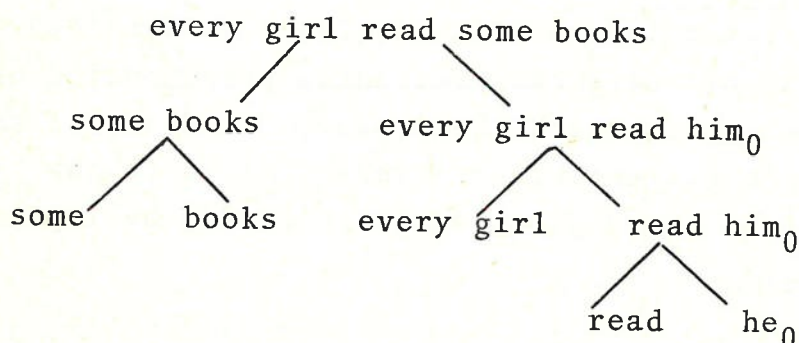
We have argued already that a handling of scope restrictions on the level of intensional logic alone (i.e. a purely 'semantic' approach) is not feasible because the translation formulas do not carry enough information. This can be seen in the case of the quantifiers every and the, which both translate by means of a restricted universal quantifier, yet are subject to different scope restrictions.

The remaining possibility to implement scope restrictions is a 'syntactic' approach (i.e. scope restrictions are handled on the level of the categorial surface syntax). A syntactic approach to implementing scope restrictions into PTQ depends largely on the syntactic handling of scope ambiguities in PTQ. Let us therefore have a brief look at the surface syntactic mechanism generating scope ambiguities. Montague handles all three types of scope ambiguities exemplified in the examples (1), (2), and (3) in one uniform way. For example, the two readings of sentence (1) are generated over the following two analysis trees:

23a)



23b)



The crucial difference between the two analyses is that the quantifiers are introduced at different stages of the derivation. In (23a) some is introduced before every, while in (24b) every is introduced

before some. This difference appears in the translation formula as a difference in the linear order of the quantifiers. Thus (23a) translates in our extension as

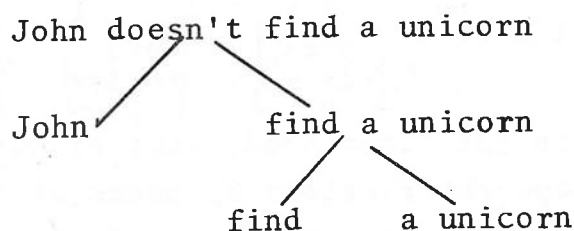
23a') $\Lambda x_3[\text{girl}'(x)] \text{ Vy}_3[\text{books}'(y)] \text{ read}_*('(\forall x, \forall y)$

while (23b) translates as

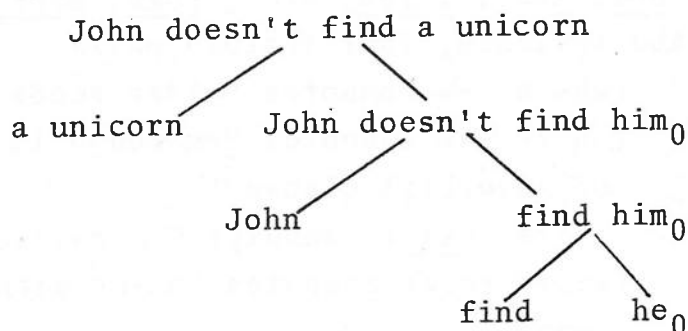
23b') $\text{Vy}_3[\text{books}'(y)] \Lambda x_3[\text{girl}'(x)] \text{ read}_*('(\forall x, \forall y)$

The syntactic basis for the alternative order of term introduction in (23) is the operation of pronoun substitution. The same operation appears in the derivation of one of the two readings of sentence (2) which are represented as (24a) and (24b), respectively:

24a)



24b)



It is the principle of pronoun substitution which in (24b) permits an alternative order of introduction of the quantifier and negation. The difference between (24a) and (24b) is again reflected in different linear orders of the quantifier and negation. (24a) and (24b) translate into (24a') and (24b'), respectively:

24a') $\sim \forall x[\text{unicorn}'(x) \wedge \text{find}_*('(\forall x, \forall x)]$

24b') $\forall x[\text{unicorn}'(x) \wedge \sim \text{find}_*('(\forall x, \forall x)]$

What is the status of these indexed pronouns he_n or him_n , which play such a crucial role for deriving scope ambiguities (as well as restrictive relative clauses, coordinate structures, etc.)? These pronouns are non-terminal symbols which do not carry any lexical information. The only information they contain is the correferential index. The basic idea of my approach to implementing scope restric-

tions is to encode more syntactic information into the pronouns (in addition to the index). For example, a pronoun in a negated sentence may not be replaced by a term of the form every+noun because this would lead to a violation of the restriction that every must have more narrow scope than negation. Let us handle syntactic information like whether a pronoun happens to be in a negated sentence or whether a pronoun happens to be in an embedded sentence or not in form of syntactic features. These features are to be encoded into the pronouns by the syntactic rules which introduce negation or embedding, etc. In order to formally implement this approach let us treat pronouns as abstract feature bundles. Instead of he_0 , he_1 , etc. our indexed pronouns in the lexicon have the form:

25) $\begin{bmatrix} -pres \\ +exist \\ 0 \end{bmatrix}$, $\begin{bmatrix} -pres \\ +exist \\ 1 \end{bmatrix}$, $\begin{bmatrix} -pres \\ +exist \\ 2 \end{bmatrix}$, etc.

The quantifiers, on the other hand, must be marked in the lexicon for their inherent scope restrictions by means of superscripts. In order to handle the scope and occurrence restrictions of the quantifiers a(n), any, no, one, two, three, etc., some, every, all, the, and both, we need the following four feature pairs:

- 26) $\pm w$ (where $+w$ connotes "wider scope than negation")
 $\pm r$ (where $+r$ connotes "embedded in a relative clause or adverbial clause")
 $\pm exist$ (where $-exist$ connotes "no existential entailment")
 $\pm pres$ (where $+pres$ connotes "being element of a presupposing term").

Anticipating our later results, the here discussed quantifiers should be marked in the lexicon for their inherent scope restrictions - if any - as follows:

- 27) $B_{T/CN} = \{a(n), any^{-exist}, no^{+exist}, one, two, three, etc., some^{+w, -r}, every^{-w, -r}, the^{+w, -r}, both^{-r}\}$

The superscript $\pm w$ in (27) has already been motivated in section 1. For example, that some and the are marked $+w$ reflects the fact that some and the take wider scope than negation. Every, on the other hand, is marked $-w$, because it takes more narrow scope than negation. The function of the features $\pm r$, $\pm exist$, $\pm pres$ will be explained below. Unmarked quantifiers in (27), e.g. the indefinite article, do not have any scope restrictions in our extension.

In addition to attaching superscripts to quantifiers we have to redefine a number of rules of the categorial surface syntax of PTQ in order to

- 28i) encode certain syntactic operations into indexed pronouns by adding or changing features,
- ii) delete certain superscripts on quantifiers
- iii) stipulate (in the rules S14-S16), i.e. the rules of quantification) that a pronoun may be replaced by a term only if the superscripts of the quantifier (of the term in question) do not disagree with the feature(s) of the pronoun.

It is assumed that sentences containing an unreplaced (indexed) pronoun or an undeleted superscript are not considered an acceptable output.⁶

4. Implementing scope restrictions regarding negation

In this and the following sections various phenomena of scope restriction will be presented and formally implemented into our extension by redefining certain rules. In order to facilitate the explication I will in some cases first define a preliminary version of a rule - stated as $\dagger S$. The final version of a rule, on the other hand, is stated as $*S$. The present section is devoted to implement the already discussed restriction of presupposing quantifiers with respect to negation. To this purpose we must redefine the rules S14 and S17 of PTQ, i.e. the rules which are involved in generating sentences containing negation with various scope.

$\dagger S17$. If $\alpha \in P_T$ and $\delta \in P_{IV}$, then $F_{11}(\alpha, \delta)$, $F_{12}(\alpha, \delta)$, $F_{13}(\alpha, \delta)$, $F_{14}(\alpha, \delta)$, $F_{15}(\alpha, \delta)$, and $F_{16}(\alpha, \delta) \in P_t$, where

$F_{11}(\alpha, \delta) = \alpha'\delta'$ and $\alpha'\delta'$ comes from $\alpha\delta$ by replacing the first verb in δ by its third person singular present and deleting all superscripts $+w, -w, +r, -r$ in $\alpha\delta$.

$F_{12}(\alpha, \delta) = \alpha''\delta''$ and $\alpha''\delta''$ comes from $\alpha\delta$ by replacing the first verb in δ by its negative third person singular present, marking all pronouns in $\alpha\delta$ with the feature $+w$, and deleting all superscripts $-w, +r, -r$ in $\alpha\delta$.

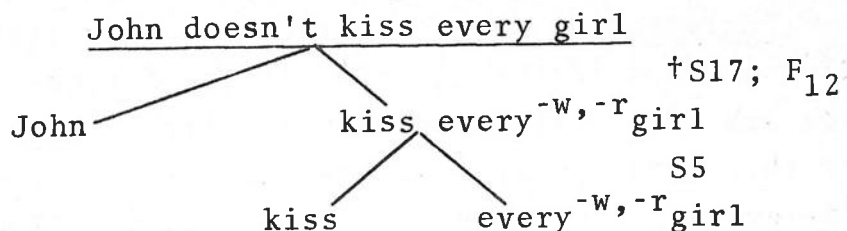
(and accordingly for F_{13}, F_{14}, F_{15} , and F_{16})

The point of the new rule $\dagger S17$ is (i) to delete $+w$ superscripts only in non-negated sentences and (ii) mark pronouns in negated sentences with the feature $+w$.

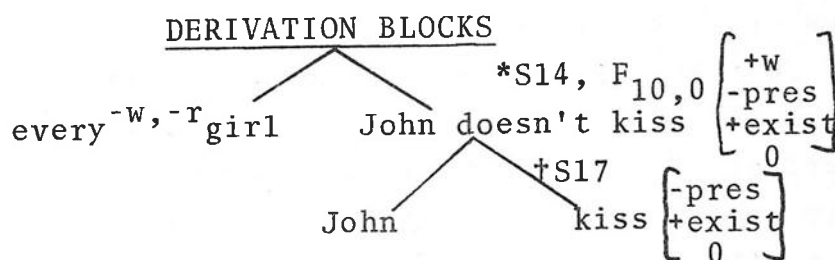
$*S14$. If $\alpha \in P_T$ and $\phi \in P_t$, then $F_{10,n}(\alpha, \phi) \in P_t$, where either (i) α does not have the form $\begin{bmatrix} \text{pres} \\ +\text{exist} \\ k \end{bmatrix}$, and $F_{10,n}(\alpha, \phi)$ comes from ϕ by replacing α for the first not disagreeing pronoun $\begin{bmatrix} \text{---} \\ n \end{bmatrix}$ in ϕ , deleting all superscripts in α , and replacing all other occurrences of $\begin{bmatrix} \text{---} \\ n \end{bmatrix}$ by $\begin{bmatrix} \text{he} \\ \text{she} \\ \text{it} \end{bmatrix}$ or $\begin{bmatrix} \text{him} \\ \text{her} \\ \text{it} \end{bmatrix}$ depending on the case marking in the indexed pronoun (c.f. rule $*S5$ below) and according as the gender of the first B_{CN} or B_T in α is masc , fem. , or (ii) $\alpha = \begin{bmatrix} -\text{pres} \\ +\text{exist} \\ k \end{bmatrix}$, and $F_{10,n}(\alpha, \phi)$ comes from ϕ by changing all indices n to k .

The point of the newly defined operation $F_{10,n}$ is to delete all superscripts on α , provided that these superscripts do not disagree with the features of the replaced pronoun. The interaction of S17 and $*S14$ is demonstrated by the following analyses:

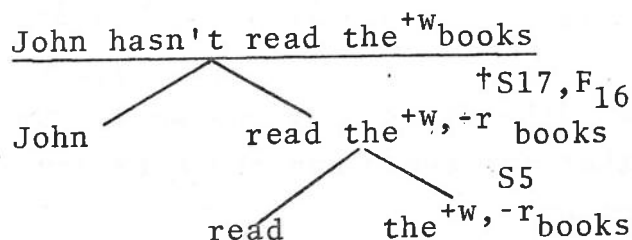
28a)



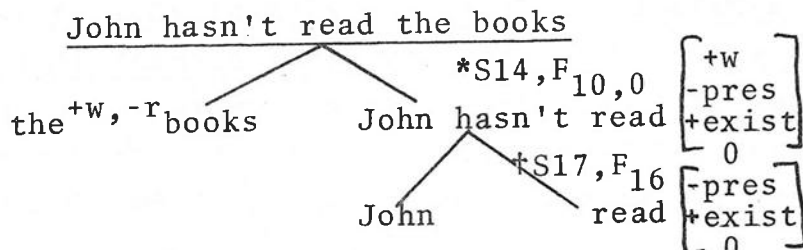
28b)*



29a)*



29b*)



We tentatively characterized +w as connoting "wider scope than negation". This description must be qualified insofar, however, as features like ±w serve a double function in our extension: on the one hand, ±w as a quantifier superscript indeed indicates the individual scope restriction of a quantifier regarding negation. As a pronoun feature, on the other hand, +w has the function of specifying what kind of term may replace the pronoun.

The reason for marking indexed pronouns in the lexicon as $\begin{bmatrix} -pres \\ +exist \end{bmatrix}$ will be explained in section 8 in connection with the assertive quantifiers any^{-exist} and no^{+exist}.

5. Implementing scope restrictions with respect to embedding

Next let us turn to the question of whether quantifiers in embedded clauses are also restricted with respect to negation. In order to answer this question we must investigate the general relation between quantifiers and the phenomenon of embedding. The first who observed that this relation is subject to constraints was Robert Rodman (1972), who considered sentences like (30):

(30) John has dated a woman who loves every man.

Rodman notes that (30) is intuitively not ambiguous. (30) can only be interpreted in the sense that a woman has wider scope than every man. In other words, even though (30) has the possible translations (30a) and (30b), only (30a) is intuitively acceptable.

(30a) $Vx[(\text{woman}'(x) \wedge \exists y[\text{man}'(y)] \text{love}'(x, \hat{P}P\{y\})) \wedge \text{date}'(^j, \hat{P}P\{x\})]$

(30b) $\exists y[\text{man}'(y)] Vx[(\text{woman}'(x) \wedge \text{love}'(x, \hat{P}P\{y\})) \wedge \text{date}'(^j, \hat{P}P\{x\})]$

According to (30a) John dates only one woman, while (30b) has the bizarre meaning that for every man there exists a woman who loves the man and John dates her.

Based on data like (30), Rodman proposed the hypothesis that

(31) In a relative clause, the element that is relativized always has wider scope than any other element in that rel. clause.

It is obvious that only translation formula (30a) obeys this constraint. Thus (31) correctly excludes translation formula (30b).

There are data, however, which show that Rodman's constraint is too strong. Consider for example (32):

(32) John is looking for a man who stole a green pick-up truck.

The point is that intuitively it is quite possible to interpret (32) in such a way that a man has a non-specific interpretation, while a green pick-up truck has a specific interpretation. In other words, a green pick-up truck may have wider scope than a man (i.e. the relativized element) and look for (i.e. the predicate which creates the opaque context). The just described intuitive reading of (32) translates in our extension as (32a):

(32a) $Vx[\text{gr.p.u.tr.}'(x) \wedge \text{look for}'(^j, \hat{P}V_y[\text{man}'(y) \wedge \text{steal}'(y, \hat{P}P\{x\})])]$

Another counterexample to Rodman's constraint arises with the quantifier any. It has been pointed out by Reichenbach, Quine, and others that any takes wider scope than negation. It can be shown furthermore that main-clause negation may trigger any in certain subordinate clauses. Consider as an example (33):

33) John didn't find a farmer who rents any horses.

Note that (33) is intuitively unambiguous. The sentence is acceptable only on the non-specific reading of a farmer who rents any horses. Furthermore, since any must have wider scope than negation (33) can only have the following translation:

33a) $\text{Ax}[\text{horse}'(x) \rightarrow \sim \text{Vy}[[\text{farmer}(y) \wedge \text{rent}'(y, \hat{\text{P}}\text{P}\{x\})] \wedge \text{meet}'(^j, \hat{\text{P}}\text{P}\{y\})]]$

(33a) does not obey Rodman's constraint: any horses has wider scope than the relativized element of the relative clause: a farmer.

While assertive quantifiers like the indefinite article and any (as I have shown) and the natural numbers (as can be easily demonstrated) do not obey Rodman's constraint, presupposing quantifiers are in fact subject to the constraint. Consider for example:

John talked to some students who solved every problem.
Here we have only one reading in which some has wider scope than every. Similarly:

John talked to every girl who ate some cookies.
Again, this sentence has only one reading in which every has wider scope than some.

The distinction we are faced with here is exactly a difference between presupposing and assertive quantifiers. Only presupposing quantifiers are restricted in the sense of Rodman's constraint. In order to make sure that presupposing terms will never have wider scope than the relativized element of a relative clause we have to stipulate that presupposing terms may never replace a pronoun in a relative clause. Rather than dividing the class of quantified terms into two categories (presupposing versus assertive terms) let us employ another feature pair: $\pm r$. Again, $\pm r$ has a double function. As a superscript on presupposing quantifiers like some, every, the, both, etc. ---^r indicates that these quantifiers may never be introduced after relative clause formation. As a pronoun feature, on the other hand, $\pm r$ is introduced by the following new version of the rule of relative clause formation:

*S3. If $\zeta \in P_{\text{CN}}$ and $\phi \in P_t$, then $F_{3,n}(\zeta, \phi) \in P_{\text{CN}}$, where $F_{3,n}(\zeta, \phi) = \zeta$ such that ϕ' ; and ϕ' comes from ϕ by replacing each occurrence of $\begin{bmatrix} \bar{\zeta} \\ n \end{bmatrix}$ or $\begin{bmatrix} \text{acc} \\ \bar{n} \end{bmatrix}$ by $\begin{bmatrix} \text{he} \\ \text{she} \\ \text{it} \end{bmatrix}$ or $\begin{bmatrix} \text{him} \\ \text{her} \\ \text{it} \end{bmatrix}$, respectively, according as the first B_{CN} in ζ is of $\begin{bmatrix} \text{masc.} \\ \text{fem.} \\ \text{neuter} \end{bmatrix}$ gender, and, furthermore, marking all other indexed pronouns in ϕ with the feature $\pm r$.

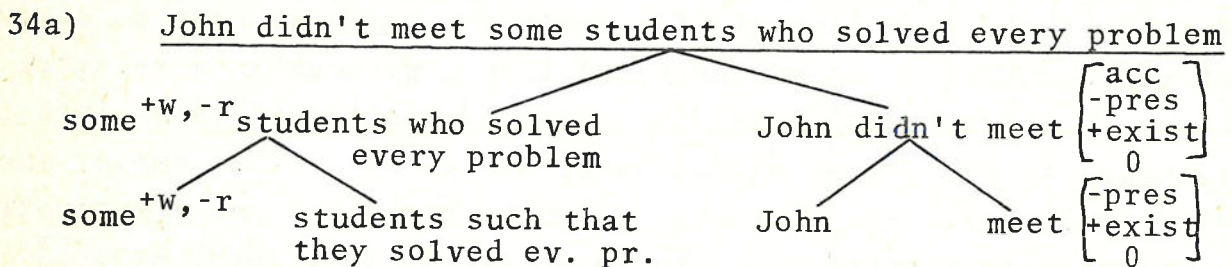
Note that as far as our rule *S14 is concerned, no further changes are necessary: some, every, and the may not replace an indexed pronoun in a relative clause, because the -r superscripts on these presupposing quantifiers disagree with the +r feature on the pronoun.

We have now implemented two different types of scope restrictions into our extension:

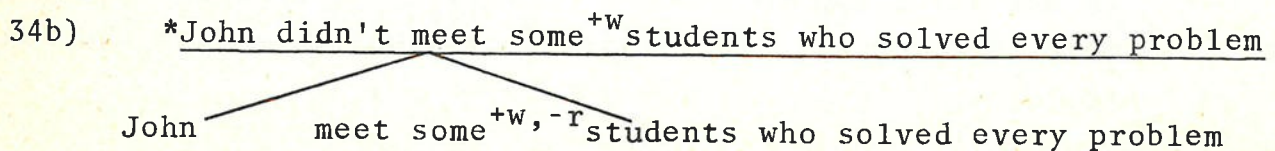
- a) restrictions on the scope of negation,
- b) restrictions on quantifying into relative clauses in case of presupposing quantifiers.

But how do these two restrictions interact? In particular, are restrictions regarding the scope of negation applicable also in those cases where the quantifier in question arises in a relative clause, while negation appears in the main clause? So far we have avoided this question by using simple examples. Sentence (34), however, raises the question of whether every in the relative clause should have more narrow scope than negation or not:

34) John didn't meet some students who solved every problem. On the one hand, some^{+w,-r} must have wider scope than negation. On the other hand, every^{-w,-r} should have more narrow scope than negation, and finally, every should be introduced into the relative clause before the relativized element some students. One of the possible analyses of (34) is (34a):



(34a) satisfies the restriction that some^{+w,-r} must have wider scope than negation as well as the condition that the presupposing quantifier every^{-w,-r} must be introduced before relative clause formation. But if some^{+w,-r} is introduced after negation - as it should - then there is no way for every in the relative clause to have more narrow scope than negation. The only way to let every have more narrow scope than negation and obey the relative clause constraint is analysis (34b):



(34b), however, violates the restriction of some to having wider scope than negation. Furthermore, (34b) - in contrast to (34a) - is not an acceptable analysis in our extension because the superscript ^{+w} on some cannot be deleted. In order to decide whether (34a) or (34b) is the right analysis of (34) we need only inspect the translation formulas corresponding to these analyses:

34a') $\forall x_3[\text{student}'(x) \wedge \exists y_3[\text{problem}'(y)]\text{solve}_*('x, 'y)] \sim \text{meet}_*(j, 'x)$

34b')* $\sim \forall x_3[\text{student}'(x) \wedge \exists y_3[\text{problem}'(y)]\text{solve}_*('x, 'y)]\text{meet}_*(j, 'x)$

(34a') is true if of the set of students who solved every problem there are some students who John meets and others who John doesn't meet. This represents the intuitive meaning of (34).

(34b'), on the other hand, is true if John meets none of the students who solved every problem. This does not represent an intuitively possible reading of (34). Since our grammar generates only (34a), but not (34b), it accounts satisfactorily for this kind of data. We can draw the following conclusion on the basis of (34):

35) Scope restrictions regarding negation do not apply if negation and the presupposing quantifier in question appear on different syntactic levels.

That (35) does not hold for assertive terms is demonstrated by example (33), in which any and negation do appear on different syntactic levels and are still subject to a scope restriction.

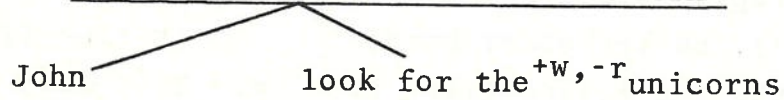
6. Implementing scope restrictions regarding opaque contexts

Sentence (34) raised the question of whether negation scope restrictions are applicable across different sentence levels. Based on intuitive semantic observations we answered this question with 'no'. A related problem is the question of whether negation scope restrictions are applicable across opaque contexts. Consider example (36):

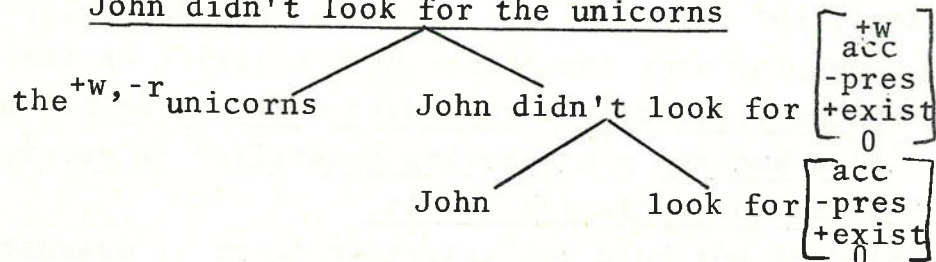
36) John didn't look for the unicorns.

(36) is ambiguous between a de dicto and a de re reading. The de dicto reading is represented by analysis (36a), while the de re reading is represented by analysis (36b):

36a) John didn't look for the^{+w}unicorns



36b) John didn't look for the unicorns



The problem is that the de dicto reading (36a) violates the restriction that the^{+w, -r} takes wider scope than negation - as indicated by the undeleted ^{+w} superscript in the analysis (36a). Yet no derivation of the de dicto reading other than (36a) is feasible. The dilemma becomes obvious when we look at the translation of (36a), i.e. (36a'):

36a') $\sim \text{look for}'(\wedge j, \hat{P} \wedge x \exists [\text{unicorn}'(x)] P\{x\})$

The logical structure of (36a') is such that the object term simply cannot be both outside the scope of negation and inside the scope of look for'. However, since (36) has a de dicto reading and since this reading is correctly represented by (36a'), we conclude that our grammar should generate analysis (36a). This means that the ^{+w} superscripts on quantifiers in non-sentential (!) opaque contexts need to be deleted. The rules in question are S5 and S8, which we replace with †S5 and †S8, respectively:

+S5. If $\delta \in P_{IV/T}$ and $\beta \in P_T$, then $F_5(\delta, \beta) \in P_{IV}$, where $F_5(\delta, \beta) = \delta\beta'$ if β does not have the form $\begin{bmatrix} - \\ n \end{bmatrix}$, and $\beta' = \beta$ if δ is an extensional verb; if δ is an intensional verb, however, then β' comes from β by deleting all ${}^{+w}$ superscripts in β .
If β has the form $\begin{bmatrix} -pres \\ +exist \\ n \end{bmatrix}$, then $F_5(\delta, \beta) = \delta \begin{bmatrix} acc \\ -pres \\ +exist \\ n \end{bmatrix}$.

†S8. If $\delta \in P_{IV//IV}$ and $\beta \in P_{IV}$, then $F_6(\delta, \beta) \in P_{IV}$, where $F_6(\delta, \beta) = \delta\beta'$, and β' comes from β by deleting all ${}^{+w}$ superscripts in β .

According to rule †S5, analysis (35a) is a wellformed output (the ${}^{+w}$ superscript is deleted!) while the corresponding analysis of

John didn't find the unicorns

would still not be wellformed (because find is classified as an extensional predicate).

Our analysis so far concentrated on presupposing terms. We have shown that

- 37a) scope restrictions of presupposing quantifiers with respect to negation apply only if the quantifier and negation "interact directly" (i.e. they do not apply across sentence boundaries or opaque contexts);
- 37b) presupposing quantifiers in relative clauses are restricted to having more narrow scope than the relativized element (corresponding conditions hold ^{for} other modifying clauses, for example sentential adverbs, which are not treated yet in PTQ).

We implemented the above findings into PTQ by means of the features $\pm w$ and $\pm r$, which are based on straightforward syntactic concepts. In the following section let us turn to the analysis of assertive quantifiers. We begin with the quantifier any, which is known to have complex scope and occurrence restrictions.

7. The scope and occurrence restrictions on ANY and NO
 What is the nature of the quantifier any? Reichenbach (1947) and Quine (1960) treat any and every as different surface realizations of the same underlying quantifier, whereby any represents the wide scope reading. Klima (1964) assumes that there are two any's and derives any after negation from some. Horn (1972), finally wants to derive any from all.

Is any one quantifier or are there two different any's? Is any an independent quantifier at all or is it merely a stylistic variant of some other quantifier(s)? Even though the various details and observations in the accounts by Reichenbach, Quine, Klima, Langacker, Vendler, Horn, and others capture important insights on the nature of any, no consistent account satisfying the strong points of the various proposals has been suggested so far. The different partial answers are like parts of a gig-saw puzzle that doesn't have a complete solution. Of course, it might be that there simply is no general solution. The other possibility, however, is that parts of the puzzle have been overlooked so far.

The notorious complexity of any constitutes a challenge for the here advocated approach to quantifiers of English. Can our over-all analysis of quantifiers be extended to the case of any? It is worth a try. I will endeavour into yet another attempt of describing any, because I believe to be in possession of one part of the puzzle that has been missing in the earlier accounts. This missing part is the distinction between presupposing and assertive quantifiers. I believe that neither Klima's some/any rule nor Horn's all/any rule is a plausible way of deriving any, because some and all (as well as every) are existential P-inducers while any is not. In agreement with Vendler (1967) we will treat any as an independent quantifier in its own right. Our analysis will go beyond Vendler, however, in that it (i) describes the syntactico-semantic occurrence restrictions of any, (ii) captures formally the similarities as well as the differences between any, on the one hand, and every, some, the indefinite article, and no, on the other; and (iii) explains formally why any seems to take different meanings in different environments.

Let us treat any as a fulfilled assertive quantifier which translates by means of a non-restricted universal quantifier:

any translates into $\hat{Q}\hat{P}\forall x [Q\{x\} \rightarrow P\{x\}]$

As a first approximation let us capture the occurrence restrictions of any by the following hypothesis:

- 38) Any may never occur in linguistic environments that exclude non-existential non-specific readings of a corresponding indefinite article.

What is meant by 'non-existential non-specific'? I assume that, e.g.

- 39) Every girl read a book.

has a non-specific existential reading, while

- 40) John didn't read a book.

and

- 41) John is looking for a book.

have non-specific non-existential readings. In short, (39), (40), and (41) are all ambiguous between a specific and a non-specific reading, but in (39) the non-specific reading still entails the existence of a book, while in (40) and (41) the respective non-specific readings do not entail the existence of a book.

According to (38) we may replace the indefinite article in (40) and (41) by any without obtaining an ungrammatical sentence. This is indeed the case:

- 40a) John didn't read any book.

- 41a) John is looking for any book.

In (39), on the other hand, replacement of the indefinite article by any leads to an ungrammatical sentence:

- 39a) *Every girl read any book.

It is important to note that the non-specific reading of (40) is synonymous to (40a):

- 40a) John didn't read a book.

This synonymy is captured in our extension of PTQ in form of a logical equivalence. The respective translations of (40) and (40a) are:

- 40') $\sim \forall x[\text{book}(x) \wedge \text{read}_*(j, \forall x)]$

- 40a') $\Lambda x[\text{book}(x) \rightarrow \sim \text{read}_*(j, \forall x)]$ ⁷

A similar synonymy can be found between the non-specific reading of (42a), and (42b):

- 42a) If John finds a unicorn, Bill will be surprised.

- 42b) If John finds any unicorn, Bill will be surprised.

Again, the corresponding translation formulas (42a') and (42b') are equivalent:

- 42a') $\forall x[\text{unicorn}'(x) \rightarrow (\text{find}_*(j, \forall x) \rightarrow \text{surprise}_*(b))]$

- 42b') $\Lambda x[\text{unicorn}'(x) \rightarrow \text{find}_*(j, \forall x) \rightarrow \text{surprise}_*(b)]$

In (40a) and (42b) any is subject to a scope restriction in that

only the wide scope translations (40a') and (42b') represent intuitively possible readings of (40a) and (42b), respectively.

Any is not always synonymous with a non-specific indefinite article, however. For example, the non-specific reading of

41) John is looking for a book.

means something different from

41a) John is looking for any book.

Similarly, the non-specific reading of

43a) John can invite a member of the club to the party.

is not synonymous with

43b) John can invite any member of the club to the party.

Let us call the any in (41a) and (43b) intensional-any - in contrast to the any in (40a) and (42b), which we will call negation-any. Does the fact that negation-any is synonymous with the non-specific indefinite article, while intensional-any is not, mean that negation-any and intensional-any are two different quantifiers? Not at all. We want to give intensional-any and negation-any the same translation and treat the difference between the two as a difference in the semantic interaction with their characteristic environments. In other words, I use the notions 'negation-any' and 'intensional-any' as a manner of speaking in order to distinguish between any in interaction with negation (in which case it is synonymous with the non-specific indefinite article) and any in interaction with an opaque context. In the latter case any is not synonymous with the non-specific indefinite article. This lack of synonymy is captured in our extension in form of a lack of equivalence of the respective formulas. Consider for example the translation of the non-specific reading of (41) and the translation of (41a):

41') $\Lambda x[\text{book}'(x) \rightarrow \text{look for}'(\hat{\wedge}j, \hat{P}P\{x\})]$

41a') $\text{look for}'(\hat{\wedge}j, \hat{P}Vx[\text{book}'(x) \rightarrow P\{x\}])$

Note that for intuitive reasons any must again have wide scope in the translation of (41a). Thus negation-any and intensional-any not only have the same translation, but also the same scope restriction regarding their respective triggers. By definition, however, negation-any and intensional-any have different occurrence restrictions.

The restrictions on the distribution of any may be summarized as follows:

44a) Any may never occur in linguistic environments that exclude non-existential non-specific readings of a corresponding indefinite article.⁸

44b) Any must always occur in the same clause as its trigger, unless any happens to be synonymous with a corresponding (non-specific) indefinite article.

(44a) accounts for the contrast between (45) and (46):

45) John didn't meet a farmer who rents any horses.

46) *John didn't meet the farmer who rents any horses.

If we replace any by the plural of the indefinite article (which is morphologically $\emptyset$) we obtain

47) John didn't meet the farmer who rents horses.

The point is that (47) has only a specific reading regarding horses!

On the other hand, if we replace any horses in (45) by horses we obtain

48) John didn't meet a farmer who rents horses.

and (48) does have a non-existential non-specific reading with respect to horses.

The second restriction on the distribution of any, (44b), accounts for the contrast between (45) and (49):

45) John didn't meet a farmer who rents any horses.

49) *John is looking for a farmer who rents any horses.

In other words, only negation-any may appear in other clauses than its trigger, while intensional-any must appear in the same clause as its trigger. ⁹

Why is it that only any is prohibited from non-negated, non-opaque declarative sentences? Consider the following quotation from Zeno Vendler (1967), which in my opinion represents a perceptive intuitive characterization of any (in contrast to every):

[by using any] "we did not really refer to a set of such individuals, but we focused on the condition of being a doctor, a trespasser, or what not, and on the consequences of fulfilling that condition for no matter what individual. Accordingly, the proposition did not presume to identify the candidates; in this respect it remained indefinite and open. To use a simile: we were not interested in the fish caught in the net, but in the net that might catch certain fish; and we were not disturbed if, in fact, it did not catch any." (Vendler 1967, p.89, my emphasis.R.H.)

It is a happy surprise that our formal translations of every and any, respectively, capture Vendler's intuition quite literally:

any ζ translates into $\hat{P}\Lambda x[\zeta'(x) \rightarrow P\{x\}]$

every ζ translates into $\hat{P}\Lambda x\exists[\zeta'(x)] P\{x\}$

While the translation of every refers indeed to a set of individuals (namely all individuals of which ζ' holds) is any the only quantifier in our extension which translates into an inherent conditional. The conditional nature of any together with any's restriction to having wide scope capture the intuitive fact that any lacks existential import. Note, however, that this inherent lack of existential import does not in itself motivate the restrictions of any to 'non-existential' environments. For one, we have seen that there are non-existential environments in which any may not occur (e.g. (49)). And secondly, there are other quantifiers inherently without existential import which are not restricted to non-existential environments, for the example the quantifier no. What is the relation between any and no? Consider:

- | | | |
|------|--|----------|
| 49a) | *John found <u>any</u> unicorn. | [+exist] |
| b) | John found <u>no</u> unicorn. | [+exist] |
| c) | John didn't find <u>any</u> unicorn. | [-exist] |
| d) | *John didn't find <u>no</u> unicorn. | [-exist] |
| e) | * <u>Any</u> sailor kissed Mary. | [+exist] |
| f) | <u>No</u> sailor kissed Mary. | [+exist] |
| g) | * <u>Any</u> sailor didn't kiss Mary. | [-exist] |
| h) | <u>No</u> sailor didn't kiss Mary. | [-exist] |
| i) | John is looking for <u>any</u> unicorn. | [-exist] |
| j) | John is looking for <u>no</u> unicorn. | [-exist] |
| k) | John isn't looking for <u>any</u> unicorn. | [-exist] |
| l) | *John isn't looking for <u>no</u> unicorn. | [-exist] |

In (49) a sentence is marked [+exist] if replacement of the underlined quantifier by the indefinite article renders an unambiguous sentence which entails the existence of a unicorn. A sentence is marked [-exist], on the other hand, if replacement of the underlined quantifier by the indefinite article renders a sentence which has at least one reading which does not entail the existence of a unicorn. Note that negation-any and no are in complementary distribution (c.f. (49a-h)). Intensional-any and no, on the other hand, are not in complementary distribution, according to (49i-l).

Following Montague (1974) let us translate the quantifier no as $\hat{Q}\hat{P}\sim Vx[Q\{x\} \wedge P\{x\}]$. On the basis of this semantic representation

of no let us show that the particular occurrence restrictions on any and no cannot be stated on the level of translation formulas alone. Consider (49f') and (49g'), which are translations of (49f) and (49g), respectively:

49f') $\sim \forall x[\text{sailor}'(x) \wedge \text{kiss}_*('(\forall x, m))]$

49g') $\Lambda x[\text{sailor}'(x) \rightarrow \sim \text{kiss}_*('(\forall x, m))]$

The point is that (49f) is grammatical while (49g) is not; yet (49f') and (49g') are logically equivalent! Therefore the occurrence restrictions on any and no cannot be stated on the level of translation formulas alone.

The here presented analysis of any in its relation to other quantifiers like every, some, the indefinite article, and no is based on the distinction between presupposing and assertive quantifiers in the following way:

By translating P-inducers like every and some by means of restricted quantification we reserved the non-restricted universal quantifier for the representation of any. We have seen that the resulting formal translation captures the intuitive properties of any. Furthermore, we reserved the equivalence $\Lambda x[f(x) \rightarrow \sim g(x)] = \sim \forall x[f(x) \wedge g(x)]$ for representing the intuitive synonymy between negation-any, the negated indefinite article on its non-specific reading, and no. The equivalence $\forall x\exists[f(x)]\sim g(x) = \sim \Lambda x\exists[f(x)]g(x)$, on the other hand, captures the intuitive synonymy between some not and not every.

8. Implementing restrictions on assertive quantifiers

In addition to the features $\pm w$ and $\pm r$, which we used for treating the scope restrictions of presupposing quantifiers, we will use the features $\pm exist$ and $\pm pres$ for the treatment of assertive quantifiers. As mentioned in (27) above (c.f. section 3), the assertive quantifiers any and no are marked in the lexicon as any^{-exist} and no^{+exist}. In order to prevent any from appearing in non-negated, non-opaque declarative sentences we must stipulate

- i) that any^{-exist}_{+noun} may not replace a pronoun in a non-negated, non-opaque sentence, and
- ii) that any^{-exist}_{+noun} may not be introduced directly (i.e. has to be introduced via a rule of quantification).

The first condition will be implemented on the basis of the $\pm exist$ -marking of pronouns.. Only after certain syntactic operations like negation or embedding in an opaque context have switched a pronoun from $\pm exist$ to $\mp exist$ can the pronoun be replaced by any^{-exist}_{+noun}. The second condition will be implemented in that we simply do not provide for deleting $\mp exist$ superscripts in the rules *S5, *S8, and *S17. The second condition also insures that any will always have wider scope than its trigger.

The just outlined occurrence restrictions on any do not suffice, however. We still have to capture the fact that (47) is acceptable, while (48) is not:

47) John didn't meet a farmer who rents any horses.

48) *John didn't meet the farmer who rents any horses.

In short, any may occur as part of an assertive term (e.g. 47), but not as part of a presupposing term (e.g. 48) - given that the trigger of any is in a higher clause. In order to implement this further condition we have marked pronouns in the lexicon not only $\pm exist$, but also $\pm pres$. The rule *S4, which in our extension has the function to combine a quantifier with a CN-phrase to make a term, will be defined in such a way that all pronouns in the CN-phrase are switched from $\mp pres$ to $\pm pres$ if the quantifier is a presupposing quantifier. Furthermore, we must stipulate in rules like *S17 or *S5 that $\begin{bmatrix} \pm pres \\ \mp exist \end{bmatrix}$ pronouns may not be switched to $\begin{bmatrix} \pm pres \\ \mp exist \end{bmatrix}$. In other words, any_{+noun} can never replace a pronoun marked $\pm pres$.

The general difference between the restrictions on any and the restrictions on presupposing quantifiers is that the conditions (37a) and (37b) do not apply to assertive quantifiers. We have seen in section 7 that negation may very well trigger any across sub-sentence

boundaries (the example in question is (47)). It is the fact that any may appear on the surface in arbitrary distance to the left of certain triggers and that at the same time any takes wider scope than its trigger (in the underlying formula) which makes it necessary to mark pronouns in the lexicon $\begin{bmatrix} -\text{pres} \\ +\text{exist} \end{bmatrix}$.

In order to implement the restrictions on any and no we don't have to change the new rules *S3 and *S14 (c.f. section 5 and 4, respectively). The new rules S4, +S5, +S8, and +S17, on the other hand, have to be replaced by *S4, *S5, *S8, and *S17, respectively.

*S4. If $\zeta \in P_{CN}$ and $q \in P_{T/CN}$, then $F(q, \zeta) \in P_T$, and $F_4(q, \zeta) = q\zeta'$, and (i) ζ' comes from ζ by switching all pronouns in ζ to +pres if q is a presupposing quantifier; (ii) if q is an assertive quantifier, then $\zeta' = \zeta$. However, if q is a negative quantifier, then all $\begin{bmatrix} -\text{pres} \\ +\text{exist} \end{bmatrix}$ pronouns in ζ are switched to -exist.

By a "negative quantifier" I mean a quantifier which creates a non-existential environment in relative clauses, for example the assertive quantifier no or the presupposing quantifier none of the. Consider:

50) No student who had solved any problems got fired.

51) None of the students who solved any problems got fired.

Note that not every is not a negative quantifier:

52) *Not every student who solved any problems got fired.

In our extension we may treat not every as a basic presupposing quantifier which translates into $\hat{Q}\bar{P}\sim\lambda x\exists[Q\{x\}] P\{x\}$. Not every seems to share the same restrictions as no with respect to negation and opaque contexts. Consider:

53) *John didn't find $\begin{Bmatrix} \text{no} \\ \text{not every} \end{Bmatrix}$ girl.

54) *John looked for $\begin{Bmatrix} \text{no} \\ \text{not every} \end{Bmatrix}$ girl.

But:

55) John kissed $\begin{Bmatrix} \text{no} \\ \text{not every} \end{Bmatrix}$ girl.

56) $\begin{Bmatrix} \text{No} \\ \text{Not every} \end{Bmatrix}$ girl kissed John.

The restrictions on the quantifier not every should be implemented by means of the superscript +exist.

Next consider the final version of rule +S5:

*S5. If $\delta \in P_{IV/T}$ and $\beta \in P_T$, then $F_5(\delta, \beta) \in P_{IV}$. If β is not a pronoun, then $F_5(\delta, \beta) = \delta\beta'$; (i) if δ is an extensional verb, then $\beta' = \beta$; (ii) if δ is an intensional verb, then β' comes from β by deleting all +w superscripts in β . If β is

a pronoun with index n and (iii) δ is an extensional verb, then $F_5(\delta, \beta) = \delta\beta''$; (iv) if δ is an intensional verb, then $F_5(\delta, \beta) = \delta\beta'''$. β'' is $\begin{bmatrix} \text{acc} \\ -\text{pres} \\ +\text{exist} \\ n \end{bmatrix}$ and β''' is $\begin{bmatrix} \text{acc} \\ -\text{pres} \\ -\text{exist} \\ n \end{bmatrix}$.

Rule *S8 stated below has a similar function as *S5 - as far as occurrence restrictions are concerned. It is simpler than *S5, however, because there don't seem to exist IV//IV-phrases which are extensional with respect to their complement.

*S8. If $\delta \in P_{IV//IV}$ and $\beta \in P_{IV}$, then $F_6(\delta, \beta) \in P_{IV}$, where $F_6(\delta, \beta) = \delta\beta'$, and β' comes from β by (i) deleting all $+w$ superscripts in β and (ii) if β is of the form $\gamma\delta$, where $\gamma \in P_{TV}$ and δ is a pronoun with index n , then $\beta' = \gamma \begin{bmatrix} \text{acc} \\ -\text{pres} \\ -\text{exist} \\ n \end{bmatrix}$.

Finally, we have to reformulate †S17. The new *S17 differs from the preliminary version insofar as the feature -exist and the special consequences of negative quantifiers are treated.

*S17 If $\alpha \in P_T$ and $\delta \in P_{IV}$, then $F_{11}(\alpha, \delta)$, $F_{12}(\alpha, \delta)$, $F_{13}(\alpha, \delta)$, $F_{14}(\alpha, \delta)$, $F_{15}(\alpha, \delta)$, $F_{16}(\alpha, \delta) \in P_t$, where:

$F_{11}(\alpha, \delta) = \alpha'\delta'$ and $\alpha'\delta'$ comes from $\alpha\delta$ by replacing the first verb in δ by its third person singular present, and deleting all superscripts except -exist in $\alpha\delta$. Furthermore, if α is a negative quantifier + noun, then all $[-\text{pres}]$ pronouns in δ are marked +w and -exist.

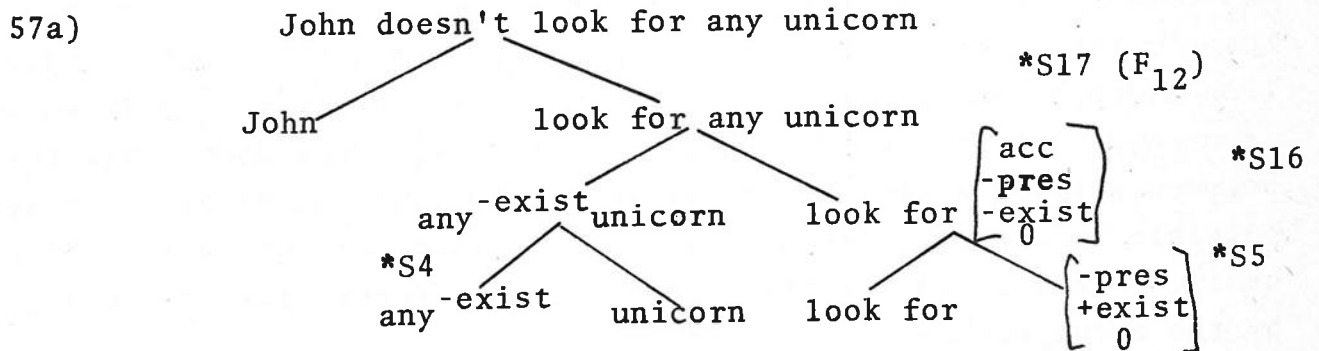
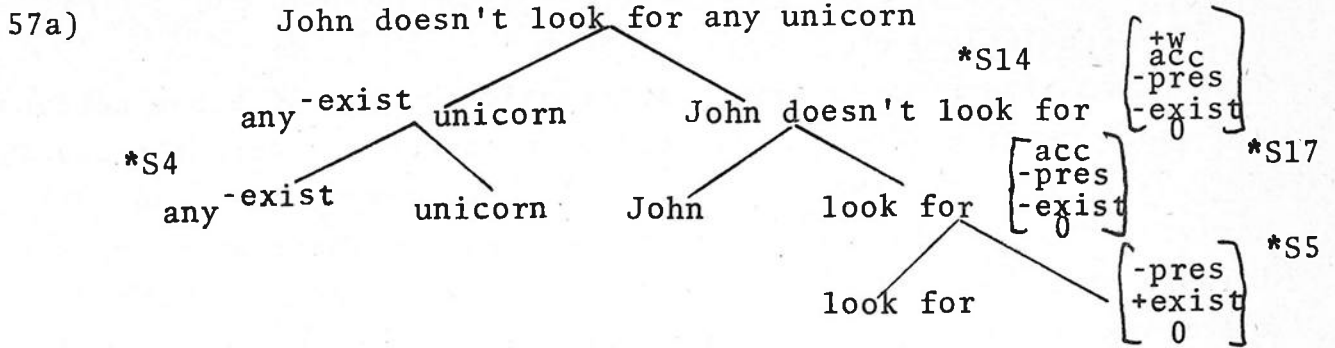
$F_{12}(\alpha, \delta) = \alpha''\delta''$ and $\alpha''\delta''$ comes from $\alpha\delta$ by replacing the first verb in δ by its negative third person singular present, marking all pronouns in $\alpha\delta$ with +w, switching all $[-\text{pres}]$ pronouns in δ to -exist, and deleting all $-w$, $-r$ superscripts in $\alpha\delta$.

F_{13} and F_{15} are defined similar to F_{11} , while F_{14} and F_{16} correspond to F_{12} .

Larry Horn (1972, p.168) observes that any does not take widest scope in general, but only wider scope than its trigger. This observation is reflected in our extension of PTQ. Consider for example (57):

57) John doesn't look for any unicorn .

(57) is ambiguous between a (non-stressed) negation-any reading and an intensional-any reading. These two readings are derived in our extension as follows:



The respective translations are (57a') and (57b'):

57a') $\Lambda x[\text{unicorn}'(x) \rightarrow \sim \text{look for}'(^j, \hat{P}P\{x\})]$

57b') $\sim \Lambda x[\text{unicorn}'(x) \rightarrow \text{look for}'(^j, \hat{P}P\{x\})]$

In (57b') any has wider scope than its trigger (i.e. the intensional predicate look for), but any does not have wider scope than negation.

Unfortunately, lack of space prohibits to further demonstrate the particular functioning of our new rules. However, as far as I can see, all of the restrictions on any and no observed in section 7 are now formally implemented.

9. Conclusions

This paper attempted to give a systematic account of scope ambiguities and scope restrictions as they arise in connection with the quantifiers a(n), any, no, one, two, three, etc., some, every, the, and both. We analyzed the intricate restrictions on many of these quantifiers in terms of the distinctions between presupposing versus assertive quantifiers, intensional versus extensional verbs, negated versus non-negated sentences, and embedded versus non-embedded clauses. We saw that scope restrictions do not depend either on surface syntactic information alone or on semantic information alone, but must be defined with reference to both levels. Once this (language dependent) interaction between surface syntax and semantics is recognized, however, it seems possible to account systematically for a large amount of data on the basis of relatively few distinctions. Our overall analysis was guided by the assumption

- i) that scope restrictions are properties of individual quantifiers, which can be handled by a small number of features,
- ii) that the features in question are not arbitrary, but represent clearcut syntactico-semantic concepts.

In order to implement our empirical findings (which include a unified analysis of the quantifier any and a refinement of Rodman's constraint) into PTQ we supplemented the syntactic mechanism of generating scope ambiguities with a general formal way to restrict scope. Our technical solution had to fulfill the double purpose of excluding not only ungrammatical sentences but also intuitively unacceptable translations of grammatical sentences from the output of the grammar. The here proposed treatment of scope restrictions relies on the tight connection between the surface syntax and the (interpretable) semantic representation in Montague Grammar, which permits a surface syntactic approach towards achieving certain semantic goals.

FOOTNOTES

- 1) Following Montague we assume that combining a quantifier with a CN-phrase (i.e. a noun) results in a term (noun phrase). Only terms can serve as subject, object, etc. of a sentence. Consequently proper names are basic terms, and not nouns. Finally, the plural of the indefinite article is analyzed as morphologically $\emptyset$. Thus, e.g., "girls" in "John kissed girls" must be categorized as a term (i.e. a noun phrase) and not a noun.
- 2) For theoretical reasons, data of this kind have been the subject of intense discussion within transformational grammar (Katz&Postal (1964), Jackendoff (1968), Lakoff (1971)). Still, no systematic account of scope phenomena has been presented with the various schools of transformational grammar. The question of which quantifiers tend to take wider scope with respect to other quantifiers (on the same surface syntactic level) has been investigated by Georgette Ioup (1973). Ioup formulates her results in form of hierarchies of quantifiers and hierarchies of grammatical function. I agree with Ioup's criticism of Jackendoff (1968) and Lakoff (1971) in that surface order is only one possible factor influencing the probability of a certain scope interpretation.
- 3) This restriction of some with respect to the scope of negation has been noted by Baker (1970).
- 4) In "Universal Grammar" Montague distinguishes between 'syntactic ambiguity' (our 'structural indeterminacy') and 'semantic ambiguity' (our 'syntactic ambiguity'). In light of the traditional distinction between 'syntactic' as opposed to 'lexical' ambiguities, I find Montague's notion of a 'syntactic ambiguity' linguistically unfortunate and use instead 'structural indeterminacy'.
- 5) This sentence is quoted from Partee (1972). I disagree with Partee's assumption that example (21) presupposes the existence of the man in Apt. 3 on "any interpretation of the sentence". C.f. Partee (1972), p. 417.
- 6) Pronouns play a central role in the surface syntax of PTQ. To extend this mechanism by treating pronouns as indexed feature bundles

permits the solution of various phenomena. For a treatment of the constraints on backward pronominalization within PTQ see Hausser (1976c).

7) Reichenbach (1947) employed this logical equivalence in order to show that any can have "the meaning of an existential statement" (p.106). In our analysis this equivalence is used to capture an actual class of synonymies.

8) An interesting exception to (44a) are sentences containing only. Consider for example:

i) Only Bill has any shoes.

This sentence entails the existence of shoes and is thus an apparent counterexample to our assumption that any is restricted to non-existential environments. The whole problem hinges, however, on the semantic analysis of only. Groenendijk and Stokhof (personal communication) have arrived at an analysis of only according to which (i) would roughly be represented as

ii) $\text{Ax}[x \text{ has any shoes} \leftrightarrow x = \text{Bill}]$.

In other words, according to this analysis of only, any arises (in the underlying formula of (i)) in the antecedent of a (bi)conditional, which is a non-existential environment.

9) In other words, negation-any is characterized through

a) the synonymy with a corresponding (non-specific) indefinite article,

b) the ability to appear in different clauses than its trigger, while intensional-any is characterized in that (a) and (b) don't hold.

On the basis of these criteria we can show that any in questions and generics is another instance of negation-any, while any in comparisons is another instance of intensional-any. Consider:

Question: Did you rent horses?

Did you rent any horses?

Did you find a farmer who rents any horses?

Generic: An owl sees poorly in daylight.

Any owl sees poorly in daylight.

A man who has any sense drives a Toyota.

Comparison: This ape is bigger than a human being.

This ape is bigger than any human being.

*John runs faster than a martian who took any doping pills.

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Mass-nouns and Aspects, or:

Why we can't eat gingercake in an hour. ¹⁾

J. Hoepelman.

The analysis of mass-nouns is one of the most difficult problems in formal semantics. There are various proposals - worked out more or less formally - such as can be found in (Quine, 1960), (Cartwright, 1965, 1970), (Parsons, 1970), (Moravcsik, 1973), (Montague, 1973), (Pelletier, 1974), but none of them seems to be wholly satisfying. One of the first worked out fragments of a Montague-grammar with mass-nouns is (ter Meulen, 1976).

One of the main phenomena that is neglected in these treatments is the behaviour of mass-nouns in object position in combination with perfective transitive verbs. Traditionally (Cf. (Dowty, 1972)) one of the tests to discriminate perfective from imperfective verbs in English is to compare them in combination with time indicating adverbs such as "in an hour" and "for an hour". Compare (although the examples are a bit outworn):

- 1) John closed the door in ten minutes
- 2) John closed the door for ten minutes
- 3) * John pushed a cart in ten minutes
- 4) John pushed a cart for ten minutes.

1) is a correct sentence. It means intuitively that John brought it about that the door was closed and that it took him ten minutes to do so.

2) is taken automatically as being about a repetition of events, because it is somehow impossible to attain the result that a door is closed on every moment of an interval of time.

3) is not acceptable. The "in ten minutes"-phrase seems to be closely connected with the attainment of a result.

4) is correct, but need not be about a repetition of events. One can be pushing a cart at all moments of an interval of time.

In the terminology of Vendler (1967) verbs like "to close" are called

"accomplishments" and verbs like to push "activities" (For tests to discriminate several kinds of verbs see (Dowty, 1972) and (Hoepelman, 1976 1). Accomplishment verbs in English are - so it seems - perfective, and activities imperfective. Now activity verbs can change their aspect from imperfective into perfective in certain contexts:

5) John pushed a cart to London in an hour.

6) John pushed a cart to London for an hour.

5) and 6) show that "push" in combination with direction indicating adverbs like "to London" behaves like an accomplishment (for more details (Hoepelman, 1976 1). Conversely, it seems that (perfective) accomplishments become (imperfective) activities, in particular when they are transitive, and their grammatical object is a mass-noun or indefinite plural:

7) * John dissolved salt in an hour

8) John dissolved salt for an hour

9) * John read books in an hour

10) John read books for an hour.

But we can have:

11) John dissolved a quantity of salt in an hour

12) John dissolved a portion of salt in an hour

13) John read a quantity of books in an hour.

Another phenomenon that, to my mind, is not adequately covered by any of the proposals mentioned above, is, that any common count noun can be converted into a mass noun. This may have sometimes unusual effects, but in most cases it is not difficult to imagine an appropriate context:

14) I have been eating encyclopaedia all my life, said the wise bookworm.

15) Are we having missionary for dinner, asked the hungry cannibal.

Generally speaking we must lay a connection between "a gingercake" and

"gingercake", "a water" and "water" and explain why

"John ate gingercake in an hour" is "strange", but "John ate a gingercake in an hour" is correct, and similarly for sentences with indefinite, resp. definite plurals of common count nouns.

I will now put forward an analysis of mass-nouns and indefinite plurals of common count nouns in the framework of a Montague-grammar, which accomodates at least some of these phenomena. On many points the grammar will be restricted. For more details about the treatment of verbs I refer to (Hoepelman, 1976 1,2)

I. Syntax of a fragment of English

Let e and t be two objects, $\mathbb{N}$ the set of natural numbers.

Def.1 CAT is a set such that i) for any $n \in \mathbb{N}$ (n,e) and $(n,t) \in \text{CAT}$

ii) If $A, B \in \text{CAT}$, then for any $n, m \in \mathbb{N}$
 $(n, m, A, B) \in \text{CAT}$

iii) for no $n, m, r \in \mathbb{N}$, $A, B \in \text{CAT}$ $(n, m, A, B) = (r, e)$
 or $(n, m, A, B) \in (r, t)$

iv) for any $D, D \in \text{CAT}$ iff D satisfies i)-iii) .

Def.2 $(A/B) = (0, 0, A, B)$

Def.3 $a = (0, e)$, $b = (0, t)$

Let S be a set of symbols, B a function from CAT such that if $R(B)$ is the range of B and $\mathcal{P}(S)$ is the powerset of S , then $R(B) \subset \mathcal{P}(S)$ and for any $a, b \in R(B)$ $a \cap b = \emptyset$ or $a = b$. For any $a \in R(B)$ $\text{card.}(a) \in \mathbb{N}$ or $\text{card.}(a) = \aleph_0$ and if $Q = \{b : b \in R(B) \ \& \ b \neq \emptyset\}$ then $\text{card.}(Q) \in \mathbb{N}$.

Let $\mathbb{P}$ be a function from CAT such that $B \subset \mathbb{P}$ and for any $n, m, r, s, t \in \mathbb{N}$ and $M, N, E \in \text{CAT}$, if $D = M$, $\mathbb{P}(D) = Y_k$, $\mathbb{P}(n, m, E, M) = Y_j$, $\mathbb{P}(E) = Y_i$, $\alpha \in Y_k$, $\beta \in Y_j$ then $\beta(\alpha) \in Y_i$ and if $D = (r, s, M, N)$, $C = (r, t, M, N)$, $\mathbb{P}(D) = Y_k$, $\mathbb{P}(n, m, E, C) = Y_j$, $\mathbb{P}(E) = Y_i$, $\alpha \in Y_k$, $\beta \in Y_j$, then $\beta(\alpha) \in Y_i$.

Let P be a function like $\mathbb{P}$, except that $R(P)$ is the set of smallest sets that belong to $\mathbb{P}$ and moreover satisfy the syntactical rules of section II.

Def. 3. The language $L = (B, P)$.

Abbreviations:

$I_{ph} = (b/a)$ protoverbs

$T = \{(0, i, (1, t), I_{ph})\}$ for any $i \in \mathbb{N}$. We have, notably: $T_c = (0, 0, (1, t), I_{ph})$, (count terms); $T_m = (0, 1, (1, t), I_{ph})$, (non-count terms), $T_{col} = (0, 2, (1, t), I_{ph})$, (collective terms); $T_{var} = (0, 3, (1, t), I_{ph})$, (variable terms).

$IV = \{(0, i, b, T)\}$ intransitive verb - phrases (for any $i \in \mathbb{N}$)

$TV = \{((0, i, b, T)/T)\}$ transitive verb phrases (for any $i \in \mathbb{N}$)

$CN = \{(1, i, b, a)\}$ nouns (for any $i \in \mathbb{N}$). More specifically we have:

$CN_c = (1, 0, b, a)$ (count-nouns); $CN_m = (1, 1, b, a)$, (mass-nouns).

$ADJ = \{((1, i, b, a)/(1, i, b, a))\}$ adjectives (for any $i \in \mathbb{N}$)

I.1 Basic Expressions

$B_{T_c} = \{\text{something}, \text{John}, \text{Mary}\}$

$B_{T_{var}} = \{\underline{he}_0, \underline{he}_1, \dots, \underline{he}_n \dots\}$

$B_{I_{ph}} = \{\underline{melt}, \underline{dissolve}, \underline{purify}, \underline{eat}, \underline{drink}\}$

$B_{(0, 2, b, T)} = \{\underline{leak}, \underline{stream}\}$

$B_{((0, 1, b, T)/T)} = \{\underline{be}_1, \underline{be}_2\}$

$B_{((0, 2, b, T)/T)} = \{\underline{stir}, \underline{file}\}$

$B_{(1, 0, b, a)} = \{\underline{missionary}, \underline{woman}, \underline{fish}, \underline{gingercake}, \underline{water}, \underline{book}, \underline{cannibal}\}$

$B_{(1, 1, b, a)} = \{\underline{gold}, \underline{silver}, \underline{meat}, \underline{milk}, \underline{iron}, \underline{salt}\}$

$B_{ADJ} = \{\underline{blue}, \underline{black}, \underline{hot}, \underline{widespread}\}$

$B_{(i, 0, b, T)} = \{\underline{in\ an\ hour}, \underline{for\ an\ hour}, \underline{again}\}$

$B_{(0, 0, b, T)/(1, t)} = \{\underline{cause}\}$

For any $A \in CAT$ other than those mentioned above, $B_A = \emptyset$

Def.4. Any member of P_b is a sentence of English.

Def.5. Any member of B_{IV} , B_{TV} and any member of B_{Iph} will be called a verb.

1.2 Syntactic rules

1.2.1 Basic rules

S_1 . For any $A \in CAT$ $B_A \subseteq P_A$

S_2 . If $h \in P_{(1,0,b,a)}$, then $F_1(h)$, $F_2(h)$, $F_3(h) \in P_{T_c}$, where $F_1(h) =$ every h , $F_2(h) =$ the h , $F_3(h) =$ a h or an h , according as the leftmost word in h takes a or an.

S_3 . If $h \in \left\{ P_{(1,0,b,a)}^{(1,1,b,a)} \right\}$ then $F_4(h) =$ ± h and ± $h \in P_{T_m}$.

S_4 . If $h \in \left\{ P_{(1,0,b,a)}^{(1,1,b,a)} \right\}$ then $F_5(h) =$ some h and some $h \in P_{T_m}^{(2)}$

S_5 . If $h \in \left\{ P_{(1,0,b,a)}^{(1,1,b,a)} \right\}$ then $F_6(h) =$ ± h and ± $h \in P_{T_m}$

S_6 . If $h \in \left\{ P_{(1,0,b,a)}^{(1,1,b,a)} \right\}$ then $F_7(h) =$ all h and all $h \in P_{T_m}$

S_7 . If $h \in \left\{ P_{(1,0,b,a)}^{(1,1,b,a)} \right\}$ then $F_8(h) =$ some h and some $h \in P_{T_c}$.

S_8 . If $h \in \left\{ P_{(1,0,b,a)}^{(1,1,b,a)} \right\}$ then $F_9(h) =$ all the h and $F_9(h) \in P_{T_c}$

S_9 . If $h \in \left\{ P_{(1,0,b,a)}^{(1,1,b,a)} \right\}$ then $F_{10}(h) =$ C h and $F_{10}(h) \in P_{T_{col}}$.

Def.6 The expressions ±, ± and C are called designated expressions.

S_{10} . If $h \in P_{(1,0,b,a)}$ then $F_{11}(h) \in P_{T_m}$ and $F_{11}(h)$ is the indefinite plural of h .

S_{11} . If $h \in P_{(1,0,b,a)}$ then $F_{12}(h) \in P_{T_{col}}$ and $F_{12}(h) =$ all h' , where h' is the indefinite plural of h .

S_{12} . If $h \in P_{(1,i,b,a)}$ and $\varphi \in P_t$, then $F_{13.n}(h, \varphi) \in P_{(1,i,b,a)}$ for any $i \in \mathbb{N}$, where $F_{13.n}(h, \varphi) = h$ such that φ' and φ' comes from φ by replacing each occurrence of he_n or him_n by $\begin{Bmatrix} \text{she} \\ \text{he} \\ \text{it} \end{Bmatrix}$ or $\begin{Bmatrix} \text{her} \\ \text{him} \\ \text{it} \end{Bmatrix}$, respectively, according as the first element of

B_{CN} in h is of $\begin{Bmatrix} \text{fem} \\ \text{masc} \\ \text{neuter} \end{Bmatrix}$ gender.

I.2.2 Rules of relational application

- S₁₃. If $\delta \in P_T$ and $\eta \in P_{Iph}$ then $F_{14}(\delta, \eta) \in P_{(1,t)}$ and $F_{14}(\delta, \eta) = \delta \eta$
- S₁₄. If $\varphi \in P_{(i,t)}$ and $\eta \in P_{((i,t)/(i,t))}$ then $F_{15}(\eta, \varphi) \in P_{(i,t)}$ and $F_{15}(\eta, \varphi) = \varphi \eta^*$
- S₁₅. If $\varphi \in P_{(1,t)}$, either i) $\varphi = F_{14}(\delta, \eta)$, where $\delta \in P_T$ and $\eta \in P_{Iph}$, or ii) for some $\eta \in P_{((i,t)/(i,t))}$ $\varphi = F_{15}(\eta, F_{14}(\delta, \eta))$ and if $\xi \in P_{((0,0,b,T)/(1,t))}$, then $F_{16}(\xi, \varphi) \in P_{(0,0,b,T)}$ and $F_{16}(\xi, \varphi) = \varphi'$, where φ' comes from φ by replacing $F_{14}(\delta, \eta)$ by $\eta \delta$
- S₁₆. If $\delta \in P_{IV}$, $\beta \in P_T$ then $F_{17}(\delta, \beta) \in P_b$ and $F_{17}(\delta, \beta) = \beta \delta'$, where δ' comes from δ by replacing the first verb in δ by its third person present singular form.
- S₁₇. If $\delta \in P_{TV}$, $\beta \in P_T$, then $F_{18}(\delta, \beta) \in P_{IV}$ and $F_{18}(\delta, \beta) = \delta \beta'$, where $\beta' = \underline{him}_n$ if $\beta = \underline{he}_n$, otherwise $\beta' = \beta$
- S₁₈. If $\delta \in P_{ADJ}$ and $\xi \in P_{CN}$, then $F_{21}(\delta, \xi) \in P_{CN}$ and $F_{21}(\delta, \xi) = \delta \xi$.

I.2.3 Rules of quantification

- S₁₉. If $\alpha \in P_T$, $\varphi \in P_b$, then $F_{22.n}(\alpha, \varphi) \in P_b$, where either i) α does not have the form $\underline{he}_k$ and $F_{22.n}(\alpha, \varphi)$ comes from φ by replacing the first occurrence of $\underline{he}_n$, $\underline{him}_n$ by α and all other occurrences of $\underline{he}_n$, $\underline{him}_n$ by $\left\{ \begin{smallmatrix} \underline{he} \\ \underline{she} \\ \underline{it} \end{smallmatrix} \right\}$, $\left\{ \begin{smallmatrix} \underline{him} \\ \underline{her} \\ \underline{it} \end{smallmatrix} \right\}$ respectively, according as the gender of the first member of B_{CN} or B_T in α is $\left\{ \begin{smallmatrix} \text{masc} \\ \text{fem} \\ \text{neuter} \end{smallmatrix} \right\}$, or ii) α has the form $\underline{he}_k$ and $F_{22.n}(\alpha, \varphi)$ comes from φ by replacing all occurrences of $\underline{he}_n$, $\underline{him}_n$ by $\underline{he}_k$, $\underline{him}_k$ respectively.

I.2.4 Rules of tense

- S₂₀. If $\varphi \in P_b$, then $F_{23}(\varphi) \in P_b$, where $F_{23}(\varphi) = \varphi'$ and φ' comes from φ by replacing the leftmost verb in φ by its third person singular simple past form.

I.2.5. Editing rule

- S₂₁. If φ is a sentence of English, then $F_{24}(\varphi)$ is a sentence of English, where $F_{24}(\varphi)$ comes from φ by removing all designated expressions.

II. Intensional Logic.II.1 Syntax

Let s be a fixed object, $s \neq e$, $s \neq t$.

Def.1 TYPE is a set such that i) $e, t \in \text{TYPE}$

ii) if $A, B \in \text{TYPE}$ then $(A, B) \in \text{TYPE}$

iii) For no $(A, B) \in \text{TYPE}$: $s = (A, B)$, $e = (A, B)$,
 $t = (A, B)$.

iv) for any $A \in \text{TYPE}$: $(s, A) \in \text{TYPE}$

v) for any D : $D \in \text{TYPE}$ iff D satisfies

i)- iv) .

Let S_1 be a set of symbols, B_1 a function from TYPE such that

$R(B_1) \subset \mathcal{P}(S_1)$, for any $P, Q \in R(B_1)$: $P \cap Q = \emptyset$ and for any $A \in \text{TYPE}$

$B_1(A)$ is the set of constants and variables of type A . There are supposed to be at least denumerably many of these.

Me is a function from TYPE such that $R(\text{Me})$ is the set of smallest sets which satisfy:

1) For any $A \in \text{TYPE}$: $B_1(A) \subseteq \text{Me}(A)$

2) If $\alpha \in \text{Me}(A, B)$, $\beta \in \text{Me}(A)$ then $\alpha(\beta) \in \text{Me}(B)$

3) If $\alpha \in \text{Me}(A)$, $u \in \text{Me}(B)$ then $\lambda u \alpha \in \text{Me}(B, A)$

4) If $\alpha, \beta \in \text{Me}(A)$ then $\alpha = \beta \in \text{Me}(t)$

5) If $\phi, \psi \in \text{Me}(t)$ and u is a variable, then $\neg \phi$, $(\phi \supset \psi)$, $(\phi \vee \psi)$, $(\phi \equiv \psi)$,
 $(\phi \& \psi)$, $(\forall u)(\phi)$, $(\exists u)(\phi)$, $S(\phi, \psi)$, $U(\phi, \psi)$, $\phi \text{ CA } \psi$, $\text{Ag } \phi$,
 $\text{Ih}(\phi)$, $\text{Fh}(\phi) \in \text{Me}(t)$

6) If $\phi \in \text{Me}((s, e), t)$, then $o\phi \in \text{Me}(s, e)$ and $+ \phi \in \text{Me}((s, e))$.

7) If $u \in \text{Me}(s, e)$, then $sm u \in \text{Me}((s, e), t)$

8) If $\alpha \in \text{Me}(A)$ then $(^A \alpha) \in \text{Me}(s, A)$

9) If $\alpha \in \text{Me}(s, A)$ then $(^s \alpha) \in \text{Me}(A)$

10) Let O_n be any operator such that, if $p_1, \dots, p_n \in \text{Me}(t)$, then

$O_n(p_1, \dots, p_n) \in \text{Me}(t)$. Then $I(O_n(p_1, \dots, p_n)) \in \text{Me}(t)$.

11) If $\phi \in \text{Me}(t)$, then $\Delta \phi \in \text{Me}(t)$

Def.8 . $P(\varphi) = S(\varphi, \varphi \supset \varphi)$

$H'(\varphi) = S(\varphi \supset \varphi, \varphi)$

Def.9 T is the ordered pair (B_i, Me) .

II.2 Semantics

Let I and J be sets, $I \cap J = \emptyset$, to be thought of as a set of worlds and a set of times, respectively.

For each $i \in I$,

I is ordered by the relation $\sqsubseteq_i$. $j \sqsubseteq_i k$ is to be read: "world j is at least as similar to world i as world k ". $(\sqsubseteq, I)$ is meant to be a centered comparative similarity system cf. (Lewis, 1973, 48f.). I choose this one only to have some semantics for causation, but it doesn't play an important role. ^{at this stage} We take J to be the set of reals, $\leq$ is the usual ordering on this set.

Let A be a set, consisting of non-empty sets. U_A is the universe class of A . ^{relative to some suitable set of axioms} Among the members of U_A we have M , $M = \{m : \exists b \in A \text{ \& } m \in b\}$;

$Q, Q = \mathcal{P}(M)$; $T, T = A \cup M \cup Q$. M we call the set of atoms (not in the physical sense of course), Q the set of quantities, T the set of denotations of type e . ³⁾

Let Z be any set. Then by E_Z we mean a function from $ST \times J$ to $\mathcal{P}(Z) - \{\emptyset\}$ such that for any $i \in I$ and $j \in J$ $E_Z(i, j)$ is a subset of Z to be considered as the set of members of Z existing at (i, j) .

$E_M(i, j) = \{m : \exists b \in E_A(i, j) \text{ \& } m \in b \text{ \& } m \neq \emptyset\}$

$E_Q(i, j) = \mathcal{P}(E_M(i, j)) - \{\emptyset\}$

$E_T(i, j) = E_A(i, j) \cup E_M(i, j) \cup E_Q(i, j)$.

Let D_a be the total set of denotations of expressions of type a . $[0, 1]$ is the closed interval of reals between 0 and 1. On $[0, 1]$ we have the usual operations on the reals. The least upperbound and the greatest lower bound of each subset of $[0, 1]$ are denoted by $\vee$ and $\wedge$ respectively.

The sets of denotations of expressions of all types are defined recursively:

$$\begin{aligned}
 \text{Def. 10. } D_e &= T \\
 D_t &= [0,1] \\
 D_{(a,b)} &= D_b^{D_a} \\
 D_{(s,a)} &= D_a^{I \times J}
 \end{aligned}$$

The septuple $(T, I, J, \sqsubseteq, \leq, E, F)$ is called a model, $\mathcal{A}$, where for each type a and each i, j $D_a(i, j)$ is defined in the following way:

$$\begin{aligned}
 \text{Def. 11. } D_e(i, j) &= E_T(i, j) \\
 D_t(i, j) &= [0,1]
 \end{aligned}$$

$$D_{(a,b)}(i, j) = E_{D_b^{D_a}}(i, j)$$

$$D_{(s,a)}(i, j) = E_{D_a^{I \times J}}(i, j)$$

F is a function from the set of constants C , such that for any c of type a $F(c) \in D_{(s,a)}$. Let V be the set of variables of (B_i, Me) , then g is an $\mathcal{A}$ -assignment iff for any variable u of type a , $g(u) \in D_{(s,a)}$. If $\alpha \in Me(a)$, then $[\alpha]^{\mathcal{A}, g} \in D_{(s,a)}$ and $[\alpha]^{\mathcal{A}, g}$ is called the intension of α ; $[\alpha]^{\mathcal{A}, i, j, g} = [\alpha]^{\mathcal{A}, g}(i, j)$ and is called the extension of α at (i, j) .

Def. 12.1. If α is a constant, then $[\alpha]^{\mathcal{A}, i, j, g} = F(\alpha)(i, j)$.

2. If α is a variable, then $[\alpha]^{\mathcal{A}, i, j, g} = g(\alpha)(i, j)$

3. If α is a variable, then $[\alpha]^{\mathcal{A}, g}$ is that function h with domain $I \times J$ such that whenever $(k, l) \in I \times J$, $h(k, l) = [\alpha]^{\mathcal{A}, k, l, g}$

4. If $\alpha \in Me(a)$ and u is a variable of type b , then $[\lambda u \alpha]^{\mathcal{A}, i, j, g}$ is that function h with domain D_b such that, whenever x is in that domain, $h(x) = [\alpha]^{\mathcal{A}, i, j, g'}$, where g' is the $\mathcal{A}$ -assignment like g , except for the possible difference that $g'(u)(i, j) = x$

5. If $\alpha \in Me(a, b)$, $\beta \in Me(a)$, then $[\alpha(\beta)]^{\mathcal{A}, i, j, g} = [\alpha]^{\mathcal{A}, i, j, g}([\beta]^{\mathcal{A}, i, j, g})$

6. If $\alpha, \beta \in Me(a)$, then $[\alpha = \beta]^{\mathcal{A}, i, j, g} = 1$ if $[\alpha]^{\mathcal{A}, i, j, g} = [\beta]^{\mathcal{A}, i, j, g}$, otherwise $[\alpha = \beta]^{\mathcal{A}, i, j, g} = 0$.

- 6) If $\varphi \in \text{Me}(t)$, then $[\neg\varphi]^{a,i,j,g} = 1 - [\varphi]^{a,i,j,g}$
- 7) If $\varphi, \psi \in \text{Me}(t)$, then $[\varphi \supset \psi]^{a,i,j,g} = \bigvee \{c: [\varphi]^{a,i,j,g} \cdot c \leq [\psi]^{a,i,j,g}\}$
- 8) If $\varphi, \psi \in \text{Me}(t)$, then $[\varphi \& \psi]^{a,i,j,g} = [\varphi]^{a,i,j,g} \cdot [\psi]^{a,i,j,g}$
- 9) If $\varphi, \psi \in \text{Me}(t)$, then $[\varphi \vee \psi]^{a,i,j,g} = [\varphi]^{a,i,j,g} + [\psi]^{a,i,j,g} - [\varphi]^{a,i,j,g} \cdot [\psi]^{a,i,j,g}$
- 10) If $\varphi \in \text{Me}(t)$, and u is a variable of type a , then

$$[(\exists u)(\varphi)]^{a,i,j,g} = \bigvee \{[\varphi]^{a,i,j,g'}\}$$
 for all g' such that $g'(u)(i,j) \in D_a^{(i,j)}$
 If $\varphi \in \text{Me}(t)$ and u is a variable of type a , then

$$[(\forall u)(\varphi)]^{a,i,j,g} = \bigwedge \{[\varphi]^{a,i,j,g'}\}$$
 for all g' such that
 $g'(u)(i,j) \in D_a(i,j)$, where for any g', i, j and any variable δ
 other than u , $g'(\delta)(i,j) = g(\delta)(i,j)$.
- 11) If $\varphi, \psi \in \text{Me}(t)$, then $[S(\varphi, \psi)]^{a,i,j,g} =$

$$\bigvee_{\forall k: k < j} \{c: c = ([\varphi]^{a,i,k,g} \cdot \bigwedge_{\forall j': k < j' < j} \{d: d = [\psi]^{a,i,j',g}\})\}$$

 and $[U(\varphi, \psi)]^{a,i,j,g} =$

$$\bigvee_{\forall k: j < k} \{c: c = ([\varphi]^{a,i,k,g} \cdot \bigwedge_{\forall j: j < j' < k} \{d: d = [\psi]^{a,i,j',g}\})\}$$
- 12) If $\varphi, \psi \in \text{Me}(t)$, then $[\varphi \text{ CA } \psi]^{a,i,j,g} =$

$$[\psi]^{a,i,j,g} \cdot \bigvee_{\forall k: i \in_i k} \{c: c = ([\neg\varphi]^{a,k,j,g} \cdot \bigwedge_{\forall i': i' \in_i k} \{d: d = ([\neg\varphi \supset \neg\psi]^{a,i',j,g})\})\}$$

13) Let $\varphi \in M_e(t)$.

Let the map $f(t) = [\varphi]^{a,i,t,g}$, with $j' \leq t \leq j$ for some $j' \in J$ be at least piecewise continuous (Lang, 1969, 188). Let P_n be a partition of the interval $[j', j]$ of J . $P_n = (j' =) a_0, a_1, \dots, a_n (= j)$. For each $i = 1, \dots, n$ we have a continuous function $f_i(t)$ such that $f(t) = f_i(t)$ if $a_{i-1} < t < a_i$. Let $G[\varphi]^{a,i,t,g}_{[j',j]}$ be the average truth-value of $[\varphi]^{a,i,t,g}$ at j with respect to $[j', j]$.

$$G[\varphi]^{a,i,t,g}_{[j',j]} = \frac{\int_{a_0}^{a_1} f_1(t) dt + \dots + \int_{a_{n-1}}^{a_n} f_n(t) dt}{a_n - a_0}$$

Let $G(\varphi)_{j'}(t) = G[\varphi]^{a,i,t,g}_{[j',t]}$. Then $G(\varphi)_{j'}(t)$ is differentiable, and we have:

$$\begin{aligned} [\Delta \varphi]^{a,i,j,g} &= 1 - \frac{1}{e^{c \cdot (|G'(\varphi)_{j'}(j)| + G'(\varphi)_{j'}(j))}} \quad \text{if} \\ &1 - \frac{1}{e^{c \cdot (|G'(\varphi)_{j'}(j)| + G'(\varphi)_{j'}(j))}} \leq B \\ &= 1 \quad \text{if} \quad 1 - \frac{1}{e^{c \cdot (|G'(\varphi)_{j'}(j)| + G'(\varphi)_{j'}(j))}} > B \\ &= 0 \quad \text{if} \quad [\varphi]^{a,i,j,g} = 1 \end{aligned}$$

where c, B are constant numbers, $0 \leq B \leq 1$, $j' \in J$ and c, B, j' depend on λ . $G'(\varphi)_{j'}(j)$ is the first derivative of $G(\varphi)_{j'}(t)$ at j .

14) If $\alpha \in Me(a)$, then $[\wedge \alpha]^{a,i,j,g}$ is that function h with domain $I \times J$ such that whenever $(k, l) \in I \times J$, $h(k, l) = [\wedge \alpha]^{a,i,l,g}$

15) If $\alpha \in Me(s, a)$, then $[\vee \alpha]^{a,i,j,g} = [\alpha]^{a,i,j,g}(i, j)$

16) If $\delta \in Me((s, e), t)$, then $[\circ \delta]^{a,i,j,g}$ is a function f such that for every i', j' $f(i', j') = \{m : (\exists d) ([\delta]^{a,i',j',g}(d) = 1 \ \& \ m \in d)\}$

17) If $\delta \in Me((s, e), t)$, then $[+ \delta]$ is a function h such that for every i', j' : $h(i', j') = \{d : [\delta]^{a,i',j',g}(d) = 1\}$

18) If $u \in Me(s, e)$, then $[sm u]^{a,i,j,g}$ is a function k such that for every i', j' : $k(i', j') \in \left(\mathcal{P}([\alpha]^{a,i,j,g}(i', j')) - \{\emptyset\} \right)_{[0,1]}$

19) If $\varphi \in Me(t)$, then $[Ag \varphi]^{a,i,j,g} = [\varphi \ \& \ P(\neg \varphi \ \& \ P \varphi)]^{a,i,j,g}$

20). Let $\varphi \in M(t)$

$$\text{Then } [Ih^{\wedge}\varphi]^{a,i,j,g} = \frac{1}{e^{c \cdot ||j'-j|-|j''-j||}} \cdot [\varphi]^{a,i,j,g} \quad \text{if} \quad (4)$$

i) $j', j \in J, j' < j$ and $[j', j]$ is a period of one hour

ii) $j'' \in J, j'' < j$ and for all $j''' \in [j'', j) : [\Delta \varphi]^{a,i,j'',g} > 0$

Otherwise $[Ih^{\wedge}\varphi]^{a,i,j,g} = 0$. c is a number depending on $\mathcal{A}$.

$$21) \text{ Let } \varphi \in Me(t), \text{ then } [Fh\varphi]^{a,i,j,g} = \frac{1}{e^{c \cdot ||j'-j|-|j''-j||}} \cdot \frac{[\varphi]^{a,i,j_0,g} + \dots + [\varphi]^{a,i,j_n,g}}{n} \quad (4)$$

i) (i) $j', j \in J, j' < j$ and $[j', j]$ is a period of one hour

ii) $j'' \in J, j'' < j$ and there is a partition

$P_n = (j'' =) a_0, \dots, a_n (= j)$ of $[j'', j]$, where n depends on $\mathcal{A}$.

but $n > 2$, such that for any $i \in \{0, \dots, n-1\} : [\varphi]^{a,i,a_i,g} > 0$.

Otherwise $[Fh\varphi]^{a,i,j,g} = 0$.

22) Let O_n be an n -place operator on expressions of type t . Let

$\varphi'_i(v_i)$ be an expression of type t with a variable v_i (of arbitrary type)

bound by a quantor. Let $O_n(\varphi_1, \dots, \varphi_n) \in Me(t)$ and let $\varphi'_1(v_1), \dots, \varphi'_m(v_m)$

be the only formulae among $\varphi_1, \dots, \varphi_n$ with a variable v_j bound by a quantor,

$1 \leq i < m \leq n$. Then $[I(O_n(\varphi_1, \dots, \varphi_n))]^{a,i,j,g} = [O_n(\varphi_1, \dots, \varphi_n)]^{a,i,j,g}$ if there

are $\mathcal{A}$ -assignments $g'_1, \dots, g'_m$ such that

i) for any $l, 1 \leq l \leq m : [\varphi_l(v_l)]^{a,i,j,g'_l} = [\varphi'_l(v_l)]^{a,i,j,g}$

and

ii) for any $h, k, 1 \leq h \leq k \leq m : g'_h(v_h)(i, j) = g'_k(v_k)(i, j)$.

Otherwise $[I(O_n(\varphi_1, \dots, \varphi_n))]^{a,i,j,g} = 0$

If $\varphi \in Me(t)$ then φ is true with respect to $\mathcal{A}, i, j$ iff $[\varphi]^{a,i,j,g} = 1$ for every $\mathcal{A}$ -assignment g .

III. Translation rules

We will make use of the notational conventions of PTQ (pp. 259-261) .

Let $f: \text{CAT} \rightarrow \text{TYPE}$ be a mapping such that $f(i, e) = e$, $f(i, t) = t$ for any $i \in \mathbb{N}$; and for any $m, n \in \mathbb{N}$ and $A, B \in \text{CAT}$: $f(n, m, A, B) = f(A/B) = ((s, f(B)), f(A))$.

T is a one-to-one function with a domain consisting of the members of B other than in an hour, for an hour, again and the members of B_T , B_{IV} , B_{TV} such that for any α in the domain of T , if $\alpha \in B_A$ for some $A \in \text{CAT}$, then $(\alpha)^T$ is a constant of type $f(A)$.

μ is a one-to-one function which assigns to every element δ of B_{IV} or B_{TV} a constant μ_δ of type $((s, e), t)$. The following rules together provide a part of the translation-relation T^+ , $T \subset T^+$. Let ";" abbreviate "translates into".

III.1 Basic rules

$$T_1. \underline{be}_1 ; \lambda p \lambda q (2 \{ \hat{x} (\mathcal{D} \{ \hat{y} (x=y) \} \} \} p)$$

$$\underline{be}_2 ; \lambda p \lambda q (2 \{ \hat{x} (\mathcal{D} \{ \hat{y} (x=y) \} \} \} p).$$

$$T_2. \underline{\text{in an hour}} ; \lambda p (Ih \vee p).$$

$$\underline{\text{for an hour}} ; \lambda p (Fh \vee p).$$

$$\underline{\text{again}} ; \lambda p (Ag \vee p).$$

$$T_3. \underline{\text{something}} ; \hat{P}(\exists x)(P \{ x \}).$$

$$\underline{\text{John}} ; \hat{P}(\exists u)(^j = ^u \& P \{ ^u \}).$$

$$\underline{\text{Mary}} ; \hat{P}(\exists u)(^m = ^u \& P \{ ^u \}).$$

$$T_4. \underline{he}_n ; \hat{P}(\exists y)(x_n = y \& P \{ y \}).$$

$$T_5. \text{If } \delta \in B_{(0,2,b,T)} \text{ then } \delta ; \lambda p (\exists p) (\mathcal{D} \{ \hat{x} (\mu_\delta(x) \text{ CA } P \{ x \} \} \} p).$$

$$\text{If } \delta \in B_{((0,2,b,T)/T)} \text{ then } \delta ; \lambda p \lambda q (\exists p \lambda x (2 \{ \hat{y} (\mathcal{D} \{ \hat{z} (\mu_\delta(x) \text{ CA } P \{ y \} \} \} \} z) \} p) q).$$

$$T_6. \text{If } h \in P_{(1,0,b,a)} \text{ and } h ; h' \text{ then } F_1(h) ; \hat{P}(\forall x)(h'(x) \supset P \{ x \}).$$

$$F_2(h) ; \hat{P}(\exists y)(\forall x)(h'(x) \equiv x=y \& P \{ y \}).$$

$$F_3(h) ; \hat{P}(\exists x)(h'(x) \& P \{ x \}).$$

$$T_7. \text{If } h \in P_{CN} \text{ then } F_4(h) ; \hat{P}(\exists x)(\forall y)(sm \circ h'(x) \& sm \times (y) \supset P \{ y \}).$$

$$F_5(h) ; \hat{P}(\exists x)(\forall y)(sm \circ h'(x) \& sm \times (y) \supset P \{ y \}).$$

$$F_6(h) ; \hat{P}(\forall x)(sm \circ h'(x) \supset P \{ x \}).$$

$$F_7(h) ; \hat{P}(\forall x)(sm \circ h'(x) \supset P\{x\}).$$

$$F_8(h) ; \hat{P}(\exists x)(sm \circ h'(x) \supset P\{x\}).$$

$$F_9(h) ; \hat{P}(\exists x)(\forall y)(h'(y) \equiv y = x \supset P\{x\}).$$

$$F_{10}(h) ; \hat{P}(\exists u)(\circ h' = \wedge u \supset P\{\wedge u\}).$$

$$T_8. \text{ If } h \in P_{(1,0,b,a)} \text{ then } F_{11}(h) ; \hat{P}(\exists x)(\forall y)(sm + h'(x) \supset sm \times (y) \supset P\{y\}).$$

$$F_{12}(h) ; \hat{P}(\exists u)(+h' = \wedge u \supset P\{\wedge u\}).$$

$$T_9. \text{ If } h \in P_{CN}, \varphi \in P_t, h ; h', \varphi ; \varphi', \text{ then } F_{13.n}(h \cdot \varphi) ; \wedge x_m (h'(x_m) \wedge \varphi). \quad 5)$$

III.2 Rules of functional application

$$T_{10}. \text{ If } \delta \in P_t, \delta ; \delta', h \in P_{Iph}, h ; h', \text{ then } F_{14}(\delta \cdot h) ; \delta'(\wedge h')$$

$$T_{11}. \text{ If } \varphi \in P_{(i,t)} \text{ and } h \in P_{((i,t)/(i,t))}, \varphi ; \varphi', h ; h' \text{ then } F_{15}(h \cdot \varphi) ; h'(\wedge \varphi').$$

$$T_{12}. \text{ If } \varphi, \xi \text{ are as in } S_{15}, \varphi ; \varphi', \text{ then}$$

$$F_{16}(\xi \cdot \varphi) ; \lambda \lambda [(\exists P)(\{S(2\hat{x}(P\{x\}(A \Delta \varphi'))\}, \Delta \varphi') \vee H'(\{2\hat{x}(P\{x\}(A \Delta \varphi'))\}) \& \varphi')]$$

$$; \text{ if } \delta \in P_{TM}, \text{ and } F_{16}(\xi \cdot \varphi) ; \lambda \lambda [(\exists P)(\{I(S(2\hat{x}(P\{x\}(A \Delta \varphi'))\}, \Delta \varphi') \vee H'(\{2\hat{x}(P\{x\}(A \Delta \varphi'))\}) \& \varphi')]$$

in all other cases.

$$T_{13}. \text{ If } \delta \in P_{IV}, \beta \in P_T, \delta ; \delta', \beta ; \beta' \text{ then } F_{17}(\delta \cdot \beta) ; \delta'(\wedge \beta')$$

$$T_{14}. \text{ If } \delta \in P_{TV}, \beta \in P_T, \delta ; \delta', \beta ; \beta' \text{ then } F_{18}(\delta \cdot \beta) ; \delta'(\wedge \beta')$$

$$T_{15}. \text{ If } \delta \in P_{ADJ} \text{ and } \xi \in P_{CN}, \delta ; \delta', \xi ; \xi' \text{ then } F_{21}(\delta \cdot \xi) ; \delta'(\wedge \xi').$$

III.3 Rules of quantification

$$T_{16}. \text{ If } \alpha \in P_T, \varphi \in P_b, \alpha ; \alpha', \varphi ; \varphi' \text{ then } F_{22.n}(\alpha \cdot \varphi) ; \alpha'(\wedge x_n \varphi')$$

III.4 Rules of tense

$$T_{17}. \text{ If } \varphi \in P_b, \varphi ; \varphi' \text{ then } F_{23}(\varphi) ; IP \varphi'$$

Now let us see how a sentence like

16) John melted gold for an hour

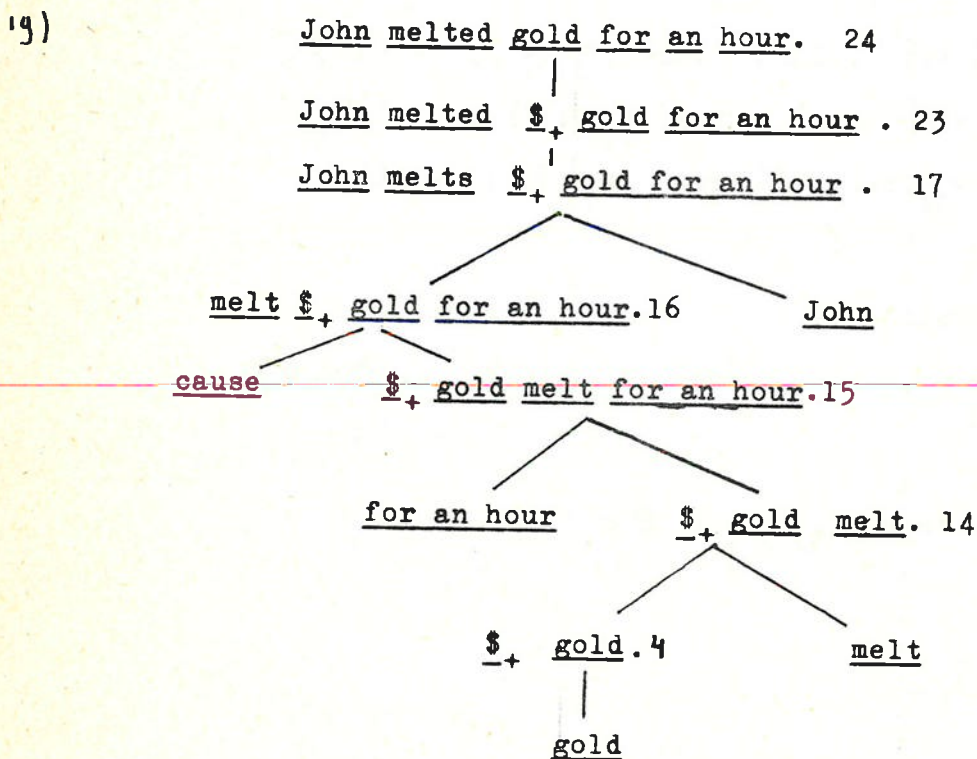
would be construed. In the first place note that 16. is ambiguous in the same way as

17) The sherriff of Nottingham jailed Robin Hood for four years

(Dowty,1974,18). This ambiguity is related to the one which can be found in

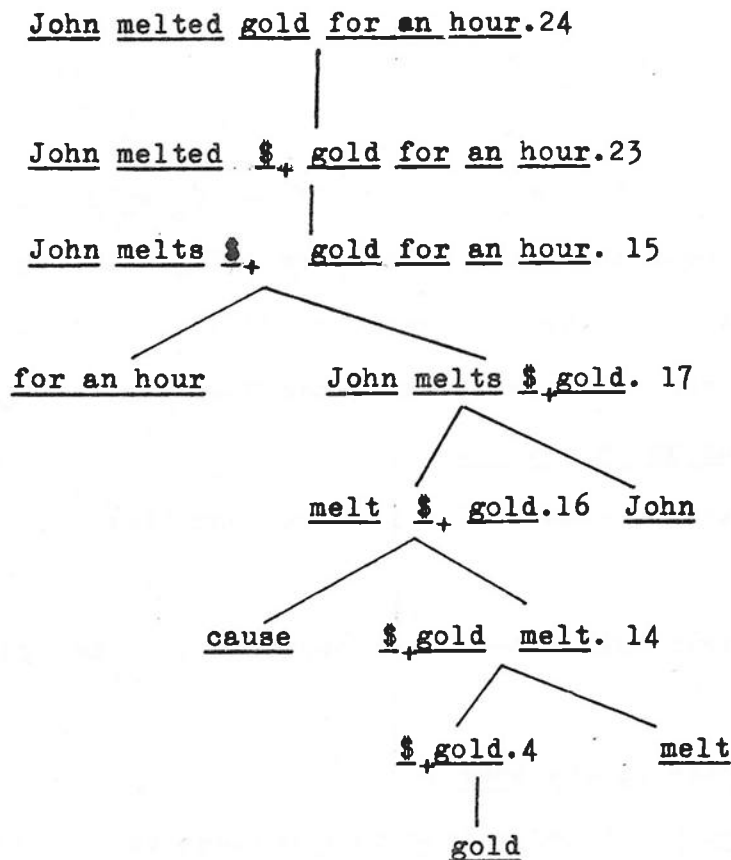
18) John pushed the cart to London again.

18) can be used when it's John's second time to push the cart to London, but also when somebody else pushed the cart to London a first time. In (Hoepelman,1976,1) I was able to treat this ambiguity for activity verbs which become perfective in certain contexts, here we can do the same for accomplishment verbs. These are, therefore, no longer considered as basic elements of the language, but formed out of more "primitive" elements, in the way proposed by generative semanticists (cf. Lakoff,1965, McCawley,1968). The analysis for 16) would be as follows:



The above analysis tree is supposed to render the fact that John brought it about that gold was in a melted aggregation state for one hour, but it doesn't tell how long John was busy doing so. The following tree is meant to render that John was melting gold during an hour, but it doesn't say how long the melted gold remained that way:

20)



The corresponding translations in intensional logic are

$$\begin{aligned}
 & \text{2) } \Pi[(\exists p)(\ (S(\exists u)(^j = ^u \ \& \ P\{^u\} \{CA \Delta Fh^{\wedge}(\exists x)(\forall y)(Sm \circ gold^T(x) \& Sm \ x(y) \supset melt^T(y)))\}, \\
 & \qquad \qquad \qquad \Delta Fh^{\wedge}(\exists x)(\forall y)(Sm \circ gold^T(x) \& Sm \ x(y) \supset melt^T(y))) \\
 & \vee H'((\exists u)(^j = ^u \ \& \ P\{^u\} \{CA \Delta Fh^{\wedge}(\exists x)(\forall y)(Sm \circ gold^T(x) \& Sm \ x(y) \supset melt^T(y)))) \& \\
 & \qquad \qquad \qquad Fh^{\wedge}(\exists x)(\forall y)(Sm \circ gold^T(x) \& Sm \ x(y) \supset melt^T(y)) \]
 \end{aligned}$$

For the first analysis tree, and

$P[Fh^*(\exists p)(S((\exists u)(^j = ^u \& P\{^u\}CA \Delta (\exists x)(\forall y)(Sm \circ gold^T(x) \& Sm x(y) \supset melt^T(y)))$

$\Delta (\exists x)(\forall y)(Sm \circ gold^T(x) \& Sm x(y) \supset melt^T(y)))$

$\vee H'((\exists u)(^j = ^u \& P\{^u\}CA \Delta (\exists x)(\forall y)(Sm \circ gold^T(x) \& Sm x(y) \supset melt^T(y)))) \&$

$(\exists x)(\forall y)(Sm \circ gold^T(x) \& Sm x(y) \supset melt^T(y))]$

for the second one .

Another source for gold in 19 and 20 could be C₊ gold, stemming from S₉. 16) would then mean that John melted the thing which is the union of all things that are gold in a certain world, at a certain time (for an hour) . This is queer of course, but we can have e.g.

23) Mayonne created mayonnaise in one hour .

We need the collective mass-nouns to deal with locutions like

24) Water is widespread

which certainly does not mean "all water is widespread" . Like 23) we could have

25) Ginger created gingercake in one hour .

So we see that, if gingercake is understood as a collective term, it can go together with the locution in an hour. Why then is

26) John ate gingercake in an hour ,

where gingercake is taken to be a mass term , strange ? From 21) and

22) it can be seen that I take melt(ed) in 16) to be a perfective expression, contrary to what is commonly accepted, namely that accomplishments with a mass-term as grammatical object turn into imperfectives. That it is not necessary to use a special imperfective form for accomplishments with mass-terms can perhaps intuitively been felt when 16) is understood as 20) and finds a hint of a confirmation in the fact that in Russian objects in the partitive genitive (this corresponds to mass-terms) usually occur with perfective verbs (Forsyth, 1970, 91-92, 201).⁶⁾

strange

That 26) is . should be imputed to the semantics for mass-terms and "in an hour" locutions, as well as to the way we normally eat things. If we translate 26) into intensional logic in the same way as 16) in the version 19) then we will get:

$$27) \mathcal{P}[(\exists p)(\mathcal{S}((\exists u)(^aj = ^au \& P f^au \} CA \Delta Ih^*(\exists x)(\forall y)(Sm \circ gingercake^T(x) \& Sm x(y) \supset eat^T(y))) ,$$

$$\Delta Ih^*(\exists x)(\forall y)(Sm \circ gingercake^T(x) \& Sm x(y) \supset eat^T(y)))$$

$$\vee H^*((\exists u)(^aj = ^au \& P f^au \} CA \Delta Ih^*(\exists x)(\forall y)(Sm \circ gingercake^T(x) \& Sm x(y) \supset eat^T(y)))) \&$$

$$Ih^*(\exists x)(\forall y)(Sm \circ gingercake^T(x) \& Sm x(y) \supset eat^T(y))].$$

Now we normally eat a quantity of gingercake (or of anything else, for that matter) in either of two ways: we swallow it in one bite or we munch it away bit by bit. The first case makes

$$28) Ih^*(\exists x)(\forall y)(Sm \circ gingercake^T(x) \& Sm x(y) \supset eat^T(y))$$

untrue, because there is at the chosen reference point j no j'' , $j'' < j$ such that for all j''' , $j'' < j''' < j$

$$[\Delta(\exists x)(\forall y)(Sm \circ gingercake^T(x) \& Sm x(y) \supset eat^T(y))]^{a, i, j'', g} > 0$$

The second case makes the formula 28) untrue, because, according to the semantics of Ih , if there is an interval $[j'', j]$ and John takes a morsel of gingercake at any j''' of $[j'', j]$, then at j'''

$$29) [(\exists x)(\forall y)(Sm \circ gingercake^T(x) \& Sm x(y) \supset eat^T(y))]^{a, i, j''', g}$$

has the truth value 1 and therefore 28) the truthvalue $\overset{at j}{0}$. But if there is an interval $[j'', j]$ such that John doesn't take a bite in $[j'', j]$, then $j' < j'' < j$, so that 28) cannot have the truth-value 1 at j . So the truth-value of 27) will be < 1 in any case, when "eat" is taken to have its usual meaning, which makes 27) untrue.

There are other processes, however, which in general are more evenly distributed in time among the subquantities of a quantity of matter. Cooking is one of these. And a sentence like

28) I cook French onion soup in one hour, but it takes my wife two hours to do so.

seems to be quite acceptable.

I leave it to the reader to work out other examples, e.g. for sentences with indefinite plurals and to look after the several relations of entailment that can be obtained .

- 1) Research for this paper was supported by the Netherlands Organisation for the Advancement of Pure Research.
- 2) The treatment of mass terms like "water" as "some water" (where some is not accentuated) stems from (Pelletier, 1974).
- 3) This way of treating D_e is derived from (Cresswell, 1973) 98f.
- 4) These definitions should be made more precise, of course.
- 5) The given formulation stems from R. H. Thomason (PTQ, 261, n.) and is meant to avoid collision of variables. Ψ is the result of replacing all occurrences of x_n in ϕ' by x_m , where x_m has no occurrences in either ϕ' or ϕ .
- 6) Although Forsyth contradicts himself on these pages.

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A Computer Program for Montague Grammar: theoretical aspects and proofs for the reduction rules.

by

T.M.V. Janssen

ABSTRACT

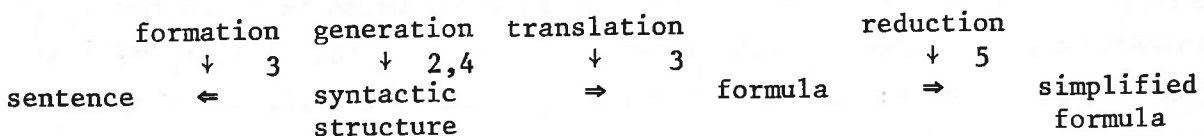
This paper deals with a computer program that follows the proposals presented by R. MONTAGUE in his article "The Proper Treatment of Quantification in Ordinary English". The problems are discussed which arose during the design of the algorithm. The reduction rules which were needed to simplify the formulas of intensional logic, are presented. The correctness of these rules is proved. Examples of generated sentences are discussed, inaccuracies and errors in Montague's article are signalized.

KEY WORDS & PHRASES: *Montague Grammar, Intensional Logic, Natural Languages, Computational Linguistics*

1. INTRODUCTION

This contribution deals with a computer program that follows the proposals presented in the article "The Proper Treatment of Quantification in Ordinary English" (MONTAGUE (1973)). This article will be referred to as "PTQ", page numbers are taken from THOMASON (1974). Although the program only takes PTQ into account, I prefer the more general title because the program can handle extensions of PTQ with comparatively little change. A modified version of the program has been used in the development of the proposal in GROENENDIJK & STOKHOF (1976). I will first give a survey of the main parts of the program.

The program is a generating program. It generates syntactic structures according to the syntactic rules in PTQ. Such a structure is a labelled tree resembling those presented in PTQ. On the one hand, the sentence corresponding to this structure is formed; on the other hand each structure is translated into the corresponding formula from intensional logic. Furthermore this formula is reduced in order to obtain a simplified formula, resembling the formula given in PTQ. This whole process is indicated in the following scheme.



In the next sections several parts of the program will be considered; the numbers in the scheme above indicate in which section those parts of the program will be considered; the numbers in the scheme above indicate in which section those parts are dealt with. After that a list is presented of the reduction rules used (section 6), and their correctness is proved in sections 9 and 10. Finally some interesting examples are considered (section 11). I will try to indicate the essence of the algorithms and provide motivation for their design. Text of the ALGOL-60 program, technical details and more examples can be found in JANSSEN (1976). I apologize for the fact that I will speak about the computer in rather antropomorphic terms, like "he chooses" or "he wishes"; needless to say, this has nothing to do with reality.

2. GENERATION

In this section will be demonstrated how the computer generates syntactic structures; one aspect of this demonstration will be revised in section 4. The computer generates according to rules $S_1, \dots, S_{14}$ from PTQ. For convenience two of them are indicated:

S4: if $\alpha \in P_T$ and $\beta \in P_{IV}$ then $F_4(\alpha, \beta) \in P_t$

S5: if $\alpha \in P_{TV}$ and $\beta \in P_T$ then $F_5(\alpha, \beta) \in P_{IV}$

As you notice, the rules are formulated in some function-like notation; a corresponding terminology is used: α is called the first argument of the rule, β is called the second argument and F_4 and F_5 are called (string) formation functions.

The computer wishes to make a sentence. He knows several instructions which tell him how a sentence could be formed, e.g. a sentence could be the conjunction of two sentences, *necessarily* followed by a sentence, or formed according to rule S4. The computer makes at random a choice from these instructions; say S4. According to this rule he has to make as the first argument a (member of the category) term (T), and as the second argument an intransitive verb (IV). There are several instructions which tell him how a term could be formed. One is: take a lexical element of the category T. Assume he chooses to do so and takes *Mary*. One of the instructions for making an IV is S5. In this case he has to make as first argument a transitive verb (TV), and as second one a term. Suppose in both cases he chooses to take a lexical element; e.g. *Love* and *John*. In this way he has formed the syntactic structure corresponding to the sentence *Mary loves John* (see fig. 1),

As you notice, making an expression of some category involves making expressions of other categories: the arguments of the chosen rule. For each category the way things go is in essence the same. So the "natural" way to describe this process is by means of a recursive procedure. The language used to write the program in is ALGOL-60; this language (as distinct from FORTRAN) allows for writing recursive procedures.

The kernel of the generating part of the program will be indicated below. The symbol " $:=$ " should be read as "becomes"; it means that the expression to the left of it is determined by the expression to the right.

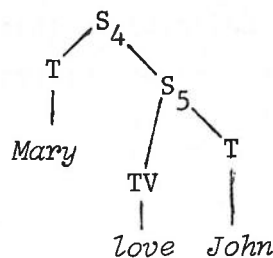
In a construction with brackets, e.g. *make (category)*, the expression outside the brackets can be considered as an operator and the expression between the brackets as its argument. *category* is a variable which may be replaced by any specific category.

```

procedure make (category)
begin   rule := choose rule for (category)
         if rule is not take lexical element
         then begin make (argument 1 of (rule));
              if has two arguments (rule)
              then make (argument 2 of (rule))
         end
         else choose lexical element of (category)
end

```

figure 1



3. FORMATION AND TRANSLATION

The syntactic structure is some internal data structure, figure 1 gives a graphical representation of the main aspects of such a structure. We wish to obtain as output of the program the sentence corresponding to this structure. In fact, to each vertex (= node) of the tree there corresponds a string (and the sentence corresponds to the root). Such a string is formed by some combination of the strings corresponding to the arguments (except for the lexical elements). The formation of the string is effected, just as in section 2, by a recursive procedure. Some parts of the procedure (the instructions for S4 and S5) are indicated on the following page.

procedure form string (vertex)

begin do instruction corresponding to (rule mentioned at (vertex));

instruction F4: begin form string (argument 1 of (vertex));

replace first verb in (form string (argument 2
of (vertex)))

end

instruction F5: begin replace in some cases he by him

in (form string (argument 1 of (vertex)));

form string (argument 2 of (vertex))

end

end

In order to obtain a visual representation of the tree, the strings corresponding to the lower nodes of the tree are also printed. The output corresponding to figure 1 is presented below. In the remaining part of this paper all syntactic structures will be indicated in this way. Occasionally the formed category and the used syntactic rules are indicated

T: Mary
TV: love
T : John
IV: S5: love John
t: S4: Mary loves John

The syntactic structure has to be translated into a formula of intensional logic. Corresponding to each syntactic rule there is a translation instruction. All these instructions are of the following type:

in order to make the translation, you must first make the translations of the arguments and combine then in a certain way. Therefore, the essence of the translation part is again a recursive procedure. Note that "making the translation of" is indeed a function since it is defined on structures instead of on strings.

English words like *walk* are distinguished from logical constants by a prime' (as in *walk'*). Instead of the constant *j* from PTQ we will use *John'*. The translation of a structure will be presented in the same way as the syntactic structures. As an example the output of the translation corresponding to figure 1 is presented on the following page.

$$\begin{array}{l}
 \text{Mary}^{*,*} \\
 \text{love}^{*,*} \\
 \text{John}^{*,*} \\
 \text{love}'(\wedge \text{John}^{*,*}) \\
 \text{Mary}^{*,*}(\wedge [\text{love}'(\wedge \text{John}^{*,*})])
 \end{array}$$

4. PROBLEMS WITH HE_1

The generation process as described in section 2 leads to a problem with respect to the rule for Term-substitution; this is rule S14,n (if $\alpha \in P_T$ and $\phi \in P_t$ then $F_{10,n}(\alpha, \phi) \in P_t$). A structure that is obtained by using an instance of this rule can be partially indicated as follows

T: *a unicorn*
 t: *Mary seeks him₁*
 t: S14,1 *Mary seeks a unicorn*

This sentence could indeed be generated by the computer with this structure: S14 is one of the instructions and he_1 is a possible choice for a term. However it should be noticed that also the string *Mary seeks him₁* can be the final result of the generation process. *Him₁*, however, is not an English word, and thus the computer would have produced a string which is not a correct English sentence. On the other hand, the computer could have chosen another term instead of *him₁* in the structure presented above, e.g. *John*. In that case *a unicorn* has to be substituted for the first occurrence of he_1 or *him₁* in the string *Mary seeks John*. There is no such occurrence, so the substitution has no effect. This results in a sentence, with an absurd syntactic structure (and also in an absurd logical structure). A related problem arises with respect to *such that* constructions; these are made by rule S3,n (if $\zeta \in P_{CN}$ and $\phi \in P_t$ then $F_{3,n}(\zeta, \phi) \in P_{CN}$). In case ϕ does not contain an occurrence of he_n , an incorrect logical interpretation may appear. This is demonstrated by the following example (due to STOKHOF & GROENENDIJK (1976)).

T: *Mary*
 CN: *woman*
 he₁ walks
 S3,2: *woman such that he₁ walks*
 $\vdots$
 t: *he₁ loves the woman such that he₁ walks*
 S14,1: *Mary loves the woman such that she walks*

In the final sentence *she* must refer to *woman*. The presented structure, however, would imply that *she* refers to *Mary*.

In order to avoid all these problems, we will require a "nice" correspondence between occurrences of he_n and the rules S3,n and S14,n. Let us call these rules " he_n -binding rules", and the second argument of them the "scope of the rule". Now we require that whenever a he_n -binding rule is used in the syntactical structure, then there is at least one occurrence of he_n within the scope of this rule. Moreover, if there is an occurrence of he_n in the structure, then it is within the scope of an he_n -binding rule.

This correspondence between the use of he_n -binding rules and occurrences of he_n , makes the choice of a term dependent on the whole syntactic structure. Therefore we must change the generation process. Besides, for technical reasons it is convenient to use for each index n at most once a he_n -binding rule (see also section 6). The stages of the generation process are now as follows.

- 1) Generate the whole syntactic structure without the lexical elements. So the *else* part in the procedure *make* (section 2) must be removed.
- 2) Insert the terms he_n . Within the scope of a he_n -binding rule there must be at least one insertion of he_n ; a he_n may not be inserted outside the scope of such a rule.
- 3) Insert the words.

5. REDUCTION PRINCIPLES

A formula that is obtained by translating a complete syntactic structure may be fairly complex. The program contains instructions for reducing formulas in order to obtain simplified formulas like the ones presented in PTQ. Such an instruction (=rule) is of the form: under certain conditions,

replace a subformula by another one. A reduction rule should transform a formula into a logically equivalent one. For some rules, this needs to be proved. These proofs are presented in sections 9 and 10 in this paper. The main principle of the reduction process is: apply every instruction that can be applied and stop when none can be applied any more. If one actually translates "by hand" one will already during translation simplify the intermediate results. The justification for this way of working is given in section 8. In fact, the computer does his job in this way too, but for perspicuity of exposition I treat the reduction part as a separate stage that starts after the whole translation has been made.

We want the computer to manipulate formulas. For this purpose it is convenient to take for a formula not a string, but a labelled tree. Consider the formula $\lambda x^{\vee \wedge} man'(x)$. This formula is split up in tree parts: the main operator λ , the variable x , and the remaining part of the formula. That part is split up in the operator $\vee$ and the formula $^{\wedge} man'(x)$. This formula is called the argument of the operator $\vee$. This, in its turn is, also split up. The tree thus obtained is sketched in figure 2.

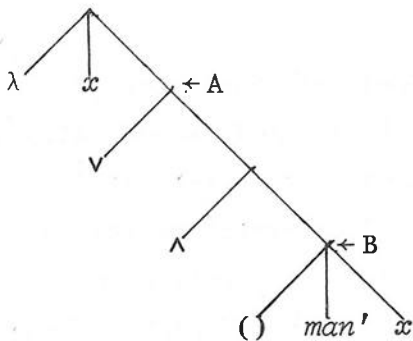


figure 2

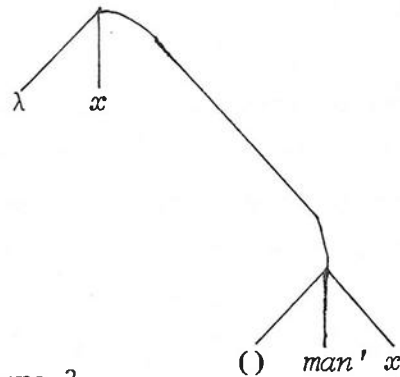


figure 3

One of the reduction rules allows us to replace $^{\vee \wedge} \alpha$ by α , thus to replace the formula $\lambda x^{\vee \wedge} man'(x)$ by $man'(x)$. Since formulas are considered as trees, this involves a tree transformation. The edge (in figure 2) connecting the root of the tree with A must be replaced by an edge connecting the root with B. So we obtain the tree sketched in figure 3. This replacement is produced in the program by an instruction such as *replace* (A,B). The condition for application of this transformation is that there is some operator $\vee$ followed by the operator $^{\wedge}$. This condition is "local", it can be verified by inspecting a little part of the tree. The change is also local: it con-

sists of replacements of some connections in a rather small part of the tree. The program only contains rules of this "simple" kind (see also section 11).

A fragment of the reduction part is indicated below. It is (again) a recursive procedure. Only the reduction rule treated above is presented. The program tries to apply this rule in a top-down order.

```

procedure reduce (vertex)
  begin
    if operator of (vertex) = extension
      and operator of (argument of (vertex)) = intension
      then replace (vertex, argument of (argument of (vertex)))
      else begin reduce (argument 1 of (vertex));
        if has two arguments (rule mentioned at (vertex))
          then reduce (argument 2 of (vertex))
      end
  end

```

6. REDUCTION RULES

Three types of reduction rules can be distinguished. These are (I) notational conventions, (II) rules which are true in all models and (III) rules based upon meaning postulates (MP's). For each rule is indicated where its justification can be found: for instance "p.259,-16" refers to THOMASON (1974), page 259, the 16th line from below (a "+" would mean from the top) and "th.8.2" indicates the theorem in section 8 part 2. Some rules are accompanied by remarks or conditions for their application.

Number of rule; formula 1 is replaced by formula 2; type; motivation is on

- | | | | | |
|-----|-----------------------|-----------------------------|---|----------|
| (1) | ϕ^* | $\lambda P[P(\wedge \phi)]$ | I | p.260,+5 |
| (2) | $\wedge \psi\{\eta\}$ | $\psi(\eta)$ | I | p.259,-5 |

The notational convention for braces states that $\phi\{\eta\} \equiv \vee \phi(\eta)$. Reduction rule 7 is applied in order to obtain this formulation.

- | | | | | |
|-----|--------------------|-------------------|---|----------|
| (3) | $\phi(\psi)(\eta)$ | $\phi(\eta,\psi)$ | I | p.259,-8 |
|-----|--------------------|-------------------|---|----------|

Condition in PTQ: $\phi(\psi)(\eta)$ is a well formed expression of type t. In section 11 we will see that this condition turns out to be too general. The computer applies this rule when ϕ is the translation of some verb.

- (4) $\delta(\wedge u)$ $\delta_*(u)$ I p.265,+10

Condition: δ is the translation of an intransitive verb or of a common noun

- (5) $\delta(\wedge u, \wedge [v]^*)$ $\delta_*(u, v)$ I p.265,+10

Condition: δ is the translation of a transitive verb.

- (6) $\delta(\wedge u, \wedge \lambda PP\{\wedge v\})$ $\delta_*(u, v)$ I

This is alternative formulation for reduction rule 5 (with the same condition as in (5))

- (7) $\forall \wedge \phi$ ϕ II th.10.1

- (8) $\lambda z[z](\alpha)$ $[\alpha]$ II section 9

Conditions for application are found in section 9.

- (9) $\neg \neg \phi$ ϕ II proof is evident

- (10) $\square \square \phi$ $\square \phi$ II proof is evident

- (11) $\delta(x)$ $\delta_*(\vee x)$ III p.265,-17, (MP3)

Condition: δ is the translation of an intransitive verb other than *rise* or *change*.

- (12) $\delta(x, P)$ $P\{\wedge \lambda y[\delta_*(\vee x, \vee y)]\}$ III p.265-14 (MP4)

Condition: δ is the translation of a transitive verb other than *seek* or *conceive*.

- (13a) $\forall x[\delta(x) \wedge P\{x\}]$ $\forall u[\delta(\wedge u) \wedge P\{\wedge u\}]$ III th.10.8

Condition: δ is the translation of a common noun other than *price* or *temperature*. This rule (based upon MP2) allows us to replace a variable by a variable of a different type.

- (13b) $\forall x[\delta(x) \wedge [\dots x \dots] \wedge P\{x\}]$ $\forall u[\delta(\wedge u) \wedge [\dots u \dots] \wedge P\{\wedge u\}]$ III th.10.12

- (14a) $\Lambda x[\delta(x) \rightarrow P\{x\}]$ $\Lambda u[\delta(\wedge u) \rightarrow P\{\wedge u\}]$ III th.10.9

Condition as in 13a). Rule 14b) is obtained from 14a) by replacing $\delta(x)$ by $\delta(x) \wedge [\dots x \dots]$

- (15a) $\forall y[\Lambda x[\delta(x) \iff x=y] \wedge P\{y\}]$ $\forall v[\Lambda u[\delta(\wedge u) \iff u=v] \wedge P\{\wedge u\}]$ IV th.10.10

Condition as in 13a). Rule 15b) is obtained from 15a) in the same way as in 14).

- (16) $in(P)(Q)(x)$ $P\{\lambda y[in_*(\vee y)(Q)(x)]\}$ III p.264,+1

This rule is formulated in this way on the analogy of the formulations of meaning postulates 3 and 4 in reduction rules 13 and 14; there is a difference however: the extension on only one variable has to be taken

7. DEFINITIONS FOR INTERPRETATION

The proofs for the correctness of the reduction rules will be semantic proofs: they are based upon the interpretation of intensional logic in a model $A = \langle A, I, J, \leq, F \rangle$. We will therefore speak of formulas and interpretations. For instance, we will use phrases like "the function such that its value for the element d is the extension of α with respect to i, j and g ". It is convenient to have a symbolic notation at hand. The mentioned phrase is symbolized by " $\lambda d \alpha^{A, i, j, g}$ ". The metalanguage used, contains the symbols α, ϕ, ψ, η (for formulas); a, a_1 (for elements from A); s (from $A^{I \times J}$); i, k, p (from I); j, l, q (from J); $\exists, \forall$ (as quantifiers); $\{, \}$ (as brackets) and some symbols which are the same as the ones in intensional logic (as $=, \lambda, (,), \neg$). We will omit the sets from which a, a_1, s, i, j, k and l are taken (e.g. $\exists s$ stands for $\exists s \in A^{I \times J}$).

In the formulas of intensional logic the variables u and v will always be of type e , and x and y of type $\langle s, e \rangle$. The variables z and w can be of any type, their type will be indicated by ζ and θ . The expression $[\alpha/z]\phi$ is a notation for the formula that is obtained from formula ϕ by replacing all free occurrences of z by α .

An A -assignment g is a function with as its domain the set of all variables and such that $g(z) \in D_{\zeta, A, I, J}$ (see PTQ p.258,+7 for a full definition). Let d be an element from $D_{\theta, A, I, J}$. Then the A -assignment $[w \rightarrow d]g$ is defined by

$$\begin{cases} [w \rightarrow d]g(w) = d \\ [w \rightarrow d]g(z) = g(z) \text{ if } z \neq w \end{cases}$$

The extension is a function with parameters i, j and g . Its domain is the set of formulas and its range is $\bigcup_{\zeta} D_{\zeta, A, I, J}$. The extension of a formula ϕ with respect to i, j and g is written as $\phi^{A, i, j, g}$ and it is defined by the following recursive definition.

- (1) $c^{A, i, j, g} = F(c)(i, j)$ if c is a logical constant
- (2) $z^{A, i, j, g} = g(z)$ if z is a variable
- (3) $\{\lambda z \psi\}^{A, i, j, g} = \lambda d \{\psi\}^{A, i, j, [z \rightarrow d]g}$ where $d \in D_{\zeta, I, J, A}$
- (4) $\{\psi(\eta)\}^{A, i, j, g} = \psi^{A, i, j, g}(\eta^{A, i, j, g})$
- (5) $\{\psi = \eta\}^{A, i, j, g} = \begin{cases} 1 & \text{if } \psi^{A, i, j, g} = \eta^{A, i, j, g} \\ 0 & \text{otherwise} \end{cases}$

- (6) $\{\neg\psi\}^{A,i,j,g} = \begin{cases} 1 & \text{if } \psi^{A,i,j,g} = 0 \\ 0 & \text{otherwise} \end{cases}$ (similarly for $\wedge, \vee, \rightarrow, \leftrightarrow$)
- (7) $\{\forall z\phi\}^{A,i,j,g} = \begin{cases} 1 & \text{if } \exists d \in D_{\zeta,A,I,J} \text{ such that } \psi^{A,i,j,[z \rightarrow d]g} = 1 \\ 0 & \text{otherwise} \end{cases}$
- (8) $\{\Box\psi\}^{A,i,j,g} = \begin{cases} 1 & \text{if } \forall k, 1 \psi^{A,k,1,g} = 1 \\ 0 & \text{otherwise} \end{cases}$
- similarly for $H\psi$ and $W\psi$
- (9) $\{\wedge\psi\}^{A,i,j,g} = \lambda_{k,1} \psi^{A,k,1,g}$
- (10) $\{\vee\psi\}^{A,i,j,g} = \psi^{A,i,j,g(i,j)}$

The intension of a formula ϕ is written as $\phi^{A,g}$ and it is defined as follows: $\phi^{A,g} = \lambda_{i,j} \phi^{A,i,j,g}$

8. REDUCTION BASIS

THEOREM. Let α_1 and α_2 be formulas of the same type as z_1 , and suppose

$$(A): \forall_{i,j,g} \alpha_1^{A,i,j,g} = \alpha_2^{A,i,j,g}.$$

Then for all formulas ϕ it holds that $\forall_{i,j,g} \{[\alpha_1/z]\phi\}^{A,i,j,g} = \{[\alpha_2/z]\phi\}^{A,i,j,g}$

PROOF. By formula induction. First we prove the theorem for the case that ϕ is variable or a constant. Next we prove it for compound formulas under the induction hypothesis that the theorem holds for formulas with lower complexity. The cases we have to consider are the 10 cases from the definition of extension (section 7). With E7 we refer to the 7th clause of this definition, with IH to the induction hypothesis.

$$1) \phi \equiv c \quad \text{then } [\alpha_1/z]c \equiv c \equiv [\alpha_2/z]c$$

$$2) \phi \equiv w \quad \text{if } w \neq z \text{ then see 1) else}$$

$$\{[\alpha_1/z]z\}^{A,i,j,g} = \alpha_1^{A,i,j,g} \triangleq \alpha_2^{A,i,j,g} = \{[\alpha_2/z]z\}^{A,i,j,g}$$

$$3) \phi = \lambda w \psi \quad \text{if } w = z \text{ then } [\alpha_1/z]\lambda w \psi \equiv \lambda w \psi \equiv [\alpha_2/z]\lambda w \psi, \text{ else}$$

$$\{[\alpha_1/z]\lambda w \psi\}^{A,i,j,g} = \{\lambda w [\alpha_1/z]\psi\}^{A,i,j,g} \stackrel{E3}{=} \lambda \{[\alpha_1/z]\psi^{A,i,j,[z \rightarrow d]g}\} =$$

$$\stackrel{IH}{=} \lambda d \{[\alpha_2/z]\psi^{A,i,j,[z \rightarrow d]g}\} \stackrel{E3}{=} \{[\alpha_2/z]\lambda w \psi\}^{A,i,j,g}$$

$$8) \phi \equiv \Box \psi \quad \{[\alpha_1/z]\Box \psi\}^{A,i,j,g} = 1 \iff \{\Box [\alpha_1/z]\psi\}^{A,i,j,g} = 1 \iff$$

$$\stackrel{E8}{\iff} \forall k,1 \{[\alpha_1/z]\psi\}^{A,k,1,g} = 1 \stackrel{IH}{\iff} \forall k,1 \{[\alpha_2/z]\psi\}^{A,k,1,g} = 1 \stackrel{E8}{\iff} \{[\alpha_1/z]\Box\psi\}^{A,i,j,g=1}$$

$$9) \phi \equiv \wedge \psi \{[\alpha_1/z]\wedge\psi\}^{A,i,j,g} = \{\wedge[\alpha_1/z]\psi\}^{A,i,j,g} \stackrel{E9}{=} \lambda k,1 \{[\alpha_1/z]\psi\}^{A,k,1,g} =$$

$$\stackrel{IH}{=} \lambda k,1 \{[\alpha_2/z]\psi\}^{A,k,1,g} \stackrel{E9}{=} \{[\alpha_2/z]\wedge\psi\}^{A,i,j,g}$$

The cases 4 to 7 and 10 are left to the reader

CONSEQUENCE. The basis for the reduction process has been laid. The proofs for the reduction rules are such that we prove the equivalence in the sense of (A) of two formulas. Applying a reduction rule means that a subformula is replaced by its equivalent mentioned in the rule. The justification for the replacement of subformulas is provided for by this theorem. The same idea underlies the way we work "by hand"; a formula is reduced even when the complete context has not yet been formed.

9. LAMBDA CONVERSION

THEOREM. Let $\lambda z[\phi](\alpha)$ be a formula and suppose

I) No free occurrence of a variable in α becomes bound by substitution of α for z in ϕ .

and II) One of the following conditions holds

II.1) the variable z does not occur within the scope of $\wedge$, $\Box$, H or W or

II.2) $\forall i,j,k,1 \quad \alpha^{A,i,j,g} = \alpha^{A,k,1,g}$

then

$$\forall i,j \{ \lambda z[\phi](\alpha) \}^{A,i,j,g} = \{ [\alpha/z]\phi \}^{A,i,j,g}$$

PROOF. Note that $\{ \lambda z[\phi](\alpha) \}^{A,i,j,g} = \{ \lambda z[\phi] \}^{A,i,j,g} (\alpha^{A,i,j,g}) =$

$$\left[\lambda d \phi^{A,i,j,[z \rightarrow d]g} \right] (\alpha^{A,i,j,g}) = \phi^{A,i,j,[z \rightarrow \alpha]g} \quad (\text{the last equality}$$

holds because of the meaning of the expression between $[and]$, see section 7).

We prove the theorem by proving that for all i,j and h , where h is an assignment such that III: $h(w) = g(w)$ for all free variables w in α , the following holds:

$$\phi^{A,i,j,[z \rightarrow \alpha]g} = \{ [\alpha/z]\phi \}^{A,i,j,g}$$

This is proved by formula induction.

$$1) \phi \equiv c \quad c^{A,i,j,[z \rightarrow \alpha]A,i,j,h}_h = [\alpha/z]c^{A,i,j,h}$$

$$2) \phi \equiv w \quad \text{if } w \neq z \text{ then see 1), else}$$

$$z^{A,i,j,[z \rightarrow \alpha]A,i,j,h}_h = \alpha^{A,i,j,h} = \{[\alpha/z]z\}^{A,i,j,h}$$

$$3) \phi \equiv \lambda w \psi. \text{ If } w \equiv z \text{ then } [\alpha/z]\lambda z \psi \equiv \lambda z \psi; \text{ the same holds when } w \text{ does not occur in } \psi. \text{ In the remaining case we know that } w \text{ does not occur in } \alpha \text{ because of requirement I. Then}$$

$$\begin{aligned} \{\lambda w \psi\}^{A,i,j,[z \rightarrow \alpha]A,i,j,h}_h &\stackrel{E3}{=} \lambda d \psi^{A,i,j,[w \rightarrow d]\{[z \rightarrow \alpha]A,i,j,h\}}_h \stackrel{A}{=} \\ \lambda d \psi^{A,i,j,[z \rightarrow \alpha]A,i,j,[w \rightarrow d]h}_h &\stackrel{B}{=} \lambda d [\alpha/z] \psi^{A,i,j,[w \rightarrow d]h}_h \stackrel{E3}{=} \end{aligned}$$

$$[\alpha/z] \lambda w \psi^{A,i,j,h}. \text{ Equality (A) holds since } w \text{ does not occur in } \alpha.$$

Equality (B) holds since we can apply the induction hypothesis with the assignment $[w \rightarrow d]h$ (condition III is satisfied since w does not occur in α).

$$8) \phi \equiv \Box \psi \quad \text{If II.1 holds then } [\alpha/z]\Box \psi \equiv \psi, \text{ else}$$

$$\begin{aligned} \{\Box \psi\}^{A,i,j,[z \rightarrow \alpha]A,i,j,h}_h &= 1 \stackrel{E8}{\iff} \forall k,1 \psi^{A,k,1,[z \rightarrow \alpha]A,i,j,h}_h = 1 \\ \text{II.2 } \forall k,1 \psi^{A,k,1,[z \rightarrow \alpha]A,k,1,h}_h &= 1 \iff \forall k,1 \{[\alpha/z]\psi\}^{A,k,1,h} = 1 \\ &\stackrel{E8}{\iff} \{[\alpha/z]\Box \psi\}^{A,i,j,h} = 1 \end{aligned}$$

The proofs are similar for $H\psi$ and $W\psi$.

$$9) \phi \equiv \wedge \psi \quad \text{If II.1 holds then } [\alpha/z]\wedge \psi \equiv \wedge \psi, \text{ else}$$

$$\begin{aligned} \{\wedge \psi\}^{A,i,j,[z \rightarrow \alpha]A,i,j,h}_h &\stackrel{E9}{=} \lambda k,1 \psi^{A,k,1,[z \rightarrow \alpha]A,i,j,h}_h = \\ &= \lambda k,1 \psi^{A,k,1,[z \rightarrow \alpha]A,k,1,h}_h = \lambda k,1 \{[\alpha/z]\psi\}^{A,k,1,h} = \{[\alpha/z]\wedge \psi\}^{A,i,j,h} \end{aligned}$$

The cases 4 to 7 and 10 are left to the reader.

CONSEQUENCE: The correctness of the reduction rule for λ conversion.

Reduction rule 8: $\lambda z[\dots z \dots](\alpha)$ is replaced by $[\dots \alpha \dots]$,

provided that one of the following conditions holds:

1) α is a variable

2) α is a formula of the form $\wedge \eta$

- 3) α is the translation of a proper name
 4) z does not occur within the scope of $\wedge$, $\square$, H or W .

Correctness can be proved with the previous theorem as follows:

Condition I of the theorem holds if z is a variable that corresponds with a term he_z : the special way in which he_n -substitution takes place, guarantees that we have only one binder for x_n . For other variables we created the same situation as follows: the computer does not simply use variables as $p, P \dots$ but indexed ones. Each time a translation or reduction instruction introduces a new instance of e.g. P , the computer takes a new index i and uses P_i . So again there is only one binder for each variable and thus I is satisfied. Possibility 4) is equal to II.1; and if one of the others holds then II.2 is satisfied: for 1) and 2) because of the definition of extension, for 3) because of meaning postulate 1.

10. CORRECTNESS PROOFS

10.1 THEOREM. $\{\vee^\alpha_\alpha\} A, i, j, g =_\alpha A, i, j, g$

PROOF. $\{\vee^\alpha_\alpha\} A, i, j, g = \{\wedge^\alpha_\alpha\} A, i, j, g(i, j) = \lambda k, l \alpha A, k, l, g(i, j) =_\alpha A, i, j, g$

10.2 REMARK. It is not in general true that $\{\vee^\alpha_\alpha\} A, i, j, g =_\alpha A, i, j, g$.

Let us introduce the logical constant *Bigboss*.

Its type is $\langle s, e \rangle$, and its extension for i and j is the individual concept on which the predicate *is the most powerfull man on earth*

applies in world i on moment j . Suppose that $Bigboss^{A, i, t_1, g} = \lambda i, j \text{ Ford}^{A, i, j, g}$, and $Bigboss^{A, i, t_2, g} = \lambda i, j \text{ Bresjnev}^{A, i, j, g}$. Now the

following holds: $\{\vee^{A, i, t_2, g}_{A, i, t_1, g}\} A, i, t_2, g(i, t_1) = \lambda k, l [Bigboss^{A, k, l, g}(k, l)](i, t_1) = Bigboss^{A, i, t_1, g}(i, t_1) = \text{Ford}^{A, i, t_1, g}$.
 But $Bigboss^{A, i, t_2, g}(i, t_1) = \text{Bresjnev}^{A, i, t_1, g}$.

10.3 CONVENTION. With δ is denoted the translation of a common noun other than *price* or *temperature*

10.4 CONVENTION. With $A, i, j, g \models \phi$ is meant $\phi^{A, i, j, g} = 1$. When A, i, j , and g are clear from the context we write $g \models \phi$.

10.5 THEOREM. Suppose w, x and $\hat{u}$ are of the same type, and ϕ does not contain binders for or occurrences of x and u . Then $g \models x = \hat{u}$ implies $g \models [x/w]\phi \iff g \models [\hat{u}/w]\phi$.

PROOF. Because of the definition of extension the following holds $g \models \lambda w[\phi](x) = \lambda w[\phi](\hat{u})$; and in this situation lambda conversion is allowed.

10.6 THEOREM. If $\exists s[x \rightarrow s]g \models \delta(x)$ then $\exists a[x \rightarrow s, u \rightarrow a]g \models x = \hat{u}$.

PROOF. From meaning postulate 2 and $[x \rightarrow s]g \models \delta(x)$ it follows that $[x \rightarrow s]g \models \forall u[x = \hat{u}]$. This means exactly what we have to prove.

10.7 THEOREM. Suppose the conditions of theorem 10.5 are satisfied. Then $g \models \Lambda x[x/w]\phi \Rightarrow g \models \Lambda u[\hat{u}/w]\phi$ and $g \models \forall u[\hat{u}/w]\phi \Rightarrow g \models \forall x[x/w]\phi$

PROOF. $\{s | s = \{\hat{u}\}^{A,i,j,g}\} \subset \{s | s = x^{A,i,j,g}\}$

10.8 THEOREM. $A, i, j, g \models \forall x[\delta(x) \wedge P\{x\}] \iff A, i, j, g \models \forall u[\delta(\hat{u}) \wedge P\{\hat{u}\}]$

PROOF. $\Leftarrow$: See theorem 10.7

$\Rightarrow$: The left hand side means $\exists s[x \rightarrow s]g \models \delta(x) \wedge P\{x\}$

with theorem 10.6 we conclude $\exists a[x \rightarrow s, u \rightarrow a]g \models x = \hat{u}$

now apply theorem 10.5, then $[x \rightarrow s, u \rightarrow a]g \models \delta(\hat{u}) \wedge P\{\hat{u}\}$

and, from definition of extension, $[x \rightarrow s]g \models \forall u[\delta(\hat{u}) \wedge P\{\hat{u}\}]$

finally, since x does not occur, $g \models \forall u[\delta(\hat{u}) \wedge P\{\hat{u}\}]$

10.9 THEOREM. $A, i, j, g \models \Lambda x[\delta(x) \rightarrow P\{x\}] \iff A, i, j, g \models \Lambda u[\delta(\hat{u}) \rightarrow P\{\hat{u}\}]$

PROOF. $\Rightarrow$: apply theorem 10.7

$\Leftarrow$: by contraposition. Suppose that it was not true that

$g \models \Lambda x[\delta(x) \rightarrow P\{x\}]$

this means that

$g \models \neg \Lambda x[\delta(x) \rightarrow P\{x\}]$

which is equivalent to

$g \models \exists x[\delta(x) \wedge \neg P\{x\}]$

Now we apply theorem 10.8 and find $g \models \forall u[\delta(\hat{u}) \wedge \neg P\{\hat{u}\}]$

therefore it is not true that $g \models \Lambda u[\delta(\hat{u}) \rightarrow P\{\hat{u}\}]$

10.10 THEOREM. $A, i, j, g \models \forall y [\Lambda x [\delta(x) \leftrightarrow x = y] \wedge P\{y\}] \Rightarrow A, i, j, g \models \forall u \Lambda u [\delta(\hat{u}) \leftrightarrow u = v] \wedge P\{\hat{u}\}]$

PROOF. The left hand side is equivalent to

$\exists s$ such that I: $[y \rightarrow s]g \models \Lambda x [\delta(x) \leftrightarrow x = y]$ and II: $[y \rightarrow s]g \models P\{y\}$

From I follows $[y \rightarrow s]g \models \delta(y) \leftrightarrow y = y$, so $[y \rightarrow s]g \models \delta(y)$.

Apply theorem 10.6 $\exists a [y \rightarrow s, v \rightarrow a]g \models y = \hat{v}$,

Substitution in II (theorem 10.5) gives III: $[y \rightarrow s, v \rightarrow a]g \models P\{\hat{v}\}$

Substitution in I and theorem 10.7 gives IV: $[y \rightarrow s, v \rightarrow a]g \models \Lambda u [\delta(\hat{u}) \leftrightarrow \hat{u} = \hat{v}]$

Since $\forall i, j \{ \hat{u} = \hat{v} \}^{A, i, j, g} = \{ u = v \}^{A, i, j, g}$ we may replace

$\hat{u} = \hat{u}$ by $u = v$ accordingly to section 8. The combination of III

with the result on IV of this replacement gives the right hand side.

10.11 THEOREM. $A, i, j, g \models \forall v [\Lambda u [\delta(\hat{u}) \leftrightarrow u = v] \wedge P\{\hat{u}\}] \Rightarrow A, i, j, g \models \forall y [\Lambda x [\delta(x) \leftrightarrow x = y] \wedge P\{y\}]$

PROOF. The left hand side is equivalent to

$\exists a$ such that I: $[v \rightarrow a]g \models \Lambda u [\delta(\hat{u}) \leftrightarrow u = v]$ and II: $[v \rightarrow a]g \models P\{\hat{v}\}$.

In I we replace $u = v$ by $\hat{u} = \hat{v}$ and obtain thus I':

Let us suppose that $[x \rightarrow s]g \models \delta(x)$.

Then (theorem 10.6 and 10.7) $\exists a_1 [x \rightarrow s, w \rightarrow a_1]g \models \delta(\hat{w})$

Use I': $[x \rightarrow s, w \rightarrow a_1, v \rightarrow a]g \models \hat{w} = \hat{v}$, so $[x \rightarrow s, w \rightarrow a_1, v \rightarrow a]g \models x = \hat{v}$

We have proved that $[v \rightarrow a]g \models \Lambda x [\delta(x) \rightarrow x = \hat{v}]$

On the other hand, suppose $[v \rightarrow a, x \rightarrow s]g \models x = \hat{v}$

then by I it follows that $[v \rightarrow a, x \rightarrow s]g \models \delta(\hat{v})$, so $[v \rightarrow a, x \rightarrow s]g \models \delta(x)$

Thus we proved $[v \rightarrow a]g \models \Lambda x [x = \hat{v} \rightarrow \delta(x)]$.

Combination with II and application of theorem 10.7 gives the desired result.

10.12 REMARK. The last four proofs also hold when $\delta(x)$ is replaced by $\delta(x) \wedge [\dots x \dots]$. So the correctness of the b version of reduction rules 13, 14 and 15 follows.

11. EXAMPLES

In this section I present several examples of the treatment of sentences (or parts thereof) as these have actually been executed by the computer. Based upon these examples some comments on PTQ and on the program are made.

EXAMPLE 1. The following sentence is generated

Mary is her and love John.

This sentence illustrates two syntactic inaccuracies of PTQ. Only the first verb has been conjugated, and *her* occurs instead of *herself*. The sentences generated by the computer demonstrate several syntactic inaccuracies. For instance, disjunction and conjunction cause trouble in combination with rules S5, S14 and S17. Since PTQ has already been studied for several years, it is not surprisingly that most of these inaccuracies are known (e.g. BENNETT(1974)). On the account of PTQ, the non-obvious inaccuracies discovered with the help of the computer are rather in the "logical" part, where the situation is less perspicuous. In checking extensions of PTQ the computer assistance appeared to be also useful for the syntax.

EXAMPLE 2. The following is a part of a generated structure.

woman

he₂ loves a woman

S3,2: *woman such that she loves a woman*

he₁ runs

S3,1: *woman such that she loves a woman such that she runs*

The last string can only be taken to be about a woman which loves a running woman. The structure however indicates that there are two relative clauses specifying a single head noun. One and the same woman is loving and running. Thus we note that applying the same syntactic rule several times in succession, can lead to incorrect results (the translation of the example above mentions one loving and running woman and not, as is desired, a woman loving a running woman).

EXAMPLE 3. Syntactic Structure Translation & Reduction

T:	<i>Mary</i>	T1d:	<i>Mary</i>
IV:	<i>run</i>	T1a:	<i>run'</i>
S4:	<i>Mary runs</i>	T4:	<i>Mary'*</i> (<i>run'</i>)
		R1:	$\lambda P P\{\wedge Mary'\}(\wedge run)$
		R8:	$\wedge run' \{\wedge Mary'\}$
		R2:	<i>run'</i> (<i>Mary'</i>)
		R4:	<i>run'</i> _* (<i>Mary'</i>)

This derivation is completely regular. The notational convention R4 has been used to introduce the _{*}. Also R11 was applicable; the choice depends on the order of the reduction instructions in the program. As first step, it is always tried to apply the notational conventions. The computer has also generated *ninety rises* with the same structure. Translation and reduction proceeds in exactly the same way: *rise'* (*ninety'*) is obtained and next R4 is applied. Thus we note that the formula in PTQ (p.268,+10) is not the final one.

EXAMPLE 4. Syntactic Structure Translation & Reduction

T:	<i>John</i>	T1d:	<i>John'</i> _*
IAV:	<i>slowly</i>	T1a:	<i>walk'</i>
IV:	<i>walk</i>	T1a:	<i>slowly'</i>
S10:	<i>walk slowly</i>	T10:	<i>slowly'</i> (<i>walk'</i>)
S4:	<i>John walks slowly</i>	T4:	<i>John'</i> _* ($\wedge [slowly'(\wedge walk')]$)
		R1:	$\lambda P P\{\wedge John'\}(\wedge [slowly'(\wedge walk')])$
		R8:	$\wedge [slowly'(\wedge walk')] \{\wedge John'\}$
		R2:	<i>slowly</i> (<i>walk'</i>) (<i>John'</i>)
		R3:	<i>slowly</i> (<i>John'</i> , <i>walk'</i>)

We notice that *slowly* is treated as a two place relation. This is clearly not intended in PTQ. If expressions of the category IAV are relations then so is *about a unicorn* in *John talks about a unicorn*. In PTQ(p.267,+13) we see that this is not meant. For this reason we have in the program as condition for R3 instead of " $\gamma(\alpha)(\beta)$ is a meaningful expression of type t" the condition " γ translates a verb and for this verb R3 has not yet been applied". So the computer does not perform anymore this reduction step in

unintended situations as above.

EXAMPLE 5. Syntactic Structure

Translation with immediate reduction

CN:	unicorn	T1a:	unicorn'
S2:	a unicorn	T2 :	$\lambda P_1 [\forall x_2 [\text{unicorn}'(x_2) \wedge P\{x_2\}]]$
T:	Mary	R13:	$\lambda P_1 [\forall u_2 [\text{unicorn}'(u_2) \wedge P\{u_2\}]]$
IV:	seek	R4:	$\lambda P_1 [\forall u_2 [\text{unicorn}'_*(u_2) \wedge P\{u_2\}]]$
T:	he ₁	T1d:	Mary'
S5:	seek him ₁	R1:	$\lambda P_2 [P_2\{\text{Mary}'\}]$
S4:	Mary seeks him ₁	T1d:	seek'
S14,1: Mary seeks a unicorn		T1e:	$\lambda P_3 [P_3\{x_1\}]$
		T5 :	seek'($\lambda P_3 [P_3\{x_1\}]$)
		T4:	$\lambda P_2 [P_2\{\text{Mary}'\}] (\text{seek}'(\lambda P_3 [P_3\{x_1\}]))$
		R8:	$\wedge [\text{seek}'(\lambda P_3 [P_3\{x_1\}])]\{\text{Mary}'\}$
		R2:	seek'($\lambda P_3 [P_3\{x_1\}]$) (Mary')
		R3:	seek'($\text{Mary}', \lambda P_3 [P_3\{x_1\}]$)
		T14:	$\lambda P [\forall u_2 [\text{unicorn}'_*(u_2) \wedge P\{u_2\}]] (\lambda x_1 [\text{seek}'(\text{Mary}', \lambda P_3 [P_3\{x_1\}])])$
		R8:	$\forall u_2 [\text{unicorn}'_*(u_2) \wedge \lambda x_1 [\text{seek}'(\text{Mary}', \lambda P_3 [P_3\{x_1\}])]\{u_2\}]$
		R2:	$\forall u_2 [\text{unicorn}'_*(u_2) \wedge \lambda x_1 [\text{seek}'(\text{Mary}', \lambda P_3 [P_3\{x_1\}])]\{u_2\}]$
		R8:	$\forall u_2 [\text{unicorn}'_*(u_2) \wedge \text{seek}'(\text{Mary}', \lambda P_3 [P_3\{u_2\}])]$
		R6:	$\forall u_2 [\text{unicorn}'_*(u_2) \wedge \text{seek}'_*(\text{Mary}', u_2)]$

In the translation of *a unicorn* the variable x_2 is used since x_1 was reserved for the translation of *he₁*. When the variable x_2 is replaced, its index, for technical reasons, is kept the same.

This example demonstrates how the computer obtain a reduced formula by applying conscientiously the reduction rules. It is an excellent tool for doing such tedious computations. There is an alternative version of the program which, instead of a generating syntactic structures, takes as its input (encodings of) syntactic structures. That version is used to compute, among others, the reduced formulas of eleven syntactic structures for *John tries to find a unicorn*. Four different formulas were actually obtained.

- I try to'($\wedge \text{John}'$, $\wedge \text{find}'(\wedge P \forall u [\text{unicorn}'_*(u) \wedge P\{u\}])$)
- II try to'($\wedge \text{John}'$, $\wedge \lambda y [\forall u [\text{unicorn}'_*(u) \wedge \text{find}'_*(y, u)]]$)
- III $\forall u [\text{unicorn}'_*(u) \wedge \text{try to}'(\wedge \text{John}, \wedge \text{find}'(\wedge P P\{u\}))]$
- IV $\forall u [\text{unicorn}'_*(u) \wedge \text{try to}'(\wedge \text{John}, \wedge \lambda y \text{find}'_*(y, u))]$

EXAMPLE 6. Generated sentence: *Mary is a woman*

Reduced formula : $\forall u[\text{woman}'_*(u) \wedge \text{Mary}' = u]$

In this situation we would do one traditional reduction step more and thus obtain $\text{woman}'_*(\text{Mary}')$. It is a shortcoming of the program that it does not account for this last step. The background for this is as follows. All the reduction rules are local (as explained in section 6). The reduction step under discussion however is not local. In order to decide whether a subformula $u = \text{Mary}$ implies that all occurrences of u may be replaced by *Mary*, the whole formula must be taken into account. If we had the connective " $\rightarrow$ " instead of " $\wedge$ " then we could not reduce the formula any further. To handle this case, we need a reduction rule of a new, complex kind. The same need arises in the following situation.

Generated sentence: *The fish loses the fish*

Reduced formula: $\forall v_1[\Lambda u_1[\text{fish}'_*(u_1) \leftrightarrow u_1 = v_1] \& \\ \cdot \forall v_2[\Lambda u_2[\text{fish}'_*(u_2) \leftrightarrow u_2 = v_2] \& \text{lose}'_*(v_1, v_2)]]$

This formula expresses that there is exactly one fish and that, this fish loses itself. The formula is equivalent to $\forall v_1[\Lambda u_1[\text{fish}'_*(u_1) \leftrightarrow u_1 = v_1] \& \text{lose}'(v_1, v_1)]$. Again, to make this step a non local verification must be made.

It would of course be possible to give two rules, treating these incidental problems; that would of course be an ad hoc solution. But as easily other constructions can be envisaged where non-local rules would be needed. A general solution to this kind of problems seems difficult to obtain, needing very powerful innovations.

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THE COUNTERFACTUAL READING OF BEFORE *

Peter Rolf Lutzeier

An adequate semantics for familiar systems in tense logic requires a structured set of moments, which is usually done by imposing a weak ordering on it. This ordering is normally supposed to reflect the intuitive idea of a 'before'-relation between moments. Obviously, this relation must be also quite useful for the description of before in sentences like

- (1) John brushed his teeth before he went to bed.

Roughly, assuming that the main clause refers to an event happening at t_1 and the before-clause refers to an event happening at t_2 , then a sentence like (1) should be true, if t_1 stands in the 'before'-relation to t_2 .

So, has not every further remark concerning before to be much ado about nothing? I do not think so, because what I have said up to now about before cannot be the whole story. That is pretty clear as soon as you look at sentences like

- (2) Peter's grandfather died before he saw him graduate

- (3) Wet surface? Slow down before you start water-skiing! (a slogan which you may find on motorways).

The events referred to in the before-clauses of these sentences did not happen, because they were prevented by the happening of the events referred to in the main clauses. Therefore, the truth conditions for these sentences cannot be simply expressed by means of the 'before'-relation. For easier reference let us call these cases 'counterfactual' and the former ones 'factual'.

I shall only deal with before as conjunction, so ignoring

* A more comprehensive version will appear in Linguistische Berichte under the title: Before again or it is worth looking into it, before you take before for granted.

before as preposition or adverb.¹ I shall further restrict myself to declarative sentences; i.e. sentences like (3) or

(4) Think before you speak

will not be treated.

If we compare before with the other subordinating temporal conjunctions like after, as/so long as, as/so soon as, once, since, till/until, when and while, then before is the only one where we find the phenomenon of a 'counterfactual' reading. That gives before its distinction, which should finally justify my more detailed investigation of before.

Sentences like

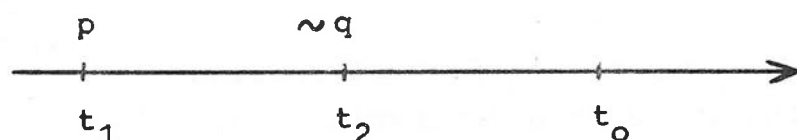
(5) John's wife shut up before John got mad at her²

are ambiguous. First, you can imagine the following situation: John's wife was talking quite a bit and he was getting increasingly annoyed about it. But after she stopped talking, he relaxed and so he did not get mad at her (compare figure 1). In other words that is a typical situation for the counterfactual reading.

Figure 1

$p := \text{John's wife shuts up}$; $q := \text{John gets mad at her}$;

t_0 moment of utterance



During her talking there was a chance that q and

$\forall t_2 \in [t_1, t_0] \sim q$.³

1 Compare R.Quirk/S.Greenbaum /GE/,p.155. You will find the semantics of before as preposition in E.König /TPE/,p.557.

2 Compare O.Heinämäki /B/,p.139.

3 The choice of this interval is an oversimplification. I shall say a bit more about this question later on.

Secondly, we can start with the same situation as before. The difference in the end is that after she stopped talking, John got mad at her. If you think this ending is very unlikely for sentence (5), then consider the following dialogue:

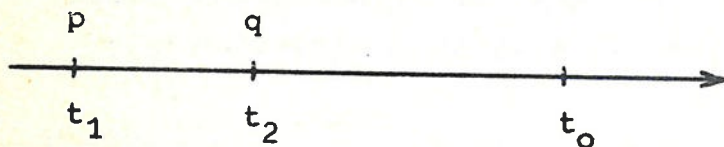
A: "What was the reason that John got mad at his wife?"

B: "Well, she was talking quite a bit and, you know, John doesn't like that at all. So he got increasingly annoyed about it and apparently he had already reached that point which drives you into the state of getting mad at someone, no matter what really happens. So he finally got mad at her, although she had stopped talking."

That shows that we get a factual reading for sentence (5) as well (compare figure 2).

Figure 2

$p := \underline{\text{John's wife shuts up}}$; $q := \underline{\text{John gets mad at her}}$;
 t_0 moment of utterance



The explanation of the factual reading should not be too difficult, whereas we can expect some problems with the counterfactual reading. Therefore, I shall mainly concentrate on this reading.

Naturally, being able to reduce the counterfactual reading somehow to the factual reading would be a desirable thing. So, is the counterfactual reading paraphraseable by means of the factual case?

For a start, using the subjunctive in the before-clause sounds like a promising attempt. Unfortunately, we do not get too far, because sentence (6)

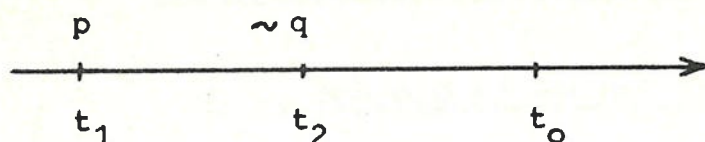
(6) John's wife shut up before he could have got mad
at her

is ambiguous too. Especially, the counterfactual reading even sounds more natural than the factual one (compare figure 3).

Figure 3

$p := \underline{\text{John's wife shuts up}}$; $q := \underline{\text{John could get mad at her}}$;

t_0 moment of utterance



During her talking there was a chance that q and

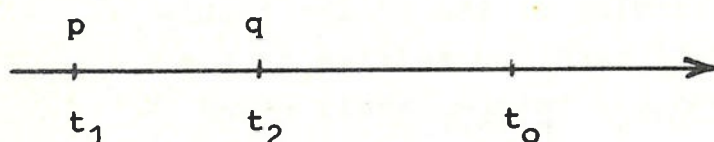
$\forall t_2 \in [t_1, t_0] \sim q$.

Anyway, the factual reading of sentence (6) (compare figure 4) is not synonymous to the counterfactual reading of sentence (5), because the first one entails that during her talking John could not get mad at her, whereas there is a chance that during her talking he gets mad at her in the counterfactual reading of sentence (5).

Figure 4

$p := \underline{\text{John's wife shuts up}}$; $q := \underline{\text{John could get mad at her}}$;

t_0 moment of utterance



q does not entail John does not get mad at her.⁴ The factual reading of sentence (6) also suggests that after she stopped talking something else happened which made John feel like getting mad at her.

We can conclude from this discussion that the choice of the subjunctive in the before-clause does not desambiguate the whole sentence (compare sentence (6)).

If we introduced the explicit negation in the before-clause, then this would not be of any help either. At least I have not found any acceptable sentence of such type. Compare sentences (7), (8), (9) and (10):

(7) * John's wife shut up before he did not get mad at her

⁴ I refer for problems of the subjunctive to M. Grabski /K/ or especially for könnte to his doctoral thesis /MV/.

- (8) * Sue died before she did not succeed in finishing
her autobiography
- (9) * Bill smoked his last cigarette before he did not
smoke any more
- (10) * John brushed his teeth before he did not go to
the theatre.

Why are these sentences odd? I do not know. Perhaps Gricean postulates do come in, because it seems to be more relevant to tell what was really going on instead of telling what did not happen.

Nevertheless, implicitly negative before-clauses are acceptable. Take, for instance, sentence (11) in comparison with sentence (9):

- (11) Bill smoked his last cigarette before he stopped
smoking.

In the end before must bear the ambiguity in a sentence like (5). So, with the normal understanding of the notion 'ambiguity' within a grammar we have to make two entries in the lexicon for before: before_f, before_c. before_f shall stand for the factual reading and before_c for the counterfactual one.

No doubt, for some sentences only the counterfactual reading is sensible, e.g. Heinämäki's example

- (12) Sue died before she succeeded in finishing her
autobiography.

However, these intuitions instead provide some adequacy criteria for our grammar. The sentence (12) in the factual reading should be senseless. This result will be guaranteed as soon as we establish something like 'meaning postulates' for to die to the effect that, at least on this world, you cannot do anything any more after your death.

Are there sentences for which only the factual reading is sensible? To find one, we have to look for some events which necessarily cause other events. However, such events

do not seem to exist.

These reflections suggest that both readings are related as follows: A before-sentence which allows a factual reading allows a counterfactual one too, but not the other way round.

Syntax

From the syntactic point of view we deal with the general pattern: sentence before sentence; i.e. before is a two-place sentential operator. There remains only one important syntactic question: Which combinations of tenses are grammatical?

To summarize it in a syntactic rule means roughly the following: If the before-clause is in Present tense, then the main clause is either in Present tense or Future tense and if the before-clause is in Past tense, then the main clause is in Past tense as well.⁵

Semantics for the factual reading

What do we expect from a sentence like (1)? Certainly, it should entail, for instance, sentences (13) and (14):

(13) John brushed his teeth

(14) John went to bed.

Sentence (14) is even a presupposition of sentence (1) as sentence (15) shows:

(15) It is not the case that John brushed his teeth
before_f he went to bed.

This derives from the fact that sentence (15) entails sentence (14) too.

We want sentence (15) to be true just in case John had not brushed his teeth up to the time he went to bed. So intuitively, sentence (15) should be synonymous to sentence (16):

⁵ As we shall see later on, the construction of the before-clause in the first place is suggested by semantic consideration.

- (16) John did not brush his teeth before_f he went to
bed.

In general, the negation of a before-sentence is synonymous to a before-sentence consisting of the negated main clause of the former before-sentence and the same subordinate clause as the former one, i.e.

$\sim(\text{sentence}_1 \text{ before }_f \text{ sentence}_2) \text{ syn } (\sim \text{sentence}_1) \text{ before }_f \text{ sentence}_2.$

The presupposition (14) plays the following role: If it refers to an event happening at t , then you have to check if John brushed his teeth up to this moment t .

Our example shows as well that we are mostly concerned with a certain limited period of time. For instance, in the case of sentence (1) we cannot start with John's birth but we have to restrict ourselves to the evening of the day. I am afraid at the moment I cannot say much more about the underlying principles for these restrictions. Nevertheless, we found here another instance of the general principle for temporal and local expressions, namely, that you have to keep to the framework established by the context.⁶

The fact that we got the before-clause as presupposition explains why we started with it in our syntactic rule. As soon as we know this presupposition, the 'allowed' sentences for the main clause are more or less determined; they are just the ones which refer to an event happening earlier than the event referred to by the presupposition.

I cannot spend more time on the factual reading. What we got is roughly the following: In addition to the 'before'-relation between the main clause and the subordinate clause we get the subordinate clause as presupposition for the factual reading.

Semantics for the counterfactual reading

Sentence (12) entails, for instance, sentences (17) and (18):

- (17) Sue died

⁶ Compare P. Lutzeler /AW/, p. 42, 43.

(18) She did not succeed in finishing her autobiography.

Although we accepted that sentence (12) only allows the counterfactual reading, we have to notice that sentence (19) is ambiguous again.

(19) It is not the case that Sue died before she succeeded in finishing her autobiography.

In the factual reading it is simply denied that Sue died up to the moment she finished her autobiography, whereas in the counterfactual reading it is denied that Sue's death was the reason that she could not finish her autobiography. So, if we stick to the counterfactual reading, then we get sentence (18) as an entailment from sentence (19). That means here, contrary to our previous discussion of the factual case, that the fact of getting the negation of the before-clause as a presupposition for sentence (12) is more or less the result of our stipulation. Nevertheless, it seems to be a plausible stipulation.

Normally, the negation of the before-clause does not have the strength of an absolute negation, i.e. that the event expressed by the before-clause has never happened or will never happen. Take, for instance, sentence (5) in its counterfactual reading. Presumably, there have been occasions when John got mad at his wife. Not only before she shut up, but later on too. Just imagine that she dropped the whole coffee service the next day. Then sentence (5) is still true for the counterfactual reading because his getting mad at her has nothing to do with her talking the day before.

The problem is even more obvious for before-sentences in Future tense, e.g.

(20) Going out with John means that he will grab me before I run in a car.

From this sentence it does not follow that I shall never run in a car.

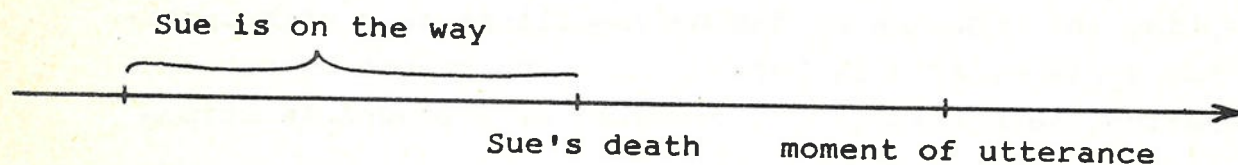
The same arguments hold for the Future tense and Present tense. Compare the examples (21) and (22):

- (21) ===== You will end up being mad before ===== you get your
===== D.Phil.
=====
- (22) ===== We are having terrible fog before ===== we start
===== driving.
=====

What we have found up to now is certainly not the whole story about the counterfactual reading. We still have to get much more insights before we can seriously discuss truth conditions.

If we take our sentence (12), then intuitively the following happened: Sue was on the way of finishing her autobiography. However, her death prevented her from continuing her writing (compare figure 5).

Figure 5



Are there more verbs besides to die which yield absolute certainty about the negation of the before-clause? Basically all verbs or verbphrases which make a definite end to a certain process belong to that category. Compare sentences (23) and (24):

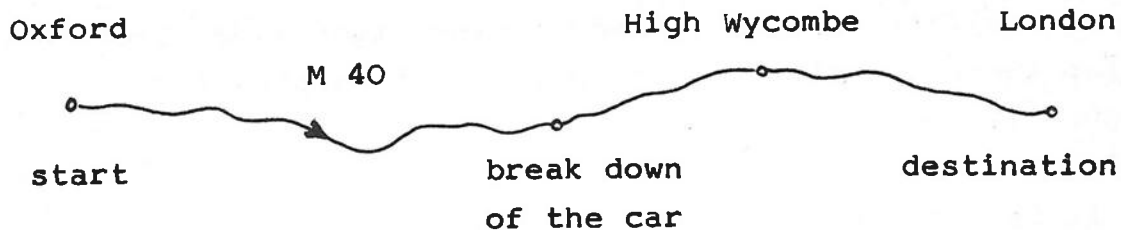
- (23) ===== Dave stopped reading the newspaper and burnt it
===== before ===== he reached the sportspages
=====
- (24) ===== John left the university and never came back before =====
===== he got his degree.
=====

These sentences have in common that the corresponding before-sentence in the factual reading is senseless.

The happening of the event to which the main clause refers might prevent the happening of many events. May every sentence which refers to one of these events occur in the before-clause? Imagine the following situation (called S 1): We started in Oxford and we were driving on the M 40 heading for London. We got a break down on the way which made it impossible to get

down to London. The weather conditions were really good all the time (compare figure 6).

Figure 6



Compare the following sentences:

- (25) Our car broke down before we reached London
 (26) Our car broke down before we reached High Wycombe
 (27) Our car broke down before we reached Stratford-upon-Avon.⁷

No doubt, the break down of our car prevented the reaching of a lot of places, e.g. Stratford-upon-Avon. However, we never intended to go on that particular ride to Stratford; simply we were not on the way to Stratford. So with regard to S 1 sentences (25) and (26) should come out true, whereas we would like to have sentence (27) senseless. By the way, there is no point in attaching falsehood to such cases.

In other words, we found another presupposition for a before-sentence in the counterfactual reading: If the main clause refers to an event happening at a moment t , then at this moment the course of events must still have been towards the happening of the event referred to in the before-clause. This total lack of any chance for getting to Stratford at the moment of the break down makes sentence (27) senseless.

I shall test this 'being on the way' of the before-clause in the before-sentence ($X\varphi$ before $X'\psi$) by means of the following counterfactual ('being on the way' counterfactual):

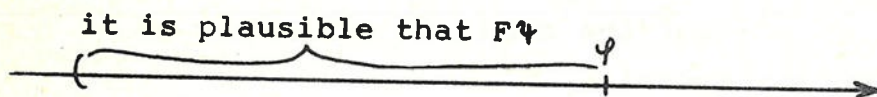
If it were not the case that φ , then it would be the case that ψ , evaluated at the moment when φ happens. We ask for ψ with the evidence available at the moment when φ happens. So

⁷ Stratford-upon-Avon does not lie on the M 40. It is situated in the north-west of Oxford.

it is at that time simply a test if Ψ is still a plausible outcome.

More precisely we should take an interval into account which is open on the left side and closed on the right side. The border for the right side is the time when Ψ happens (compare figure 7).

Figure 7



The 'being on the way' does not always have anything to do with intentions, as the following example shows:

(28) Jim caught Helen before she fell into the river.

Obviously, Helen did not intend to fall into the river.

Nevertheless, she was on the way of falling in the river.

Before we can continue with our questions about before_C, I briefly have to make some remarks on the semantics of counterfactuals. Åqvist and Lewis both gave similar analyses of the counterfactual $A \Box \rightarrow C$.⁸ According to Lewis the truth conditions for $A \Box \rightarrow C$ are as follows:

$\|A \Box \rightarrow C\|_i = 1$ iff some (accessible) AC-world is closer to i than any $A \sim C$ -world, if there are any (accessible) A-worlds.

He accepts a centering assumption, i.e. each world i is accessible from itself, and closer to itself than any other world is to it. This assumption validates automatically the following rules:

(-) $\frac{A, \sim C}{\sim(A \Box \rightarrow C)}$; (+) $\frac{A, C}{A \Box \rightarrow C}$

Åqvist gives a convincing argument for rejecting rule (+), which is based on the fact that the true conjunction may well be accidental.⁹ Actually, Lewis is able to weaken his centering assumption to: Each world is self-accessible and at least as close to itself as any other world is to it, which has the

8 L. Åqvist /SC/, D. Lewis /CF/. $A \Box \rightarrow C$ is to be read: if it were the case that A, then it would be the case that C.

9 Compare L. Åqvist /SC/, p.25ff.

effect that it invalidates the rule (+) but keeps the rule (-). However, I shall not bother about the weaker system, because for my purpose here it will be more important to modify the analysis on a deeper level.

Åqvist and Lewis totally ignored tense problems involved in connection with counterfactuals. This fact diminishes the importance of their analyses for a treatment within natural language in general and especially for our purposes as we saw already, when I formulated our counterfactual for the 'being on the way' process of the before-clause.

So, I will give a more or less ad hoc proposal for the incorporation of tenses, which nevertheless should do for a start. We are concerned in this paper with before, therefore there is no point in discussing the proposal's 'merits' here. We shall have to deal with two patterns:

$A \Box \rightarrow C$: if it were the case that A, then it would be the case that C.

$PA \Box \rightarrow PC$: if it had been the case that A, then it would have been the case that C.

My modified versions of Lewis' truth conditions are as follows: The accessibility relation and the closeness relation are both dependent on time.

$\|A \Box \rightarrow C\|_{\langle i_0, t_0 \rangle} = 1$ iff some (at t_0 accessible) world i_1 s.t.
 $\|A \wedge FC\|_{\langle i_1, t_0 \rangle} = 1$ is closer to i_0 at t_0 than any world i_2 s.t.
 $\|A \wedge \sim FC\|_{\langle i_2, t_0 \rangle} = 1$, if there are any (at t_0 accessible) worlds i s.t.
 $\|A\|_{\langle i, t_0 \rangle} = 1.$ ¹⁰

10 I ignore here a possible Present tense reading for the consequent C. Compare: If I had 5 million pounds, I would be happy.

$\|PA \Box \rightarrow PC\|_{\langle i_0, t_0 \rangle} = 1$ iff some (at t_0 accessible) world i_1
 s.t. $\|P(A \wedge FC)\|_{\langle i_1, t_0 \rangle} = 1$ is closer
 to i_0 at t_0 than any world i_2 s.t.
 $\|P(A \wedge \sim FC)\|_{\langle i_2, t_0 \rangle} = 1$, if there are
 any (at t_0 accessible) worlds i s.t.
 $\|PA\|_{\langle i, t_0 \rangle} = 1$.

By the way, an attempt to define $PA \Box \rightarrow PC$ as $P(A \Box \rightarrow C)$ is untenable. Roughly, the truth conditions for $PA \Box \rightarrow PC$ must appropriately reflect the relations to the speech point.

We can check the 'being on the way' of the before-clause by means of our established counterfactual. Another test we still have to make is, if the main clause was the 'real' reason which prevented the outcome of the before-clause. In other words, is the event referred to in the main clause the cause for the effect of the non-outcome of the event referred to in the before-clause?¹¹

Lewis gives a test for causal dependence:¹² If x is an event and $O(x)$ the proposition that x itself occurs, then: e depends causally on c iff $O(c) \Box \rightarrow O(e) \wedge \sim O(c) \Box \rightarrow \sim O(e)$, or in his words: iff "the family $O(e), \sim O(e)$ depends counterfactually on the family $O(c), \sim O(c)$ " (p.186). Therefore according to Lewis'

11 If the temporal relation between cause and effect were reversible, then we would have a counterfactual reading for after as well. The happening of the event referred to in the main clause would provide the explanation for the failure of the outcome of the event referred to in the after-clause, although the first one happened later than the second one was due to.

12 See D.Lewis /C/, p.186ff.

proposal, we want in our case $X\varphi$ before_C $X'\psi$ that the family $\sim X\psi, X\psi$ depends counterfactually on the family $X\varphi, \sim X\varphi$, i.e. it looks like we would have to add the two counterfactuals:

$$X\varphi \Box \rightarrow \sim X\psi$$

$$\sim X\varphi \Box \rightarrow X\psi.$$

But one realizes fairly soon that we cannot get very far with them. First, we are only interested in the question, if the event referred to in the main clause is the 'real' cause or not under the assumption that it really happened. That means that the first counterfactual $X\varphi \Box \rightarrow \sim X\psi$ is superfluous for our purpose, because this counterfactual is true anyway according to rule (+). Secondly, the second counterfactual $\sim X\varphi \Box \rightarrow X\psi$ cannot be of much help either. Imagine the following situation (called S 2):

We started in Oxford and we were driving on the M 40 heading for London. We got a break down on the way, which made it impossible to get down to London. There had been very good weather conditions till about an hour after the break down. Then suddenly fog and snow started coming up and stopped all the traffic. As you may have realized S 2 is a modified version of S 1. If we apply now the second counterfactual to our sentence (25), then we get sentence (29):

(29) If our car had not broken down, then we would have reached London,

which comes out false assuming S 2. Nevertheless, sentence (25) should come out true under S 2; the car's break down was the 'real' reason for our failure to reach London. So we have to look for a substitute of the second counterfactual.

I guess the intuitive idea is that we simply forget about all other events which might have influenced the course of events and under this assumption check if the event referred to in the main clause is the 'real' cause or not. Although we normally know what was going on in between, we are only interested in the relation between φ and ψ . So we should establish a kind of idealized situation or lab-situation.

I suggest for this task the following counterfactual (counterfactual for 'causal dependence'):

It is not the case that if it had been the case that φ and nothing else had influenced the course of events, then it would have been the case that ψ , which applies for the before-sentence in Past tense or

It is not the case that if it were the case that φ and nothing else influenced the course of events, then it would be the case that ψ , which applies for the before-sentence in Present tense and Future tense.

You may ask why not rather choose the following counterfactual:

If it had been the case that φ and nothing else had influenced the course of events, then it would not have been the case

that ψ ? Assume a situation where actually nothing else happened. Then rule (+) applies, which means that we get the possibility of changing its truth value by the indicated weakening of Lewis' system, whereas I think that the truth value should remain constant under the weakening. That is precisely guaranteed for my proposal.

We are prepared now to put our insights about the counterfactual reading together into its truth conditions:

For all $i_0 \in W$, $t_0 \in T$:

$$\begin{aligned} \|X\varphi \text{ before } X'\psi\|_{\langle i_0, t_0 \rangle} = 1 \text{ iff } \|X(\varphi \wedge EF\sim\psi)\|_{\langle i_0, t_0 \rangle} = 1^{13} \wedge \\ \wedge \|X[\varphi \wedge (\sim\varphi \Box \rightarrow \psi)]\|_{\langle i_0, t_0 \rangle} = 1 \wedge \\ \wedge \|\sim[[X'(\varphi \wedge \text{nothing else influences the course of events})] \\ \Box \rightarrow X'\psi]\|_{\langle i_0, t_0 \rangle} = 1 \end{aligned}$$

13 EF is the expanded form operator. $\|EF\varphi\|_{t_0} = 1$ iff

$\exists t_1, t_2 \in T (t_1 < t_0 \wedge t_0 < t_2 \wedge \forall t \in (t_1, t_2) \|\varphi\|_t = 1)$. Compare

E.König/P.Lutzeier /EF/.

$$\begin{aligned}
& \|X\varphi \text{ before } X'\psi\|_{\langle i_0, t_0 \rangle} = 0 \text{ iff } \|X(\varphi \wedge EF \sim \psi)\|_{\langle i_0, t_0 \rangle} = 1 \wedge \\
& \wedge \|X[\varphi \wedge (\sim \varphi \Box \rightarrow \psi)]\|_{\langle i_0, t_0 \rangle} = 1 \wedge \\
& \wedge \| \sim [[X'(\varphi \wedge \text{nothing else influences the course of events})] \\
& \quad \Box \rightarrow X'\psi]\|_{\langle i_0, t_0 \rangle} = 0 \\
& \|X\varphi \text{ before } X'\psi\|_{\langle i_0, t_0 \rangle} = s \text{ iff } \|X(\varphi \wedge EF \sim \psi)\|_{\langle i_0, t_0 \rangle} = 0 \vee \\
& \vee \|X[\varphi \wedge (\sim \varphi \Box \rightarrow \psi)]\|_{\langle i_0, t_0 \rangle} = 0 \\
& X \in \{P, F, \emptyset\}, X' \in \{P, \emptyset\}.^{14}
\end{aligned}$$

In other words, the main clause, the negation of the subordinate clause restricted to a certain amount of time and the 'being on the way' counterfactual are presuppositions, whereas the counterfactual for the causal dependence decides finally about the truth value.

Obviously, we need the statement about the negation of the before-clause and the counterfactual for causal dependence. But could we do without the 'being on the way' counterfactual? No, it is an essential part, because if we had not the 'being on the way' counterfactual, then sentence (30)

(30) We had terrible fog and snow before we reached
London

would be true for S 2.

The formula $X(\varphi \wedge EF \sim \psi)$ amounts to the following: If φ expresses an event happening at t , then $\sim \psi$ is true at all times t' contained in an open interval around t .

Of course, the expression 'nothing else influences the course of events' needs its own investigation. It seems to act as a two-place operator, because 'else' refers to φ and 'the course of events' is related to ψ .

14 P stands for Past tense (it was the case that ...), F stands for Future tense (it will be the case that ...) and $\emptyset$ stands for Present tense.

In the normal case when we have only the one event referred to in the main clause and which really prevents the other one referred to in the before-clause our counterfactual for causal dependence gets the same truth value as $\sim (X'\varphi \Box \rightarrow X'\psi)$ which is equivalent to $\sim X'\varphi \Box \rightarrow X'\psi$, all under the assumption that our presuppositions hold. But the last mentioned counterfactual is just the important part of Lewis' test and Heinämäki's proposal for the counterfactual reading of before as well.

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MISUNDERSTANDING UNDERSTOOD SUBJECTS: THE MINIMAL DISTANCE PRINCIPLE IN MONTAGUE GRAMMAR

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1. Introduction

The aim of this contribution is to review two attempts at solving the 'control problem' (term from Postal 1970) that have recently been made within the framework of Montague grammar, Partee (1975a) and Thomason (1974a). As its intention is essentially a critical one, it might incur blame for criticising without proposing something better. Undeservedly, it seems to me; for not only do I find such largely negative criticism quite worth while in general and especially at the present stage of the development of Montague grammar, I also hope that something better than the 'solutions' under review is indeed being offered here, viz. some clarification of the nature of the control problem.

In conformity with the fragment-constructing and expanding methodology familiar from Montague grammar, the following pair of English sentences ought to suffice as an empirical point of departure.

(1) The Queen promised the dean to eat sardines.

(2) The Queen permitted the dean to eat sardines.

Despite the apparent surface-structural parallelism, (1)-(2) constitutes a minimal pair, which is brought out clearly by such superficially more explicit paraphrases as (1') and (2').

(1') The Queen said to/promised the dean something, viz. that she, the Queen, would eat sardines.

(2') The Queen said to/permitted the dean something, viz. that he, the dean, could eat sardines.

In (1) it is the matrix subject, and in (2) the matrix object, that is interpreted as 'coreferential' with the understood (underlying, according to a deletion approach) subject of the infinitival complement. A minimal criterion for any alleged solution of the control problem, therefore, is whether it can provide a description and an explanation of the different identity relations in (1)-(2) and similar constructions. (1') and (2')

also expose different modal interpretations of the infinitives in (1)-(2), which distinctive feature has lead Postal (1970) to suggest that the identification of understood complement subjects is contingent upon modal constraints imposed by certain matrix verbs. The overall explanatory value of such a correlation would merit closer scrutiny, but here it is more appropriate to begin with delineating a more comprehensive frame of reference for the ensuing discussion. In my opinion, these are fundamental parameters of understood-subject identification:

- a) What is the rôle of (the meaning of) matrix verbs?
- b) Does the restructuring of matrix and complement clauses (e.g. by means of passivisation) exert any influence?
- c) What is language-specific and what universally invariant about solving the control problem?

Other questions, which can only be touched upon more or less in passing, if at all, concern the contribution of semantic features of the complement clause, the relation between infinitival and gerundial complements, between complement and non-complement constructions (such as adverbial infinitives or participial clauses), and the contingency of understood-subject identification upon pronominalisation. All these questions serve to reveal the contours of the control problem; and all of them have to be answered by a genuine solution, either explicitly or by implication. Limitations of the scope of the present paper should not be taken to reflect the relative significance of individual concomitants of the control problem; it should become clear, however, that a 'solution' that merely 'works' as far as the description of a fragment of English consisting of (1)-(2) is concerned, may yet fall short of justifiably more exacting expectations.

In trying to find out how the two Montague-grammar solutions available fare on these criteria, some attention will be focused upon three issues: firstly, the internal soundness of their argumentation; secondly, the actual relationship to the one particular ready-made transformational solution they wish to model themselves after, Rosenbaum's (1967; 1970) Minimal Distance Principle (henceforth: MDP); and thirdly, the empirical status of some basic premises of both the MDP and its purported Montague-grammar analogues.

2. The Starred-Variable Convention

According to Partee (1975a), who closely follows the lead of Montague (1974a), subjectless infinitival verb phrase complements are of the same syntactic category (viz. IV = t/e) and semantic type as ordinary intransitive verb phrases. They are governed by such matrix verbs of category IV//IV as try to and wish to. It was not without reason, however, that most transformational accounts had sought to associate infinitival complements with the category of sentences. If the former are derived from the latter, the agreement of reflexive pronouns, for instance, naturally follows from the purported generalisation that reflexivisation (in English) operates within clause boundaries, upon the further condition, of course, that complement subject deletion does not precede reflexivisation:

- (3)a. Mr Heath tries (to) [Mr Heath pleases himself/*herself/*themselves]
 b. Mr Heath tries to please himself/*herself/*themselves.

For similar reasons Partee wants to improve upon Montague's (1974a) original grammar fragment, which does not generate such complements as in (3b), by also deriving IV-phrases from t-phrases (sentences or formulae). (4) exemplifies Partee's (1975a:265) syntactic rule of subject-variable deletion and antecedentless-pronoun starring and the concomitant addition of an abstraction operator to the formula in the translation into intensional logic.¹

- (4) $F_{21,0}(\text{he}_0 \text{ pleases him}_0 \text{ self}) = \text{please him*self}$
 translation (simplified): $\lambda x_0 \text{ please}'(x_0, x_0)$

A 'syntactic metarule' (Partee 1975a:266) then guarantees the appropriate surface gender form of pronouns previously represented by starred variables:

- (5) Whenever any syntactic rule applies to two (or more) arguments such that one is a T-phrase and one contains a starred variable, replace all occurrences of the starred variable by pronouns of the appropriate gender.

To return to (3b), after try to has been combined with the derived IV please him*self, the subject term Mr Heath (category t/IV) combines with the complex IV-phrase try to please him*self, at which stage convention (5) ensures the desired gender agreement of the reflexive pronoun.

One apparent drawback of Partee's analysis could be disregarded at least by those who do not mind the availability of constructional ambiguities without semantic consequences, viz. the indeterminacy as to which IV-phrases are directly generated in categorial syntax and which ones are t-

derived. What is more important is that (5) lacks any semantic consequences; if there is no starred variable, as in (6), nothing at all happens.

(6) Mr Heath wishes to stay/please Mrs Keith.

Semantically all IV-phrases alike are said to designate properties, and matrix IV//IV-verbs, roughly, relations between individuals and these properties. Even without overt clues due to the operation of (5), there prima facie is not much of a choice, then, as to who is to be the bearer of the properties of staying or pleasing Mrs Keith if Mr Heath's wishes should come true; of course Mr Heath himself. Partee's analysis seems to suggest that this is so by default: the matrix subject is after all the only T-phrase present in the matrix clause. This reliance upon manifest T-phrases, however, presents difficulties as soon as such IV//IV-matrix verbs as advise, advocate, recommend, propose and say are taken into account. Convention (5) certainly yields wrong results, whereas the right ones are sometimes more delicate to determine:

- (7)a. I don't advocate/advise pleasing *myself/oneself/yourselves/ourselves.
b. The Queen said to stay here until 9 pm and to enjoy *herself/?one-
self/?yourselves/?ourselves.
c. The Queen proposed to please herself/?themselves/?oneself/?ourselves.

Although it could conceivably be argued, on the surface analogy with try to and wish to in (3b) and (6), that advise, say etc. are also to be interpreted as relations between individuals, denoted by the matrix subjects, and properties, these advising, commanding, proposing individuals are not (necessarily, cf. 7c) identical with the understood complement subjects.

Secondly, the default option would also seem to be precluded in a configuration with two matrix T-phrases, as in the minimal pair (1)-(2), where in the presence of a starred variable convention (5) could potentially get more than one chance to apply. But upon a suggestion of Thomason's, details of which will be discussed in §3, Partee assigns basic verbs like permit to to the category TV/IV, and verbs like promise to to (IV//IV)/T, which guarantees the appropriate agreement of reflexives by exploiting the differently ordered combinatory steps, as construction trees (8) and (9) illustrate.

(8) the Queen permits the dean to please himself, t
the Queen, T permit the dean to please himself, IV (5 applies here)
permit to please him*self, TV the dean, T
permit to, TV/IV please him*self, IV

- (9) the Queen promises the dean to please herself,
the Queen,T promise the dean to please himself, IV (5 applies here)
promise the dean to, IV//IV please himself, IV
promise to, (IV//IV)/T the dean.T

What is less obvious is whether the different orders of T introduction induced by different matrix-verb categories do have any semantic repercussions, irrespective of the lexical meaning of these matrix verbs. Is there a way to infer from (8) that the dean is going to be the bearer of the property of pleasing himself if the Queen's permit is taken advantage of, and from (9), that the property of pleasing herself will have to be ascribed to the Queen if her promise is kept? According to Partee (1975a: 266) apparently not, since no further semantic need is recognised to keep track of the free variables of the underlying complement clause (or formula) after the abstraction operator has bound them (cf. 4). In the intensional-logic translation of (8) and (9), this abstraction operator cannot possibly be eliminated by means of lambda conversion as there are no arguments belonging to the lambda expressions. Constructional syntactic disparities notwithstanding, the property designated by the complement can not be linked with the appropriate individual, because apart from the surface phenomenon of reflexive-agreement there is no semantically relevant interrelation or interaction (e.g. lambda convertibility or variable identity) between the complement and the expression that contains it as a constituent part, according to Partee's analysis. For this reason it presumably has to be due to the lexical content of the matrix verbs promise to and permit to, rather than due to their syntactic categories, that the identity of understood complement subjects can be recovered. That the crucial point is indeed the conceptual understanding of what a promise or a permit is, seems to be confirmed by the corresponding nominalisations:

- (10) Mr Heath's permit to please *himself/herself surprised Mrs Keith.

- (11) Mr Heath's promise to please himself/*herself surprised Mrs Keith.

Here permit and promise are no longer verbs, and the order of independent T-phrase introduction certainly fails to associate the understood subject with Mrs Keith in (10); nevertheless, (10)-(11) is entirely parallel to (8)-(9) with respect to understood-subject identity and also reflexive-agreement.

In conclusion of this section, I would like to draw attention to a distinction that Partee (1975a:213 Fn.14) has emphasised in another con-

text, but that is highly pertinent also to the control problem:

It is necessary, though extremely difficult, to make a careful distinction between semantic properties of constructions and semantic properties of individual lexical items. For instance, in order to argue that the different semantic properties of persuade and expect in NP+infinitive constructions involve two different syntactic constructions, it is necessary to show that the differences cannot be attributed simply to the difference in meaning of persuade and expect.

If it should turn out that the control problem can be successfully approached on the basis of the meaning of individual, or groups of, lexical items, stronger and independent evidence is required to support the categorial-syntactic distinction advocated by Partee (and also Thomason), if, that is to say, such a distinction is at all necessary any longer. Within Partee's own framework, it at least does not evidently contribute to a solution of the semantic aspect of the control problem.

3. The Principle of Immediate Variable Binding

A brief sketch of G. Bech's (1955) early treatment of the control problem forms a convenient transition to the assessment of Thomason's (1974a) proposal. Like Partee, Bech (1955:31-42) observes that there may be overt distributional reflexes of an otherwise covert, though intuitively recognised, difference, reflexivisation in the complement thus being a kind of operational test to help expose it. Certain co-occurrence restrictions between (understood) subjects and predicates can be utilised similarly:

(12) The Queen *promised/permitted the deans to meet.

But unlike Partee, who exclusively deals with these superficial regularities (by means of convention (5)), Bech (1955:82-5) recognises them as epiphenomena and introduces the genuinely semantically motivated concept of 'orientation' of the infinitive or participle as a conditioning factor. This orientation, i.e. the anaphoric linking of understood subjects to matrix or other term phrases, is to be determined by a separate set of general identification or sort of coreference-assignment rules that mainly hinge upon a characteristic feature of matrix verbs; viz. the dative or accusative case specification of the object governed by them.² What is important to realise is that the necessity of such semantically relevant rules is acknowledged by Bech; as they stand, the rules themselves clearly

are empirically deficient, or have 'exceptions'. Contrary to Bech's orientation rule no. 4, for instance, dative matrix objects need not necessarily be the term phrase understood complement subjects are referentially orientated towards:

(13)(=2) Die Königin versprach dem Dekan (DAT), Sardinien zu essen.

Moreover, as morphological case frames of verbs in German are to a considerable extent idiosyncratic and unpredictable, such rules may still fail to reveal a deeper semantic generalisation that would probably also be better suited for purposes of inter-language comparison.

In order to achieve a similar effect as Bech's orientation rules, Thomason (1974a) employs the same device that was semantically redundant in Partee's analysis, viz. distinct syntactic categorisations of matrix verbs. Unlike Montague and Partee, Thomason does not recognise IV-type complements but introduces instead a syntactic category of abstract phrases ($AB = t/e$), which is involved in the construction of finite and infinite complements alike and, optionally, also of non-complex sentences. As a side-effect, this move resolves the indeterminacy as to whether infinitival complements are t -derived or not. There is a further entirely parallel, though syntactically distinct, category of infinitival complements $INF (=t//e)$, which, as AB , is without basic elements.³ The following two kinds of complementisers are required to form in turn abstract-phrases from t -phrases, and INF -phrases from abstracts:

- (14)a. $AB/t = (t/e)/t$ basic elements: $\{that_0, that_1, \dots\}$
 b. $INF/AB = (t//e)/(t/e)$ basic element: $\{to\}$

Consequently, instead of the IV-taking matrix verbs of Partee (1975a), Thomason has INF -taking but otherwise analogous ones:

- (15)a. IV/INF $\{try, want, wish, expect, promise, ask, \dots\}$
 b. $TV/INF = (IV/T)/INF$ $\{permit, ask, force, expect, \dots\}$
 c. $(IV/INF)/T$ $\{promise, ask\}$

I have to refrain from asking with what justification Thomason is lumping together under one category label verbs (such as expect and permit in 15b) whose syntactic characteristics are similar only in a very superficial sense, or how such homophonous verbs as ask in (15a,b,c) are to be related to each other; of more immediate relevance is, firstly, the semantic characterisation of sentences with infinitives. As usual, infinitival complements are taken to denote properties; promise to eat sardines, for instance, translates into intensional logic, relative to construction tree (16b), roughly as (16a), with a constant promise'.

- (16)a. $\text{promise}'(^{\wedge}\lambda x_1 \text{ eat-sardines}'(x_1))$
 b. $\text{promise to}_1 [\text{eat sardines}], \text{IV}$
 $\text{promise, IV/INF} \quad \text{to}_1 [\text{eat sardines}], \text{INF}$
 $\quad \text{to, INF/AB} \quad \text{that}_1 [x_1 \text{ eats sardines}], \text{AB}$
 $\quad \quad \text{that}_1, \text{AB/t} \quad x_1 \text{ eats sardines, t}$

Secondly, the pertinent syntactic rules. The subject-predicate rule F_3 handles reflexivisation (clause 2) but may also involve variable-binding of a particular kind (clause 3):

- (17) $F_3(\varepsilon, a) = a\bar{y}$, where $\bar{y}$ is the result of ...
 2) if a has the form $\bar{x}_j$, replacing each occurrence of $\bar{x}_j$ not preceded by any occurrence of to by occurrences of $\bar{x}_j^{\text{self}}$;
 3) if ε contains a part having the form $\text{to}_k[\theta]$, replacing this by $\text{to } \bar{\theta}$, where $\bar{\theta}$ is the result of replacing each occurrence of $\bar{x}_k$ in θ by him if a is John or Bill, or by her if a is Mary or Jane, or by $\bar{x}_j$ if a is $\bar{x}_j$, provided there are no occurrences of $\bar{x}_j$ in θ (if there are, the function is undefined).

F_4 combines transitive verbs with their objects and accomplishes pronominalisation in an analogous manner:⁴

- (18) $F_4(\varepsilon, a) = \varepsilon_1 a \varepsilon_2$, where ε_1 is the leftmost word in ε and ε_2 is the result of replacing each occurrence of $\text{to}_k[\theta]$ in the remainder of ε by $\text{to } \bar{\theta}$, where $\bar{\theta}$ is ... (as in clause 3 of F_3)

Notice the potentially transformational nature of F_4 : if the TV is complex, the direct object is inserted between the main verb, which happens to be the leftmost constituent, and the rest of the phrase. Observe, furthermore, that Thomason's rules of infinitive formation need to be constrained syntactically. As they stand, and even if they are supplemented by a mechanism that allows to identify such syntactic functions as subject and object in the first place,⁵ there is no way to prevent the deletion (and abstraction) of complement objects (with results like 19a) and to ensure that exclusive reference is made to derived complement subjects (or nominatives, in German), as in (19b).

- (19)a. *Mr Heath expects to Mrs Keith please.
 b. Mr Heath expects to be pleased by Mrs Keith.

To be sure, there has to be ~~some~~ rule that similarly affects complement objects (cf. Lasnik & Fiengo 1974):

- (20) Some sardines are delicious/ready/a pain in the ass to eat.
 but this is governed by a limited number of matrix predicates and also seems to be contingent upon the prior removal of complement subjects.

In logical analyses of natural language, (some) anaphoric personal pronouns are conceived as essentially playing the rôle of bound variables; on the condition of variable-identity, the rules of quantification and substitution are to introduce the appropriate surface pronominal forms. Now, Thomason also wants to posit a relation of genuine coreference between matrix T-phrases and understood complement subjects.⁶ However, when F_3 combines a matrix subject T, or F_4 a matrix object T, with a derived IV or TV containing an INF complement, there no longer occurs a suitable free variable within that IV or TV after infinitive formation has syntactically deleted the complement subject variable, which was already bound, in intensional logic, by the abstraction operator. Although the deleted variable can, therefore, not surface as a pronoun, T-introduction by means of F_3 or F_4 nevertheless is, according to Thomason (1974a:722), of semantic significance. In contradistinction to Partee's (1975a:266) denial of the semantic need of superficial variable-identifiability, principle (21) is intended to determine the identity, i.e. coreferential linkage, of superficially missing complement subjects and, I take it, of anaphoric pronouns in general:

- (21) Whenever a rule combines an independent T-phrase with a phrase containing an abstracted variable, this variable must immediately be bound by this T.

Taking (21) at its face value, the syntactic categorisation of such verbs as promise and permit that was given in (15) obviously guarantees the intended 'binding'. However, the concept of variable-binding that Thomason is appealing to in (21) is by no means self-evident. As was already pointed out, F_3 and F_4 no longer encounter free variables, syntactically as well as semantically. Consider another case of understood-subject identification, IV-conjunction as in (22a), with an intensional-logic translation of the IV as in (22b):

- (22)a. Fawkes walks and talks. b. $\lambda x_1 [\text{walk}'(x_1) \ \& \ \text{talk}'(x_1)]$

The two occurrences of the free variable are bound by one abstraction operator; and upon T-introduction, lambda-conversion is applicable with respect to both occurrences of the abstracted variable. The subject variable of t-phrases underlying INF-complements, however, is immediately bound by an abstraction operator, according to Thomason's rules, and the matrix verb is not within the scope of this same variable-binding operator (cf. 16a). There is thus no representation like (23), with two occurrences of a free variable within the same scope:

- (23) $\lambda x_1 \text{ promise}'(x_1, \text{'eat-sardines'}(x_1))$

The claim that (21) seems to make is that no matter how deeply embedded in whatever context an abstract expression is, as soon as an independent T-phrase, which may itself be a free variable to be bound later by some quantifier, combines with the AB-containing phrase, this T serves as antecedent of the respective abstracted (i.e. already λ -bound) variable. Uncertainties of how to bind bound variables may be responsible for the fact that it remains doubtful, in semantic terms of rules of inference, how exactly Thomason's account can establish, let alone explicate, the informally postulated "semantic connection" between sentences like (24a) and (24b);

(24)a. The Queen promises to eat sardines.

b. The Queen eats sardines.

at least the proposition that the Queen eats sardines is not analysable as a proper constituent part of the assertion (24a).

Be the technicalities of coreference assignment as they may, the anaphoric linking of personal pronouns certainly cannot in general be determined along the lines of (21). We need only consider finite complements instead of infinitives of the verbs in (15): The matrix subject, the first T to be combined (by F_3) with an AB-containing IV-phrase, does not have to be coreferential with the complement subject, if the latter is overtly present as a pronoun (cf. 25a), although sometimes it actually has to, on account of conceptual-semantic characteristics of such verbs as try (cf. 25b).

(25)a. The Queen promised/expected/wanted that he eats sardines.

b. The Queen tried how far she/*he could jump.

(21) thus does not sufficiently differentiate between pronominal and referentially less versatile null anaphors (as in 24a). Secondly, like Partee's Starred-Variable Convention, it is also relying on T-phrases with overt syntactic manifestation, as is evidenced by the dual syntactic categorisation of such verbs as promise; hence it becomes liable to analogous criticism: In complex sentences like (7) above, the matrix subject does not 'bind' the understood complement subject although it is the first and only T overtly available. Furthermore, in subjective infinitives as in (26),

(26) To please Mr Heath is easy (for someone/for Mrs Keith).

there may be no manifest T-phrases outside the infinitive at all; nevertheless, the understood infinitival subject has to be interpreted as coreferential with an overt or understood (as a kind of generic term) matrix 'dative'.⁷

Such technical and empirical considerations of the relationship be-

tween variable-binding and coreference are far from being only minor quibbles; and yet there are more fundamental questions to be raised, and these concern the status of the two assumptions at the very heart of Thomason's 'solution' of the control problem: the principle of immediate variable binding (21), on the one hand, and the matrix-verb categorisations (15), on the other. Firstly, what are the arguments in support of the category assignments (15), especially (15b,c)? Thomason offers three, two of which supposedly constitute favourable evidence independent of principle (21).

In addition to the categories in (15b,c) one could imagine a third, non-binary but simultaneous mode of combining T and INF with a matrix verb, which would then have to be of category IV/T,INF. Such different verb categories make different claims about the syntactic connection or coherence of the constituent subexpressions of derived IV-phrases. Thomason now invokes "semantic intuitions" demanding categorisations of promise and permit as in (15), upon which category assignments the grammar automatically decides that promise the dean is a coherent phrase of the same category as try, and that permit the dean, unlike permit to eat sardines, is no coherent phrase, etc. But what, one must ask, is the empirical basis of such intuitions compatible with precisely these judgments about phrase-coherence? I suspect that there is none and that, therefore, Thomason's first argument rests entirely upon convenient fictions. Despite much formal work on categorial grammar, the objective empirical correlates of the central notion of syntactic-semantic coherence are anything but well understood, as is the relationship between coherence and the notion of syntactic constituency. The criteria or operational tests commonly utilised in determining (immediate) constituent structures certainly are not indicative of a structural difference between permit- and promise-type constructions. Surface linear order, for instance, suggests a perfect parallelism; there is no evidence for an obligatory reordering of the 'object' of permit to eat sardines, for a discontinuity of only this but not the promise-construction. And in case languages (such as German), it is the basic matrix verbs alone, rather than complex 'transitive verbs' consisting of a matrix verb and INF, that govern the case-selection of their objects. If, on the other hand, definitions of phrasehood in terms of coherence are to be based on the axiom of syntactic-semantic parallelism, irrespective of syntactic constituency indicators, it has yet to be shown that in the complement constructions under discussion distinct categorial structures are necessitated by semantic

facts one could have "semantic intuitions" about. As far as I can see, or intuit, however, it is not at all implausible to interpret the relations of permitting and promising with respect to their arguments in a parallel manner.

On the assumption that only sentences with transitive verbs are passivisable, the ungrammaticality of (27) and the grammaticality of (28) allow the inference, Thomason maintains, that the category TV only figures in the active counterpart of (27), which is exactly what (15) is claiming.

(27)*The dean was promised (by the Queen) to eat sardines.

(28) The dean was permitted (by the Queen) to eat sardines.

Even if we pretend that the definition of transitivity and the statement of passivisation are essentially trivial matters, this argument surely does not carry much weight either. For not only do some bona fide transitive verbs not passivise (cf. 29a), there also are non-TV-phrases that nevertheless do have passives:⁸ IV/AB-verbs (29b); verbs with gerundive complements (29c); occasionally IV/INF-verbs (29d,e), which could suggest that infinite complements are more term-like than Thomason would have it; and, in languages like Latin or German, even basic IV-phrases (29f, 'impersonal' passive).

(29)a.*The Queen was resembled/married by the dean.

b. That the Queen eats beans has been denied by the dean.

c. Eating beans had been recommended/advocated by the dean.

d. To be able to come was hoped by everybody wishing to please Heath.

e. How to eat beans in Sardinia was also explained by the handbook.

f. Wurde getanzt/gekämpft? 'Was there dancing/fighting?'

Furthermore, consider the verb promise that co-occurs with two nominal objects (cf. 30). According to Thomason (1976), promise two sardines is connex and of category IV/T, with an indirect-object rule inserting a further T between verb and direct object.

(30)a. The Queen promised the dean two sardines.

b. The dean was promised two sardines (by the Queen).

c. Two sardines were promised the dean (by the Queen).

There are two ways to passivise (30a); but it at any rate appears reasonable, pace Thomason (1974a; 1976), to regard the syntactic relationship between promise and the indirect object the dean as entirely parallel, irrespective of whether the other constituent part of the IV is an INF-complement or a direct object T. But if all this conclusively demonstrates, as I think it does, that the ungrammaticality of (27) cannot be blamed on the lack of an active TV, and that, therefore, passivisation provides no rationale for distinguishing permit and promise categorially as in (15), then

why is (27) ungrammatical or at least, according to some speakers, worse than (28)? This question will be taken up again briefly in §4 and, in more detail, in Plank (1976).

Thomason's third argument for the categorisations (15b,c), which simultaneously is his first argument for the principle (21), is of the 'it-works' type: Given (15b,c) and (21), the control problem as exemplified in (1)-(2) can be solved, at least as far as observational adequacy is concerned. If there are no independent arguments to support the empirically clearly independent hypotheses about categorial structure (15) and about variable-binding (21) individually, these hypotheses at least support each other. Obviously, this line of reasoning is as circular as the 'solution' is arbitrary. With equally good justification one could immediately propose an alternative 'solution', by replacing (21) by an equally general principle (21') and adjusting the matrix-verb categorisations accordingly.

(21') Abstracted variables are bound by the last independent T AB-phrases are combined with.

However, there is no need to throw up the sponge yet; according to Thomason, there actually is independent evidence favouring (21) over (21') or some altogether different mechanism: (21) effectively is an analogue of Rosenbaum's MDP. This correspondence could count as an argument for the categorisations (15) only if two preconditions are met: Thomason's principle is a genuine analogue of Rosenbaum's; and secondly, the central common notion of closeness is the true determiner of control or coreference in complement subject deletion. On both counts, this last argument for Thomason's 'solution' fails.

In Rosenbaum's framework, there is a single general transformation of complement subject deletion that does not mention any specific matrix NP; the allegedly rule-independent MDP then determines precisely which matrix NP of two or more potential candidates is in a position to control the identity deletion: the one that is closest to the complement subject, distance being defined in terms of the number of branches connecting the two nodes of the constituent structure tree. In order to qualify as a genuine analogue of the MDP, with respect to the crucial notion of closeness, the particular distance metric utilised will have to mirror, or be reducible to, constituent structures defined in terms of the relations of dominance and precedence. Consider, for a moment, Stockwell et al's (1968:557-60,579) alternative to the MDP that does not draw on closeness but maintains that if the

matrix clause contains a (Fillmorean) dative and an agent, the dative is the controller (or antecedent). Ascribing erasure priority to datives, however, turns out to be equivalent to the MDP: Unless the matrix clause is passivised, datives always end up as objects and hence are closer to the complement subject than the agentive matrix subject, in terms of constituency.⁹ Thomason, on the other hand, explicitly draws on a concept of closeness in the first place, but defines it in terms of construction (or analysis) trees. Syntactic construction trees in Montague grammar do not represent constituent structures but are designed to display, for example, the relative scopes of quantifier phrases and, which apparently is a rather flexible requirement, to allow for parallel syntactic and semantic processing. As Partee (1975a:258-60) suggests, syntactic constituency structure can be superimposed at least on some strings constructed by means of context-free rules; which, however, is not tantamount to postulating that successive steps of constructing complex expressions inherently correspond to or model traditional syntactic constituency relations. Since constituent-structural closeness, therefore, need not necessarily be incompatible with constructional lateness, it is difficult to see why (21), rather than some late- or intermediate-variable-binding principle, could lay exclusive claim to the status of being an analogue of the transformational MDP. Neither of them is; if either (21) or (21') happen to produce, no matter how, the same net results as the MDP, it is by accident and not by necessity. Which entails that arguments pro and con the MDP need not at the same time be arguments pro and con Thomason's proposals. I skip the extremely few and unconvincing arguments for the MDP,¹⁰ and briefly explore what bearing the counterevidence against the MDP has upon a solution of the control problem that is founded upon the order of introduction of variable-binding T-phrases.

As a matter of fact, promise and that ask that shows up in sentences like (31) are exceptions to the MDP: At the point deletion is to apply, the matrix object is the NP closest to the complement subject.

(31) Fawkes asked Hawks when to talk.

There is no evidence whatever for adopting different constituent structures for sentences like (1) and (2), which would enable the MDP to work properly for (1) as well as (2); which again emphasises the non-equivalence of Rosenbaum's and Thomason's solutions. The conclusion that Thomason's approach is superior on this count, is, however, fallacious. The descriptive and explanatory task at hand apparently is to determine the membership of lexical i-

tems of matrix verbs in one of two complementary classes. Assigning them individually to different syntactic categories is just as arbitrary as individually marking some of them as 'exceptions', as long as we fail to recognise any generalisation that would allow us to predict which items belong to which class. The lexical semantics of complement-taking verbs would seem to be an obvious candidate on which to base such a generalisation. Meaning features consistently distinguishing permit- and promise-type verbs could, obviously, serve to define two semantically natural classes, one presumably larger (permit) and one smaller (promise), but none syntactically or lexically exceptional with respect to the control problem.¹¹ Aijmer's (1972:100) hypothesis to make deletion control contingent upon which matrix T-phrase designates the individual under an obligation to do something (the subject with promise, the object with force etc.), is a step, albeit, in my opinion, not a fully successful one, in this explanatory direction.¹²

The MDP implies that missing complement subjects are always understood as having one and only one controller (antecedent), unless two or more potential controller NPs in a superordinate clause are equidistant. This uniqueness assumption has already been challenged by Postal (1970:470), whose counterexamples are claimed to be three ways ambiguous (cf. the variants of (32) although there clearly is only one matrix NP that is closest to the deleted complement subject.

- (32) The Queen talked to the dean about $\emptyset$ eating sardines.
 $\emptyset$ =(a) his, (b) her, (c) their

While (33) is not ambiguous, there is, as in (32c), no single controlling T.

- (33) Hawks agreed with Fawkes to meet on Monday morning.

On the plausible assumption that in Thomason's fragment or an extension thereof, subjectless infinitival and gerundial complements are not handled entirely differently with respect to abstraction, such coreferential ambiguities and cases of dual control, on the other hand, do not apriori violate the uniqueness assumption that is likewise implicit in (21), or, for that matter, in (21'). A seemingly arbitrary, though technically feasible way out would be to assign talk (about) to three different categories, viz. to (15b), (15c), and, to get the reading (32c), to one that allows the simultaneous combination of matrix subject and object with the AB-containing verb phrase talk about eating sardines. Examples like (32) and (33) can, thus, never falsify Thomason's principle (21), or the alternative (21'), as long as there is no way to prevent ad hoc category assignments and to curtail the proliferation of synonymous and homophonous lexical items only

differing from each other with respect to category membership. Even if the range of construction types is extended so as to include potential controller T-phrases that are not in the one clause immediately containing the complement, such ambiguities as in (34) can in principle be accommodated by such an excessively powerful framework, albeit at the expense of having to countenance two matrix verbs disturb in two different syntactic categories.

(34) The Queen said that making a fool of (a) herself/(b) himself in public disturbed the King.

Further categorial machinery appears to be required in order to exclude one of the readings of (34) in case the INF-complement is extraposed:¹³

(35) The Queen said that it disturbed the King to make a fool of
*herself/himself in public.

I suspect that even the additional readings of (32) and (34), viz.

(32)d. $\emptyset$ =someone's

(34)c. oneself

which involve nonspecific or generic complement subjects without any overt controller (antecedent), could eventually be accommodated as follows: This time, matrix-verb categories determine that no independent T can bind the abstracted variable; it either remains unbound, which is taken to induce a nonspecific interpretation, or it is bound by an appropriately defined generic quantifier, itself without overt manifestation.

What is wrong with such a 'solution' of the control problem is that it is always right, or at least infinitely adjustable to whatever new identity-relation is discovered; in other words, it is no empirical hypothesis about the grammar of English complementation.¹⁴ The argument that leads to this conclusion might look like a travesty of Thomason's (1974a) and also Partee's (1975a) own intentions; yet it only exploits their own circular, arbitrary and non-empirical basic assumptions: Principle (21) cannot be tested against empirical data or its purported model, the MDP, independently of the syntactic categorisations of matrix verbs; these, in turn, are not independently justifiable or falsifiable. However, if one wants to adopt the view that the relevant parts of the categorial structure of complex sentences have to mirror syntactic constituency relations, the option of arbitrarily multiplying lexical entries and syntactic categories is precluded. Simultaneously, (21) collapses, due to the uniqueness assumption behind it, in the light of the above data, just as the MDP did. I do not pursue the issues of how to amend the Montague-grammar framework by introducing the host of other identity and non-identity deletions that are thought to be necessary in transformational grammar to account for all subjectless complements; instead I

want to adduce some evidence from structurally less involved English and German INF-complements corroborating the fundamental invalidity of a solution that is based on structural distance and takes for granted discrete matrix-verb classes (promise- vs. permit-type).

4. Misunderstandings, Ambiguities, and How to Avoid Them

ask is an inconsistent exception to the MDP; according to Thomason (1974a), there are three verbs ask in three different syntactic categories (cf. 15a-c). This is to account for the different identity relations in (36a,b), but in fact brings about a curious paradox.

(36)a. Hawks asked Fawkes when to talk.

b. Hawks asked Fawkes to talk.

For how does one understand, i.e. identify the different understood subjects of, (36a) and (36b)? By choosing the appropriate lexical entry in the appropriate category (or with the appropriate exception feature). But which is the appropriate one? Syntactically, both ask's fit into the environments of both (36a) and (36b); and from the superficial linear arrangement of INF-complement and T-object alone, the different orders of their categorial combination cannot be ascertained. To choose the right ask, a prior understanding of the identity relations holding between matrix and complement terms is required. But this means that we already have to have understood (36a,b) in order to find out the factors that are supposed to determine our understanding. However, this argument could seem to be faulty; the two ask's of (36a,b) apparently mean something different: (36a) reports a question, (36b) a request. Knowledge of the lexical meaning of the respective matrix verbs would then have to help us understand (36a,b) by way of determining the selection of the appropriate verbal category. In the absence of such a meaning difference, multiple category membership of matrix verbs, as advocated by Thomason, obviously entails that, from a surface-interpretative point of view, there is no non-circular way of properly disambiguating such complex sentences in order to arrive at their intended interpretations.

The matrix verb beg is a case in point. It combines with an object and an INF, and, in (37), clearly patterns like permit and unlike promise.

(37)a. Hawks begged Fawkes to invite Mr Heath.

b. Fawkes was begged (by Hawks) to invite Mr Heath.

However, given an underlying representation like (38a), upon passivisation

of the complement, the derived complement subject is no longer coreferential with the matrix object, which does not preclude its deletion.

- (38)a. Hawks begged Fawkes [Fawkes invite Hawks]
 b. Hawks begged Fawkes to be invited.

In (38b), and in similar constructions in English as well as in German (cf. 39), beg now behaves like a member of the promise-class although there is no difference observable between the lexical meanings of the two beg's.

- (39)a. Hawks begged Fawkes to be allowed to talk.
 b. Hawks bat/bettelte Fawkes, eingeladen zu werden. (=38b)
 c. Hawks bat Fawkes, reden zu dürfen. (=39a, with modal verb instead of passive)

Interestingly, passivisation of the matrix clause yields results as deviant as with promise:

- (40)a.*Fawkes was begged (by Hawks) to be invited/to be allowed to talk.
 b. Fawkes wurde (von Hawks) gebeten, eingeladen zu werden/reden zu dürfen.

If two different verbs beg are postulated, in accordance with Thomason's general strategy, we find ourselves in the paradoxical situation described above. That the identity of the missing subjects of (37)-(39) is, nevertheless, not misunderstood suggests that it is not the matrix verb alone (certainly not its syntactic category), but its interplay with the structure of the complement that determines the solution of the control problem. With a single verb beg in a single syntactic category, we, on the other hand, commit ourselves to accept the existence of verbs that are inherently neutral with respect to control, and, consequently, face the empirical problem to determine which verbs under which conditions group with the complementary promise- and permit-classes, in case they are not inherently members of either of these classes. Such verbs as pray, ask, urge, force, for instance, also seem to switch control obligatorily relative to the voice of the complement:

- (41) The dean asked/prayed/urged/forced the Queen to be allowed (by her) to please himself/*herself.

It is not altogether clear whether such verbs as require, persuade, tell and even permit are also inherently neutral, since passivising their INF-complements often yields semantically odd results in the first place. However, there is a crucial difference in so far as the factors involved in determining deletion control (i.e. understood-subject identification) do not seem to achieve complete avoidance of referential ambiguity in the case of such verbs as permit or persuade in (42), whereas they clearly do so with beg etc. in (38)-(41).

- (42) The Queen permitted/persuaded the dean to be invited (by her/him).
 That missing subjects are indeed misunderstandable, i.e. not uniquely iden-

tifiable, would seem to contradict the spirit, if not the letter, of the 'solutions' of the control problem discussed in this paper; after all, their avowed aim was to develop a special mechanism assuring unique, and uniquely recoverable, control relations no matter what is the syntactic and semantic environment of the deletions. This overall uniqueness assumption having been shown to be counterfactual, it might not be altogether ill-advised to take an opposite view and adopt, as a point of departure, a general ambiguity assumption (cf. also Postal 1970:470) claiming that within the limits of language-specific structural deletion constraints (cf. fn.1) any coreferential T is a potential controller, and that independently available factors (such as general pronominalisation constraints; cf. again Postal 1970) under certain conditions single out one of the candidates as unique controller.

This attitude may have an additional advantage. Although both Thomason and Rosenbaum were only concerned with English, the nature of their principles is such as to suggest universal rather than language-particular validity. Now suppose in comparing corresponding complex sentences of two different languages, we are able to ascertain that these sentence pairs do not differ as to categorial structure and structural difference between the relevant matrix and complement T-phrases. Both the MDP and Immediate Variable Binding no doubt entail that in this situation identical control relations hold in the two languages. Let me give you only one case in point. German does not differ from English at all as far as the neutral but unambiguous beg-type verbs and the ambiguous permit-type verbs are concerned; and the German equivalents of (1)-(2) also constitute a minimal pair. There emerges a difference, however, as soon as the complements of versprechen 'promise' are passivised or supplemented by certain modal verbs.

- (43) Die Königin versprach dem Dekan, (a) eingeladen zu werden/(b) (vom König) finanziell unterstützt zu werden/(c) Bohnen essen zu dürfen.

All these sentences are ambiguous as to deletion control whereas in their English counterparts (44), even if these are not judged perfectly well-formed, the matrix subject is unambiguously identified as controller, just as in (1).

- (44) The Queen promised the dean (a) to be invited/(b) to be financially supported (by the King)/(c) to be allowed to eat beans.

Here a universal unique-control principle is, evidently, at a loss while the ambiguity and ambiguity-reduction assumption does not a priori preclude the possibility that different semantic and syntactic factors avoid potential

referential ambiguities to a different degree in different languages. Without being able to enlarge on this topic here, I suggest that in German, there does not even exist a class of strict promise-type matrix verbs; such items as versprechen, anbieten 'offer', versichern 'assure', geloben 'vow' all seem to be inherently neutral. Mostly it is the context of use, rather than the structure of the INF-complement, that occasionally succeeds in disambiguating the identity relations of understood complement subjects.

So far the syntactic structure of the matrix clause has not seemed to play a rôle in determining or disambiguating control relations. In suggesting that it, nevertheless, is a relevant parameter, I sketch a speculative explanation of the deviance of (27) and (40).

(27) *The dean was promised (by the Queen) to eat sardines.

(40)a.*Fawkes was begged (by Hawks) to be invited/to be allowed to talk.

Thomason's (1974a) account in terms of transitivity has already been shown to be highly implausible. In fact, I do not think (27) and (40) are syntactically deviant at all, but rather involve a T-phrase configuration incompatible with a resolution of the control problem in English. In (27) and (40), after passivisation of the matrix clause, the original controller ends up as an agentive by-phrase; and one could hypothesise that such non-obligatory phrases no longer qualify as potential controllers in English. Attempts to link anaphorically the missing complement subject with the derived matrix subject instead, fail for conceptual-semantic reasons. As more explicit representations indicate, matrix verbs like beg and promise do not impose an obligatory coreference requirement upon the underlined matrix and complement terms:

(45)a. The dean was promised (by the Queen)[the Queen/Jones/..eat sardines]

b. Fawkes was begged (by Hawks)[Hawks/Jones/Fawkes be invited]

If, therefore, the matrix by-phrase is not overtly manifest, no clue remains to the identity of the complement subject. At least as far as INF-complements are concerned, English apparently tends to avoid such indeterminacies, which can be demonstrated, again in comparison with the less restrictive state of affairs in German (where the counterparts of (27) and (40) are fully grammatical), to be an even more general phenomenon. Notice, for example, that, perhaps with the exception of say (cf. 7b), English permit-type verbs do not allow the deletion or non-specification of matrix objects whereas German does so quite freely:

(46)a.*The Queen permitted/allowed/urged/advised to eat beans.

b. Die Königin erlaubte/ließ zu/drängte/riet, Bohnen zu essen.

Perhaps the constraint against passivising matrix verbs governing only an INF-complement but no nominal object, is another exemplification of this generalisation:

(47)a.*To eat beans was begun/promised (by the Queen).

b. Von der Königin wurde angefangen/versprochen, Bohnen zu essen.

In (46a) and in (47a), the matrix object alone and, respectively, the matrix agent alone could help recover the identity of the missing complement subjects. It goes without saying that this can only be a highly tentative account of some phenomena that hitherto apparently have defied all explanatory attempts, especially those that purport to have solved the control problem.

Footnotes

¹ Basically, this analysis of infinitive and gerund phrases as natural language manifestations of abstract expressions can already be found in Montague (1974b:161). Since, following Montague, infinitives and gerunds are commonly treated in a uniform manner, at least with respect to their semantics, I feel justified in occasionally using gerundial examples in my evaluation of Partee's and Thomason's proposals. Nevertheless, Tavakolian (1973) has pointed out important syntactic differences that will eventually have to be incorporated into Montague grammar: In English, infinitival complement subjects are only deletable if they are both commanded and preceded by an antecedent in an immediately dominating clause, whereas gerundial subjects are already deletable if an antecedent either precedes or commands them.

² The identity of the complement verb (cf. §4) and its infinitival or participial form ('Status') may also play a minor rôle.

³ The categorial structure of infinitive complements is discussed in some detail in Plank (1975).

⁴ The subscript indices of complementisers in (16)-(18) are, I think, superfluous; they themselves can certainly not provide a means of tracing the identity of deleted variables.

⁵ The imposition of constituent structures upon construction trees, along the lines of Partee (1975a), could serve this purpose.

⁶ Partee (1975b) has shown that complement subject deletion is based on variable identity and is no case of deletion of laziness.

⁷ In fact, such a controlling matrix dative may not even be syntactically reconstructible, as in Partee's (1975b:30) example It's against the law to eat beans with a spoon. There nevertheless is a necessary relationship of coreference between law-offenders and bean-with-a-spoon-eaters.

⁸ Thomason's fragment in fact does not contain all the relevant verbs; but the categorisations assumed here do not, I think, contradict the spirit of his categorial set-up. -- Note also that according to Thomason's surface-oriented categorisations, such ('Raising') verbs as want, wish, let, con-

template would also belong to category (15b); but they do not passivise:
*The dean was wanted/wished/let to eat beans, *He can't be contemplated eating beans.

⁹ Grosu (1971:14) claims that the MDP and Stockwell et al's principle of erasure priority are notational variants. This characterisation, however, does not seem to be altogether appropriate, since there at least is a possibility of them making different empirical claims; for instance, if the matrix clause is passivised.

¹⁰ As Jackendoff (1972) has observed, only switches of control relative to the presence or absence of a matrix object could be interpreted as demanding something like the MDP: Hawks wanted Fawkes to talk vs. Hawks wanted to talk, Hawks kept Fawkes talking vs. Hawks kept talking. For all other verb types, intuitively simpler solutions are available; e.g. verb-specifications requiring obligatory subject-control (promise) or object-control (permit). (But confer §4.)

¹¹ Some dialects of English, nevertheless, tend to regard promise as exceptional, in so far as an INF-complement is only acceptable if promise is not accompanied by an additional nominal object; otherwise, the INF has to be replaced by a finite that-complement. Other verbs patterning like promise with respect to control require prepositional objects (offer to, vow to, agree with), but with them, there are no such dialectal constraints upon the use of INF-complements.

¹² Jackendoff's (1972:178-228) solution also is, in a way, semantically based; but when it comes to distinguishing promise and permit, it turns out that these verbs are identical with respect to their thematic relations. Consequently, control has to be assigned as arbitrarily as in Thomason's and Rosenbaum's frameworks.

¹³ For contrasting explanations, cf. Grinder (1970) and Tavakolian (1973).

¹⁴ Notice, however, that this solution cannot be adjusted so as to adequately accommodate certain subjectless non-complement constructions, whatever categorial structure one might have in mind. Consider the phenomenon of 'dangling' adverbial infinitives and participles: To play golf well, your feet must be in the proper position, Looking out for a theme, several crossed Otto's mind. Even if the abstracted variables of the infinitival and participial phrases are picked up by the main clause subject or object, this does not yield the appropriate readings, since the understood subjects are unambiguously identified with constituent parts of these T-phrases, viz. the possessive pronoun or genitive.

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Circumstances and Circumstantial Expressions

1. Most sentences depend for their correct and full interpretation on the circumstance under which they are uttered. They all might therefore be called circumstantial sentences in a general sense. This is not, however, the sense in which I want to introduce the term; circumstantial sentences and, more generally, circumstantial expressions in the proper sense are only special cases of those just mentioned.

There are various ways in which the interpretation of an utterance of some sentence may depend on the circumstance. One of these is that the reference of the sentence - i.e. that part of the world for which the utterance is to hold true - if some statement is made - or to be obeyed - if some command is given or a request is made - or to be answered - if some question is put - that this reference may only be clear at some appropriate circumstance in a field of circumstances for which the utterance may be interpreted¹.

Now, among the sentences referentially dependent on the circumstance of utterance, various types are to be distinguished: There are those depending on the observable features of the circumstance of utterance - Quine's occasion sentences -, and among them the deictic sentences², depending for their reference either on the origin of the utterance, i.e. on the triple speaker, time and place of utterance, or of some marking acts such as pointing or indicating persons or objects or events such as the addressee and the object or event pointed at³.

But sentences may not only depend on an occasion strictly preceding their utterance but also on some memorized occasion. If that occasion occurred during some tolerable time interval before the utterance of the sentence, whose interpretation it depends on, Quine calls it a standing sentence⁴.

But not only occasions may be memorized, all kinds of other facts may also. During observing somebody moving a certain wooden piece on some board marked by rectangular squares one will take it as a manifestation of the fact that he is the player of some ongoing game of chess. One may even take it as a fact that this is one of the games of an ongoing championship⁵.

Let me call a system of ongoing facts - excluding general law-like statements about facts of this type, though - an ongoing-facts-system. In contrast to these there are facts memorized as no longer ongoing. A system of such facts will be called a past-facts-system.

Utterances of sentences depending for their referential interpretation on an ongoing-facts-system will be called present sentences, and those depending on a past-facts-system past sentences.

There are certainly quite a number of other ways in which facts may be considered as modalized: Facts such as possible facts, planned facts etc. etc. Accordingly quite a number of other types of sentences may be characterized. It is irrelevant for the present purpose, to go into further details.

A facts-system is usually complex, but the sentences depending on them have to be referred to a certain "location" within the complex.

I shall call this "location" a circumstance within the facts-system. Sentences that may only be evaluated referentially with respect to circumstances within a facts-system will be called circumstantial sentences. Circumstantial sentences are similar to deictic sentences: The latter depend on pointing or marking in occasions, the former on pointing or marking in facts-systems of a frame of interpretation present in the speaker or hearer (or both) at some utterance.

As a typical case I shall discuss simple past sentences without adverbs or adverbial clause; I think that these are always

circumstantial sentences as one needs to know particular circumstances for which they should hold. In some cases the speaker may provide the necessary circumstantial knowledge, but this is only possible by uttering not only the simple past sentence but a more complex sentence having the simple past sentence embedded into a circumstance determining clause, say a temporal adverbial clause - or sometimes simply a corresponding adverb. The clause (or the adverb) will be called a circumstance determiner expression in the language.

In order to illustrate let us consider talks or reports on some game of chess. Assume that at a particular moment in some particular context somebody says

(1) B1 captured Wh's rook by his king

or - correspondingly - he writes (in English descriptive chess notation)

(1') ... K ✕ R

or (in the German notation)

(1'')... K g8 ✕ h8

(where the rook is on g8).

What is the statement made? Without knowing further circumstances of the talk or the text and its interpretation we may assume that if (1) is used in a normal way then the speaker refers to F's moving a certain piece of chess from a specified position on the board in a particular game. What remains open is on the one hand, which one of the two rooks is involved and whether the speaker wants to state that a certain event describable in this way has happened in the past - this is normal use of the written version - or simply that such an event - one or the other - has happened.

Which kind of information is required to determine which of the two alternatives is meant and, if the former, which of the several possible events so describable is referred to. It is obvious that these questions have to be answered by reference to some circumstances in the context.

2. As is well-known, the usual model-theoretical answer is as follows: Translate (1) into a regimented language either by

(2) It has at least once been the case that (3)

where (3) is

(3) B1 captures Wh's rook by his king

or translate it by

(4) It has been the case at t that (3)

where t is a particular time point such that t is before the time t_0 of utterance of (3). The regimentation of the language consists in taking present tense $\bar{t}$ as in (3) ^{embedded in (2) or (4)} - always as omnitemporal - i.e. as defined for all time points - and neglecting *consecutio temporum*.

Furthermore: Assume for the interpretation of the sentences of the regimented language a fully ordered set T of time points and for each world a set D_s of functions defined in T with values in the set of truth values $\{t, f\}$ or a set-theoretical equivalent. To each sentence of the language assign a time scale function, i.e. an element from the set D_s , as its intension. Finally, if (2') and (4') are the clauses preceding (3) in (2) and (4), assign to (4) an intension of the type specified above and to (2') and (4') each a mapping from D_s to D_s (cp. e.g. R. Thomason, 1974).

Let us look closer at this procedure. Since all intensions are defined with respect to one and only one time scale T , it seems to be assumed that there is exactly one such scale. From the context of the authors it can easily be inferred that they do not think that T should be different from our classical physicalistic time scale with the conventional origin. In other words, the elements of T correspond to dates and idealized clock-readings. I doubt that these assumptions are appropriate for the analysis of ordinary languages. Note that intensions are to be taken as explicating meanings; the analysis just presented therefore amounts to saying that meanings of tensed sentences depend conceptually on the specific notions of time.

It is, however, obviously true that earlier phylogenetic and autogenetic stages of development of language must be completely independent of a unique time scale corresponding to dates and clock-readings and that for these stages meanings, since they determine understanding, should not depend on a unique time scale.

Moreover, there are even essential problems with that notion of meaning in fully developed languages. Consider again our example. Consider that speaker and hearers are talking about a particular move as described. Assume that the players played their game much slower than they actually did. Does this affect the concept speakers and hearers have on the move? I think not. Does it affect the intension as analysed by model-theoreticians with respect to a time scale? Yes, indeed. We shall have to change the intension for the sentence picking one from an alternative world to our actual; the alternative being one from the class of worlds where the moves are slowed down appropriately, all other things being equal. The assumption that the concept speakers and hearers have of the game played so far does not depend on the speed of the moves combined with the assumption that the structure of the concepts should be rendered by possible-world-time-function intensions⁶ requires us to take a class of such intensions, namely all those differing only in speed. But this is unnecessarily complicated; the concept of the speakers is a structural notion and the model-theoretic approach is analogous to an approach insisting in assuming that sentences should always be described as classes of actual or possible sound events being defined themselves as well as all their parts as functions of intervals of time. But we have learned how easy it is to treat sentences simply as strings of words, morphemes etc. and to leave the question open where and when they are realized. Why not do the same with structures of stories or of the events they describe? I think that ordinarily, except where explicitly stated or in special situations, the concepts we have of what happened are independent of speed (or only vaguely connected with it) and that therefore no physicalistic temporal concept need to figure in our metalanguage or analysis-system and certainly should not figure predominantly in meanings or their explicata.

But which notions should we use instead? I think that we should not introduce notions into our analysis language (or meta-language) beyond necessity. This resembles the Tarski-Davidson-maxim that "the statements of truth conditions for individual sentences entailed by the theory [of truth] should ... draw upon the same concepts as the sentences whose truth condition they state" (Davidson (1970), p. 179), a maxim that is motivated by the requirements to make the theory (i.e. truth theory in the Tarski-Davidson-case) empirically testable (cp. Davidson (1967), (1964)). Remark, however, that the maxim does not exclude technical apparatus for the analysis, but this apparatus has no content beyond its mere contributing to a theory of truth entailing testable statements of truth conditions for individual sentences (Davidson (1964), p. 82-84).

As a technical apparatus I should, for instance, not exclude the possibility of a relatively "natural" language of set-theoretical analoga (in the sense of Quine (1970), p. 51 ff.) and in the present article I shall in fact assume one.⁷

3. In order to get more specific I shall have to give an outline of my framework for analysis. The basic conceptual entity is an analysis situation. It consists of a sound event and an interpretation frame for that sound event. An analysis situation occurs as an analysis situation of some person in a communicative role (speaker, hearer) being based on percepts and knowledges of that person. In our context the important notion is the notion interpretation frame. It contains a central part which is usually not changed by communication (except in linguistic teaching or learning), a general part for theories, doctrines and general assumptions and a particular part. The latter two will also be called the general and particular part of the setting of the analysis situation. The first contains the determination or "definition" of the language (fragment) S analyzable, of the analysis language L, of a ^{simple} facts system F, which is some entity in the set-theoretical hierarchy H over a set Ind of basic entities or objects of discourse⁹ as well as structural properties for the expression of S and L and the simple facts in F.

An interpretation frame I is applied onto its sound event x in an analysis situation by assigning an expression $\underline{s}$ from $\underline{S}$ to the sound event; this means that by this application sound event x is taken by I as an utterance of the expression $\underline{s}$. Such an application initiates the analysis proper within I .

Analyses of expressions of $\underline{S}$ within I are indirect analyses: An expression $\underline{s}$ of $\underline{S}$ is translated into an analyzing expression $\underline{s}$ of $\underline{L}$ (i.e. an expression of the analyses language $\underline{L}$) and interpreted by a fact $\underline{s}$ of the ^{simple} facts-system $\underline{F}$. In other words, the interpretation of $\underline{s}$ is mediated by the translation into expression $\underline{s}$ of the analysis language and translation and interpretation are in turn mediated by the structural properties of the expressions and the facts interrelated in the analysis.

The central part of I contains moreover the means in terms of which the settings of an interpretation frame I with that central part are defined. Here, we shall only be concerned with the particular settings. They are definable in an "enlarged" language $\underline{K}(\underline{L})$ on the basis of $\underline{L}$ and a facts-(structure) system $\underline{G}(\underline{F})$. Intuitively, $\underline{K}(\underline{L})$ is a language generating memorized stories or reports (or some abstracts there of) and $\underline{G}(\underline{F})$ the structures expressed by these stories or reports.

These settings are used in the analysis in the following way: The result of the analysis of a sentence (a fact expressed by the sentence) is compared with the fact-structure of the setting. It may agree with that setting or not. If it does not agree either there is a clear disagreement or the setting simply does not contain the information provided by the sentence. Agreement may be considered, if one wishes, as truth relative to the setting and clear disagreement as falsity in the setting.

Usually, however, the result of the analysis of the sentence cannot be compared uniquely with the setting since there are quite a number of "locations" of the setting at which it may be comparable. So, we need an additional information specifying the "location".

What is this additional information? In Montaguan analysis it is a model selected from the family of possible models contained in an interpretation frame by means of a possible worlds index, one or more time point indices (time of utterance, time at which an event is to be taken true at etc.), the speaker index, the audience index, the pointer index (specifying the objects pointed at) etc. etc. What is my alternative to the possible worlds-and-times models? The possible worlds correspond - roughly - to stories relating particular events or facts and the times to circumstantial determiner expressions composed of circumstantial conjunctions and sentences (like "when p", "immediately after p" etc.) "pointing" to particular situations in the field of events or facts related by the stories.

To be precise, the situation is a bit more complicated in two respects: (a) Since we are not interested in the particular phrasings by which the fields of events or facts are related, the possible worlds should rather correspond to equivalence classes of stories (all elements of which relate the same field) and times to equivalence classes of circumstantial expressions referring to the same event in the field presented by a story. (b) Furthermore, I assume that a particular interpretation frame comprises not only one story but a story for each modal sector, one for present, one for the past, one for expected events, one for planned actions etc., one for alternatives already introduced into the discussion for the past, expected, planned ... fields etc.

In interpreting a sentence, one will first have to determine the modal sector on the basis of the modal operator of the sentence to be interpreted - I take "modals" in the wide sense including tense, mood, aspect etc. - and then to interpret the sentence radical - i.e. the sentence expression minus modal operator (tense, mood, aspect) - in that modal sector.

More formally expressed, we shall have to have a set $\underline{G}(F)$ of fields of facts or events - to be called facts-structures -

as set-theoretical constructs over F^8 , a set of modal sector indices Mod , and an assignment of facts-structures to modal sector indices (i.e. the elements of $\underline{G(F)}^{\text{Mod}}$). Moreover, for each element $\underline{g}$ of $\underline{G(F)}$, the class $\underline{c(g)}$ of circumstances is determined by a general definition (to be given below) and, therefore, also the class $\underline{C(G(F))}$ of all circumstances. The circumstances of a facts-structure are in one-one correspondence to the occurrences as usually defined⁹.

Elements of $\underline{G(F)}$ are denoted by story radicals to be defined as expressions of a story language $\underline{K(L)}$ and elements of $\underline{G(F)}^{\text{Mod}}$ are denoted by stories in a mode (past, present, expected, planned ...). The circumstances are denoted by circumstantial determiner expressions. We assume equivalence relations $\underline{\text{syn}}$ defined over the set of story radicals, and circumstantial determiner expressions on the basis of which $\underline{K(L)}/\underline{\text{syn}}$ and $\underline{C(K(L))}/\underline{\text{syn}}$ are determined such that there is a one-one correspondence between $\underline{G(F)}$ and $\underline{K(L)}/\underline{\text{syn}}$ and $\underline{C(G(F))}$ and $\underline{C(K(L))}/\underline{\text{syn}}$.

4. In order to facilitate understanding, I shall give the definitions and illustrate the essential features of an interpretation frame for talk on chess, i.e. the systems $\underline{L}$, $\underline{K(L)}$, $\underline{C(K(L))}$ and $\underline{(F)}$, $\underline{G(F)}$ and $\underline{C(G(F))}$ for chess. Before presenting the formal definitions, I shall remind the notation and illustrate the important aspects by discussing a section of the game. Chess is one of those games executed by a sequence of moves by the players. One move-cycle determines for each player exactly one move, the move he is playing in that cycle. The most explicit conventional notation for a simple move is given by means of quadruples of the form

$$(\alpha) \quad \underline{Q_1 P_m} - \underline{P'_m}$$

or quintuples of the form

$$(\beta) \quad \underline{Q_i P_j} \rightarrow \underline{Q'_i P'_j}$$

where (α) is read

"moves the piece of type Q_1 on position P_m to position P'_m "

and (β) is read

"captures the piece of type Q'_1 on position P'_j by means of [his] piece of type Q_1 on position P_j "

We see that Q_1 , Q_i and Q'_1 are to be filled by expressions denoting types of pieces and P_m , P'_m , P_j , P'_j by expressions denoting positions of pieces. (We neglect notation for checking (ch), for rochade, for capturing in passing etc.)

The i -th move cycle is denoted by an expression of the form

$$i. \underline{X}, \underline{Y}$$

where $\underline{X}$ and $\underline{Y}$ are expressions of simple moves i.e. expressions of form (α) or (β) . It is to be understood that $\underline{X}$ denotes the i -th move of the player White and $\underline{Y}$ denotes the i -th move of player Black. To make this convention explicit we introduce names of the player roles namely $\underline{Wh}$ and $\underline{Bl}$ and express a move cycle by the conjunction of two simple moves, one for each player.

$$i. \underline{Wh} \underline{X} \wedge \underline{Bl} \underline{Y}$$

In this denotation the $\underline{X}$ and $\underline{Y}$ are to be taken as one place predicates and the conjunction as an action state description of the game. An action state description is a sentence of our analysis language $\underline{L}$ for talk about chess in some language $\underline{S}$ and it denotes a basic fact of action in the game, namely a move of White and a move of Black. The union of the possible moves of White and those of Black constitute our system $\underline{F}$ of facts¹⁰. The conjuncts $\underline{Wh} \underline{X}$ and $\underline{Bl} \underline{Y}$ are simple sentences of $\underline{L}$ and denote constituents of basic facts.

What are, in our case, the reports or stories and the facts-structures they denote, i.e. what are the systems $\underline{K}(\underline{L})$ and $\underline{G}(\underline{F})$? Reports or stories are simply strings of sentences which are action state descriptions of $\underline{L}$ together with a mode sector specification (past, present etc.). Not all of these will be possible reports on chess games, because the sequence of moves is constrained by the rules of the game. So, in taking account of the rules of the game, we could determine the reports on chess which are in accordance with the rules of that game. We shall not, however, discuss this subset here. Facts-structures are simply strings of basic facts, i.e. elements from the free semigroup over basic facts (with respect to "concatenation", i.e. a binary associative and non-commutative operation " $\bullet$ "). The system $\underline{G}(\underline{F})$ is therefore a straight forward set-theoretical construct on the basis of $\underline{F}$.

What are circumstantial determiner expressions and the circumstances? It is more difficult to explain this in all generality in simple words. But let me present an example.

Let the following diagram present the configuration before the i -th move cycle:

<u>R</u>				<u>R</u>	<u>B</u>	<u>K</u>	
<u>P</u>	<u>P</u>		<u>B</u>		<u>P</u>	<u>P</u>	<u>P</u>
		<u>P</u>	<u>Q</u>				
<u>Kt</u>							P
						P	
		Kt	B	Kt			
P	P	P			P		
	K	Q	R				R

The sequence of move cycles following this configuration is

i. Wh Kt e3 - c4 ^ Bl Q d6 - c7
i+1 Wh B d3 - g6 ^ Bl P h7 x g6
i+2 Wh P h5 x g6 ^ Bl Kt a5 x c4
i+3 Wh R h1 - h8 ch ^ Bl K g8 x R h8
i+4 Wh R d1 - h1 ch ^ Bl K h8 - g8
i+5 Wh R h1 - h8 ch ^ Bl K g8 x R h8
i+6 Wh Q c1 - h1 ch ^ Bl K h8 - g8
i+7 Wh Q h8 - h7 mate

Note that the i+3rd and the i+5th move of White and Black and the i+4th and i+6th move of Black are exactly alike. If, then, we say

- (1) "White moved his rook on position h1 to position h8 (thereby checking)"

or if we say

- (2) "Black captured the rook (on position h8) by his king (on position g8)"

we do not make a definite statement. Even if we add "the first time" or "the second time" we are not sufficiently specific since White may well have moved already earlier his rook from h1 to h8¹¹. But under which circumstances did White make the move? Well, we might say

- (3) "In the next move after having cleared the rooks file by capturing Black's pawn on g6 by his pawn on h5"

thereby expressing that the move after i+2 was meant, or we might say

- (4) "In the move before checking first the queen with his queen and then arriving at check mate by moving the queen to h7 (where the king could not capture her because of her being protected there by the pawn on g6)"

thereby referring to White's move in the $i+5$ th move cycle. The expressions (3) and (4) are circumstantial determiner expressions. They determine the circumstance at which (1) is to be taken as having taken place by referring to other moves that occurred before after the move referred to. It should be clear that we could also have referred to what Black did before or after the move meant. It is, however, essential that the circumstantial determiner refers to a move or a sequence of moves unique in the game we are talking about. Otherwise we may still not know exactly for which of the move cycles we are to evaluate a statement like (1).

One may ask, whether we could not simply refer to the sequential number of the moves. In the written standard versions, it is true, the sequential numbers are always printed. But in recalling a game I do not think that, ordinarily, we recall the sequential numbers. We rather recall the string of moves and may construct from this knowledge the sequential numbers if needed. I want to follow this procedure in my analysis; the sequential numbers are constructed on the basis of a string of move cycles, of a game reported. We may now, after this illustration, turn to the formal definition of the languages $\underline{L}$ and $\underline{K}(\underline{L})$ and the facts-system $\underline{F}$ and facts-structure system $\underline{G}(\underline{F})$ as well as to the general definition of circumstantial determiners in $\underline{K}(\underline{L})$ and circumstances in $\underline{G}(\underline{F})$.

5. Expressions, facts-structures, denotations, and truth

a. The basic language $\underline{L}$ ^{11a} will contain a set Ind of individual constants denoting players (elements from a basic set Ind for the set-theoretical hierarchy in which $\underline{F}$ and $\underline{G}(\underline{F})$ will be constructed) and a set Pred of one-place predicates denoting moves (elements of Pred which is also a basic set). In addition to this descriptive vocabulary of basic expressions, $\underline{L}$ will contain expressions for logical connectives of the proposition calculus as well as brackets. With their help we define the complex expressions of the following types: atomic formulas, molecular formulas and (action-)state descriptions. Each action state description denotes a function

assigning to each player exactly one move; each function will be called an (action-)state. Each atomic formula denotes the set of states in whose state description it occurs^{11b}. The sets of states denoted by molecular expressions may be computed in the usual way^{11c}.

The alphabet of language $K(L)$ contains in addition a two-place functor " $\circ$ "; with its help we may form story radicals in a recursive way, starting from atomic story radicals taken as identical with (action-)state descriptions of L . Story radicals denote strings of action states (formed with the help of two-place associative and non-commutative function denoted by " $\circ$ ").

The alphabet of $K(L)$ contains, moreover, a set Mod of mode operators - corresponding to past, present etc. -, forming story-sentences from story radicals. The denotation of a story sentence is a pair (x, y) such that x is an element from a set Mod of mode sector indices and y is a string of (action-)states.

Circumstantial determiner expressions will have to be formed from an expression with a variable " $*$ ", prefixed by a λ -expression " $\lambda*$ ". The language will, therefore, have to contain in its alphabet the additional symbols " λ ", " $*$ ", and, furthermore, square brackets. The latter serve to build applications of circumstantial determiner expressions on atomic story radicals - ' $[\lambda* x \circ y] z$ ' is an example for such an application expression. It is to be taken as equivalent to $x \circ z \circ y$ -. Circumstantial determiner expressions denote circumstances and applications denote the same entities as their corresponding story radicals, namely strings of (action-)states.

The following is a more formal presentation of what has just been outlined.

b1. The definition of $\underline{L}$

The alphabet of $\underline{L}$ consists of

- (a) a finite set $\underline{Ind}$ of individual constants - $\underline{Ind} := \{\underline{Wh}, \underline{Bl}\}$.
- (b) a finite set $\underline{Pred}$ of one place predicate constants - $\underline{Pred}$ is the union of the Cartesian product $\overline{Q} \times \overline{P} \times \{-\} \times \overline{P}$ with the Cartesian product $\overline{Q} \times \overline{P} \times \{x\} \times \overline{Q} \times \overline{P}$, where $\overline{Q}$ and $\overline{P}$ are finite, disjoint sets of symbols¹².
- (c) the symbol $\text{"},"$ as a one-place connective - the unique element of the set $\underline{Con}^1$, a subset of the set of one-place Boolean connectives in $\underline{L}$.
- (d) a finite set $\underline{Con}^2$ of two-place connectives - a subset of the set of two-place Boolean connectives. $\underline{Con}^2$ should at least contain $\text{"}\wedge\text{"}$, the symbol for Boolean conjunction.
- (e) the brackets "(" and ")" .

The rules of $\underline{L}$ are:

- (f) If $x \in \underline{Ind}$ and $y \in \underline{Pred}$, then yx is an atomic formula.
- (g) If x is an atomic formula, then x is a molecular formular.
- (h) If x is a molecular formular, then $\text{"},x\text{"}$ is a molecular formula.
- (i) If x and y are molecular formulas and z is a two-place connective ($\in \underline{Con}^2$), then $\text{"}(xzy)\text{"}$ is a molecular formula.
- (k) If x and x' are elements of $\underline{Pred}$, then $\text{"}(\underline{Wh} \ x \ \wedge \ \underline{Bl} \ x')\text{"}$ is an action state description.

b2. The definition of $\underline{K}(\underline{L})$

The alphabet of $\underline{K}(\underline{L})$ consists of

- (a) the alphabet of $\underline{L}$ plus
- (b) the set $\underline{Mod}^1$ of one-place mode operators - $\underline{Mod}^1 := \{\underline{P}, \underline{N}\}$ - which are non-Boolean connectives.
- (c) the two-place connective $\text{"}\circ\text{"}$, which is also non-Boolean, but associative and not commutative.

The rules of $\underline{K}(\underline{L})$ are

- (d) If $\underline{x}$ is an action state description of $\underline{L}$, then $\underline{x}$ is an atomic story radical.
- (e) If $\underline{x}$ is an atomic report radical, then $\underline{x}$ is a story radical.
- (f) If $\underline{x}$ and $\underline{y}$ are story radicals, then ' $\underline{x}\circ\underline{y}$ ' is a story radical.
- (g) If $\underline{x}$ is an atomic story radical, then ' $\underline{N}\underline{x}$ ' is a sentence.
- (h) If $\underline{x}$ is a story radical, then ' $\underline{P}\underline{x}$ ' is a sentence¹³.

b3. The definition of circumstantial determiners ($\epsilon(\underline{C}(\underline{K}(\underline{L})))$)

Circumstantial determiners will be defined in an extended language $\underline{K}'(\underline{L})$.

Definition of the extended language $\underline{K}'(\underline{L})$:

The alphabet of $\underline{K}'(\underline{L})$ consists of

- (a) the alphabet of $\underline{K}(\underline{L})$ plus
- (b) variable $*$ for atomic story radicals of $\underline{K}(\underline{L})$
- (c) the symbol " λ "
- (d) the brackets "[" and "]".

The rules of $\underline{K}'(\underline{L})$ are

- (e) the rules of $\underline{K}(\underline{L})$ plus
- (f) If $\underline{x}$ and $\underline{y}$ are story radicals, then ' $\lambda*\underline{x}\circ*\circ\underline{y}$ ' is a circumstantial determiner expression¹⁴.
- (g) If $\underline{x}$ is a circumstantial determiner expression and $\underline{y}$ is an atomic story radical, then ' $[\underline{x}] \underline{y}$ ' is an application of a circumstantial determiner expression on the atomic story radical¹⁵.

The application $[\lambda*\underline{x}\circ*\circ\underline{y}]\underline{u}$ is to be taken as equivalent to the story radical $\underline{x}\circ\underline{u}\circ\underline{y}$ (i.e. λ -conversion holds).

c. The definition of $\underline{F}$, $\underline{G}(\underline{F})$ and $\underline{C}(\underline{G}(\underline{F}))$

We take $\underline{\text{Ind}}$ - the set of individuals - and $\underline{\text{Pred}}$ - the set of moves - as basic sets. $\underline{F}$ is the set of functions with domain $\underline{\text{Ind}}$ and values in $\underline{\text{Pred}}$; we shall call $\underline{F}$ the set of states. Let $\bullet$ be a two-place associative and non-commutative function. Take $\underline{G}(\underline{F})$ as the idempotent¹⁶ semi group $\underline{F}^*$ with respect to $\bullet$ with $\underline{F}$ as a set of generators. The elements of $\underline{G}(\underline{F})$ will be called strings of states.

With respect to $\underline{G}(\underline{F})$ we may proceed to the general definition of circumstances in a string ϕ . The definition requires the auxiliary definitions of embedding function, substring, unique embedding function and circumstantial equivalence of strings.

Let $\phi, \phi_1, \phi_2 \dots \phi'_1, \phi'_2 \dots$ be strings over the set $\underline{F}$ of models, i.e. elements of $\underline{F}^*$ (or $\underline{G}(\underline{F})$).

- (1) The embedding function determined by the pair of strings $(\phi_1, \phi_2) - [\text{Emb}(\phi_1, \phi_2)]$ - is that function from $\underline{F}^*$ into $\underline{F}^*$ which for an argument ϕ_0 yields $\phi_1 \circ \phi_0 \circ \phi_2$ as a value.
- (2) ϕ_0 is a string of ϕ iff there is a pair of strings (ϕ_1, ϕ_2) and an embedding function $[\text{Emb}(\phi_1, \phi_2)]$ such that $[\text{Emb}(\phi_1, \phi_2)] \phi_0 = \phi$.
- (3) An embedding function determined by (ϕ_1, ϕ_2) is a unique embedding function in ϕ iff there is a $c (c \in \underline{F})$ and exactly one pair (ϕ'_1, ϕ'_2) - called the frame for (ϕ_1, ϕ_2) in ϕ - such that

$$[\text{Emb}(\phi'_1, \phi'_2)] [\text{Emb}(\phi_1, \phi_2)] c = \phi$$

- (4) Let $[\text{Emb}(\phi_1, \phi_2)]$ and $[\text{Emb}(\phi_3, \phi_4)]$ both be unique embedding functions in ϕ . Then they are circumstantially equivalent in ϕ iff

$$\phi'_1 \circ \phi_1 = \phi'_3 \circ \phi_3$$

(where (ϕ'_1, ϕ'_2) and (ϕ'_3, ϕ'_4) are the frames for (ϕ_1, ϕ_2) and (ϕ_3, ϕ_4) resp.).

- (5) A circumstance in a string ϕ is an equivalence class of unique embedding functions in ϕ under circumstantial equivalence.

d. Interpretation for $\underline{K}(\underline{L})$ and circumstantial determiner expressions

An interpretation for $\underline{K}(\underline{L})$ is a function M with $\underline{K}(\underline{L})$ as domain and values in $\underline{G}(\underline{F})$ resp. $\{\{\Lambda\}, \{\{\Lambda\}\}\} \times \underline{G}(\underline{F})$. It may be recursively defined as follows:

- (1) $M(\underline{Wh}) = \underline{Wh}$;
- (2) $M(\underline{Bl}) = \underline{Bl}$;
- (3) $M(\underline{m}_i) = \underline{m}_i$ for all $\underline{m}_i \in \underline{Pred}$ and all moves $\underline{m}_i$;
- (4) $M(\underline{Wh} \underline{m}_i \wedge \underline{Bl} \underline{m}_j) =$ that function $(\in \underline{F})$ assigning $\underline{m}_i$ to $\underline{Wh}$ and $\underline{m}_j$ to $\underline{Bl}$.

The recursive specifications are (for string-radicals x, y):

- (5) $M(\underline{x} \circ \underline{y}) = M(\underline{x}) \bullet M(\underline{y})$;
- (6) $M(\underline{Nx}) = (\{\Lambda\}, M(\underline{x}))$;
- (7) $M(\underline{Px}) = (\{\{\Lambda\}\}, M(\underline{x}))$.

For circumstantial determiners and their application we have

- (8) $M(\lambda * \underline{x} \circ * \underline{y}) =$ that function $(\in \underline{G}(\underline{F}))$ assigning to each state description $\underline{z}$ the string ' $M(\underline{x}) \bullet \underline{z} \bullet M(\underline{y})$ ';
- (9) $M([\lambda * \underline{x} \circ * \underline{y}] \underline{z}) = M(\underline{x} \circ \underline{z} \circ \underline{y})$.

e. Communicative evaluation

The result of the analysis of a sound event x by the analysis part of the interpretation frame $I(x)$ may be compared with the particular setting of the interpretation frame. This comparison may yield either agreement, disagreement or neither agreement nor disagreement. If there is agreement, we shall also say that the comparison yields the value γ (yes), if it is disagreement the value $\mathcal{N}$ (no), and if neither, the value σ (neutral)¹⁷.

Depending on the value assigned to an utterance one may further proceed to change the particular setting. If the value assigned is σ and the interpretation frame $I(x)$ contains a mark $\mathcal{L}$ ("confidence") then the result of the interpretation may be added to the interpretation frame (at an appropriate location). By this operation x is taken as a communication, e.g. as an informative communication or as a counsel, in which case it is to be added to the mode sector of planned actions.¹⁸⁾

Which are the conditions for agreement or disagreement? As it stands, our model can only yield agreement or disagreement for sentences analyzed as expressing state descriptions in a certain mode. In this case, if x can be taken as an utterance of some sentence $\underline{s}$ (of the language $\underline{S}$ to be analyzed) and $\underline{s}$ is analyzed as the atomic report radical $\underline{ap}$ (of $\underline{L}$) which is interpreted by a pair of a mode sector index $\underline{a}$ and a state $\underline{p}$ (i.e. an element of $\underline{F}$), then the value $\underline{y}$ may be assigned to $(x, \underline{s})$ iff either the $\underline{a}$ -sector of the particular setting of $I(x)$ contains exactly $\underline{p}$ or the circumstance of the $\underline{a}$ -sector of the particular setting of $I(x)$ is $\underline{c}$ and $[\underline{c}]\underline{p}$ is a unique substring of the string of states of the $\underline{a}$ -sector¹⁹. The comparison yields the value $\underline{N}$ iff $[\underline{c}]\underline{p}$ is not a substring of the string of states of the $\underline{a}$ -sector. A more general condition for agreement will be given in the appendix.

6. Illustrations

Let us assume the sequence of moves in a game of chess as discussed above (see p.12), and a discussion between observers at the last move. During this discussion, one observer may produce a sound event x that may be taken as an utterance of the sentence

($\underline{s}$) White moved his rook to h 8 thereby checking and Black captured the rook by his king.

The analysis situation shall include an interpretation frame comprising (a) the linguistic devices for analyzing the sentence and producing an interpretation, (b) general theoretical "knowledge" comprising the rules of chess and strategies for chess, and (c) as a particular setting (at least) the sequence of action states corresponding to the state descriptions i to $i+7$ on p.12 and the configuration present before move cycle i , and, as a circumstance in the setting, the embedding function $\text{Emb}(\phi, \underline{g})$, where $\underline{g}$ is the state corresponding to the state description rendered in $i+4$.

Now, by means of (a) and (b) the analysis translates s into

(s) P Wh R h1 - h8 (ch) $\wedge$ B1 K g8 $\times$ R h8

Since the mode operator is P (= past), the action state description following it is to be interpreted by ($\{\{\Lambda\}\}, f$) such that f is that function assigning to player White the action of moving his rook from h1 to h8 and to player Black the action of capturing this rook by his king.

The comparison of this interpretation with the particular setting shows that there are two such action states in the setting. However, the setting contains also the embedding function $\text{Emb}(\phi, q)$ which "points" to the move cycle $i+3$. Since the embedding of the move cycle $i+3$ into the embedding function is indeed a substring of the string in the past-sector, the comparison results in agreement. Had the embedding function been $\text{Emb}(q', \phi)$, where q' is the state expressed by the state description in $i+1(!)$ the comparison results in disagreement. Since in this case the theoretical setting, namely the rules of chess, would show, that the move expressed by s would be impossible at this particular setting, the sentence s cannot really be considered as claimed by the speaker and must somehow indicate an error by the speaker or a misunderstanding of the communication of the appropriate circumstance as taken over into the interpretation frame from a situation earlier in the discussion.^{19a}

7. Change of interpretation frame

So far we considered only one particular analysis situation, in which the interpretation frame of the situation is applied onto the sound event of that situation producing the interpretation of that sound event in terms of language analysis and setting. But this interpretation is not the only outcome of the application of the interpretation frame; the other outcome is a change of the interpretation frame itself into an interpretation frame that would be part of the next analysis situation, if there were a further sound event to be interpreted. The communicated sound does not only require interpretation, it usually also modifies the particular setting, sometimes the

general setting (theories, doctrines, general beliefs) and at times even the language structure (i.e. the central part of the frame). If we consider the particular setting to be a kind of information state of the interpretation frame, then the sounds communicated ordinarily change the information states (and only sometimes the "system" consisting of general "theoretical" and linguistic dependencies)²⁰.

A particularly simple case of a change of information state is the one where the information state may be represented by a story in the past and the sounds producing it are simply the sequence of utterances of the corresponding sentences in the present. This kind of change of information change occurs typically in somebody listening to a direct report given by an observer at the scene whom the listener pays confidence. I shall not further discuss the forms of the change of particular settings; they will usually be much more complicated than just indicated²¹.

Another important generalization of the notion of analysis situation should also be mentioned. Not only sounds which are utterances of sentences or words of some language may change the settings of interpretation frames; the corresponding observations will do the same, if the interpretation of such observations is available in terms of an interpretation frame. Moreover, the acts of speakers accompanying the production of the communicative sound events (such as pointing as well as gestures, mimics or other signaling movements) are very important data²². Considering this, the notion analysis situation will have to be generalized as follows: An analysis situation consists of a pair $(x, I(x))$, where x is a triple of percepts (x_1, x_2, x_3) and $I(x)$ is an interpretation frame for that triple. x_1 is the percept of a sound event, x_2 the percept of accompanying signaling acts and x_3 the percepts of the occasion. $I(x)$ produces an interpretation for x and, depending on that interpretation, a next interpretation frame $I(x')$ for a next percept x' .

8. Remarks on concepts of time

In the framework discussed so far "time" is represented (a) by the classificatory distinction of sectors of the particular part of the interpretation frame as well as an order relation

for each sector implicitly given by the two place associative and non-commutative function, and (b) by the strings of percepts or analysis situations discussed in the last paragraph. (a) and (b) are correlated; this has been discussed in the case of a sequence of utterances by an observer or by the sequence of corresponding observations. Note, that we assumed that the set $G(F)$ of strings of states should be an idempotent semi group. The reason was, that we did not want to say that a next state has started if that next state was characterized exactly like the previous one. A sequence of states comes only about if we have change of states.

We may ask, whether, on the one hand, our concepts are the most primitive ones and whether, on the other hand, they are sufficient for the purposes of linguistic analysis. Both questions have to be answered in the negative. As soon as our language contains words like "recently", "soon" etc. we have to analyze either more primitively or in a more sophisticated way.

Let us start by the first. I think the most primitive basis of the notion of time is the contrast between the presence of a perception and its having vanished suddenly. This distinction may be expressed by "p" - "no more p". As an example consider the mother leaving the child in his bed in the evening switching off the light: "light" - "no more light". There is an internal remnant of seeing light though there is no longer light. The inverse contrast occurs in learning a sequence of events. When the first event has occurred, an "expectation" of the next is formed but the event is not yet present and then the event is in fact present. Hearing the mother open the door, when it is dark in the room, may create the expectation of light and then there actually is light.

Linguistically the second contrast is rather expressed by an utterance of "light" together with a certain intonation or other means of accompanying signaling followed by "there-light" when it actually is present. In an early stage of learning when just these two contrasts are there, there is already the most primitive notion of time, and, obviously, it is related to the concepts of "(very) recently" and "(very) soon".

The next stage after this most primitive notion of time is, I assume, a classificatory notion of time with the mode sectors recent past, present, and the various futures (expected, desired, feared etc.), each sector comprising an unordered set of states. It may be that, parallel to these sectors, there are already "theoretical" sectors, which are non-temporal though related and partially determining the temporal²³.

The next stage is, then, the introduction of temporal relations as "before" or "after", which all might be defined in terms of a corresponding primitive of concatenation. With these concepts we reach the conceptual level of time assumed by our analysis above.

From there we may proceed further (a) by assigning to each state a duration and (b) by assigning to each state an interval on a dense linear scale. If we assume furthermore that there is only one such scale the time axis onto which all real states are to be mapped and that that scale may be rendered by the set of real numbers, we have, finally, reached the sophisticated notion of time of classical physics. For relativistic physics we have to introduce one such time scale for each relativistic system together with a system of mappings between the systems depending on their movement relative to each other.

In order to relate our system to temporal notions referred to under (a) and (b) I shall define the following languages $\underline{K}'(\underline{L})$ and $\underline{K}''(\underline{L})$ to be interpreted with respect to (quantitative) value spaces.

Definition of the language $\underline{K}'(\underline{L})$

The alphabet of $\underline{K}'(\underline{L})$ consists of

- (a) the alphabet of $\underline{K}(\underline{L})$
- (b) a denumerable set D of numerical functors - $d_1, d_2, \dots, d_i \dots$
being elements of D -
- (c) the numerical addition symbol '+'
- (d) the numerical identity symbol '='

The rules of $K'(\underline{L})$ are:

- (e) The rules of $K(\underline{L})$ plus:
- (f) For each $d_i (d_i \in D)$ if x is a report radical, then $d_i x$ is a temporal duration expression.
- (g) If x and y are temporal duration expressions, then ' $x+y$ ' is a temporal duration expression.
- (h) If x and y are temporal duration expressions, then ' $x=y$ ' is an identity sentence.

We may require the following axiom to hold (as usual):

For each $d_i (d_i \in D)$ if x and y are report radicals, then $d_i xoy = d_i x + d_i y$.

Definition of language $K''(\underline{L})$

The alphabet of $K''(\underline{L})$ consists of

- (a) the alphabet of $K(\underline{L})$,
- (b) a denumerable set T of interval functors - $t_1, t_2, \dots, t_j, \dots$ being elements of T - ,
- (c) a functor l .

The rules of $K''(\underline{L})$ are:

- (d) The rules of $K(\underline{L})$ plus:
- (e) For each $t_j (t_j \in T)$, if x is a report radical, then $t_j x$ is a temporal interval expression.
- (f) If x and y are temporal interval expressions, then ' $x=y$ ' is an identity sentence.
- (g) If x is a temporal interval expression, then ' lx ' is a temporal duration expression.

$K'(\underline{L})$ will be interpreted as $K(\underline{L})$ with the additional (natural) proviso that temporal duration expressions denote real numbers, addition and identity being defined as usual.

$K''(\underline{L})$ will be interpreted as $K(\underline{L})$ with the additional proviso that temporal interval expressions designate intervals in the strictly ordered set of real numbers and that the temporal duration expression obtained from an interval expression denotes the length of the interval.

We assume that the set of temporal interval expressions is only partially interpreted: Only "factual" expressions will have an interpreted temporal interval expression and will thereby get located on the one and only time scale represented by the real numbers. The other expressions which are simply stories, fairy tales etc. will not have interpreted temporal interval expressions.

9. Notions of time

There are philosophical notions of time such as e.g. Augustine's that would require us to bring in additional concepts. Since these concepts are important anyway, I shall briefly discuss them. In the Confessions XI 28,38 Augustine refers to the realization of a song. Before starting to sing it, it is completely in the mode sector of plans (or expectation - as Augustine says). During the song, part of it has already been transferred to the mode sector of past and part of it is still in the mode of planning. In the present there is just my attention: "praesens tamen adest attentio mea, per quam traicitur quod erat futurum, ut fiat praeteritum." Gradually, then, the past, as much as it refers to the song, becomes longer and the plan still to be executed with respect to the song becomes shorter. Augustine concludes this passage by philosophical generalization that the same holds for the parts of the song the syllables and their parts as well as with the longer processes of which the song is a part, the action scheme of the singer, his life and the socio-historical process his life is part of. The same may be applied to the game of chess discussed above. It was part of a game between Mannheimer (Wh) and A.N. Other (Bl), which in turn was a part of a championship in Regensburg 1912 which were part of the lives of the players etc.

Augustine concludes the famous chapter XI by taking up the same theme and drawing theological conclusions (cp. 3141). He conceives of a spirit having complete knowledge of everything past and future in the same way as a human being knows a song. He would still not be God, as Augustine conceives him, since

through expectation and memory his feelings and perceptions are separated, which is not the case for God. It is because of this that He is non-temporal. Human beings are temporal exactly because first, they do not know the "order of things", and second, their distribution in past, present, and expected or planned future absorbs them in passions. "At ego in tempora dissilui, quorum ordinem nescio, et tumultuosis varietatibus dilaniantur cogitationes meae, donec in te confluam purgatus et liquidus igne amoris tui" (XI, 29,39).

These last passages show that for Augustine accounts in terms of our modern physicalistic "time" scale do not involve a concept of time at all, since time involves (a) that new, unforeseen events or facts may happen and (b) that feelings and perceptions divided into past, present, and future be involved. Note, that the "order of things" is something like the constitution of the actual world as it actually is. It, therefore, does not correspond to a "theory of things" which would comprise in addition the regularities manifested in the "order of things" (though, for Leibniz, both accounts would come to the same).

Note that the puzzles of explanation and prognosis come only about, when a theory of regularities of events of some type (e.g. physicalistic) is not only confronted with a distribution of events over a time scale but also some user of the theory is localized at a particular time point on the time scale, thereby determining past, present, and future on the time scale. Carnap distinguishes in this connection between absolute and relative time scales (coordinate systems): "A coordinate system is absolute for a person, if-if the specification of an object in the system tells him the spatial relation (so to speak, the path) between his own position and the object." (Carnap (1970), p. ...). In terms of this, we may say that for Augustine a relative time scale is not a time scale at all.

10. A further generalization

But the essential lesson to be drawn in our case from Augustine's analysis of singing a song seems to be the following: There is a cross-correlation between the events and facts in different sectors and there is even a hierarchy of parts and wholes of such cross-correlating facts. We shall call such a cross-correlating fact "under" which the facts that constitute it, whether they occur in the same mode sector or not, a particular topic. Augustine's particular topic is first that of singing a song, then that of its scenic context, then that of the life of the singer etc. The particular topics form a hierarchy. In our example: Under the topic of a capturing move we may for instance state that the player just removed the piece captured and was now going to move his capturing piece to the position of the piece removed. Under the topic of the ongoing game we may refer to the capturing move just described as well as to past and expected moves of the game. Under the topic of a championship at Regensburg 1912 we may refer to that game as one that occurred after so-and-so games and that so-and-so many games will still have to be played. Under the topic of the chess biography of Mannheimer we may refer to the championship at Regensburg 1912 as one of a sequence of others constituting this biography.

These particular topics must be distinguished from the general topics, characterizing theories, fields of general knowledge, involving in our example e.g. the concepts, rules and strategies for chess in general (and not particular chess games).

According to these remarks we have to generalize our model further: The particular part of the setting should contain the indication of a particular topic in addition to mode sector index, fact structure, and circumstance. In our example discussed on p.12, the fact-structure would contain in the past sector the configuration and the sequence of moves as expressed and a circumstance is a particular move cycle as indicated by a circumstantial determiner. But there would also be a particular topic index indicating that the particular topic is a particular game that took place between Mannheimer and A.N. Other at a championship at Regensburg 1912.

To sum up: Instead of possible worlds, we have contents of stories under various topics for the grammatically determined mode sectors and instead of time indices we have circumstances rendered by circumstantial determiner expressions. Dates and clockreadings are special cases of circumstantial determiners available only at advanced stages of language development and therefore not primarily to be connected with an explication of tense.

Footnotes

- ¹The interpretation may, moreover, depend on the circumstance where the field of reference is clear, but where it is not yet clear, how the utterance is to be taken - straight forwardly (e.g. as a factual claim or assertion), ironically, representatively (as on the stage), or as not meaning really what it seems to mean, but meaning rather something that could be rendered more directly by another expression or - finally - even as a code of such another expression.
- ²Quine calls them sentences with indicator words (see Quine (1960), p. 35 ff., p. 173 and elsewhere).
- ³The term "origin" is Bühler's (cf. Bühler, 1934). The marking acts within occasions provide for what Bühler calls "deixis ad oculos". Circumstantial determination in the strict sense introduced below is a case of what Bühler calls "deixis ad phantasma".
- ⁴Quine seems to think that standing sentences are essentially connected with the notion of present perfect. I doubt that the "tolerable time interval" between the occasion that prompts an utterance in present perfect and that utterance itself is to play an essential role in the analysis of present perfect, as Åquist and Günthner (1976) seem to assume.
- ⁵Note that the ongoing game as such is not a part of the occasion as it is present via stimuli. The occasion is rather taken as belonging to a class of occasions (or even some structure) manifesting the ongoing game. The same holds, obviously, for the championship.
- ⁶By the way: Why only take possible worlds and not possible times? It seems that part of the motivation is that with possible times we would have to relate them not only among each other (as in relativistic theory which would require anyway several time scales), but each also to the time point of utterance. If not, we would not be able to talk of some possible time point earlier than the actual time of the utterance.
- ⁷This enables me to present the analysis in a way which is easily comparable to the usual model theoretic analysis.
- ⁸Below we shall take simply strings over $\underline{F}$, i.e. elements of a semi group $\underline{F}^*$ with $\underline{F}$ as a set of generators.
- ⁹E.g. for strings where each occurrence of a string $\underline{g}$ is determined by an initial string in the string $\underline{g}$. A circumstance is, by contrast, the class of all strings containing exactly one initial string - the standard "determiner" of the circumstance, somehow - and all other strings occurring as substrings in $\underline{g}$ and determining the same "position" as the given initial string. This impressionistic account will be made more precise below.

- ¹⁰ The basic facts cannot yet, i.e. in the present description, be reduced to a set theoretical construct over the individuals of the language, the players. This can only be done in a more complete description of the game referring also to the pieces and positions as individuals and to their configurations, as I shall show in the appendix. I, therefore, assume, provisionally, an analysis like that of Carnap's Basic System (Carnap (1970), p. 43 ff.) assuming an attribute space for the modality of moves of players in chess (i.e. taking each move as an attribute) and models for these attributes (in the sense of Carnap (1970), p. 54) as appropriate basic facts. We shall provide the details in the definitions below.
- ¹¹ In knowing the rules of the game we may, though, infer that in our configuration this could not have been the case because of the pawns on the rook's file (i.e. file h).
- ^{11a} The language L is a subtype of the type of language described in Carnap (1970). Its sentences are only non-general sentences without the identity sign.
- ^{11b} If there are two players denoted by $\underline{Wh}$ and $\underline{Bl}$ and three moves denoted by $\underline{m}_1$, $\underline{m}_2$, and $\underline{m}_3$, then $\lceil \underline{Wh} \underline{m}_2 \rceil$ denotes the set of states described by $\lceil \underline{Wh} \underline{m}_2 \wedge \underline{Bl} \underline{m}_1 \rceil$, $\lceil \underline{Wh} \underline{m}_2 \wedge \underline{Bl} \underline{m}_2 \rceil$, $\lceil \underline{Wh} \underline{m}_2 \wedge \underline{Bl} \underline{m}_3 \rceil$.
- ^{11c} Compare D3-3 p. 57 of Carnap (1970).
- ¹² The role of the symbols $\bar{Q}$ and $\bar{P}$ becomes clear only in a definition of a language for the description of the configuration of chess boards. There the symbols from $\bar{Q}$ turn out to be properties of the pieces of the game and the $\bar{P}$ numerical values - to be interpreted as coordinates - which a position function assigns to the pieces.
- ¹³ Note that sentences may be derived from complex story radicals!
- ¹⁴ We could also define circumstantial determiner expressions for story radicals if we would interpret the variables as variables for story radicals.
- ¹⁵ An application $\lceil [\underline{x}] \underline{y} \rceil$ may be read as $\lceil \underline{y} \text{ at } \underline{x} \rceil$ or $\lceil \underline{y} \text{ when } \underline{x} \rceil$.
- ¹⁶ An idempotent semi group is a semi group in which the law $x \bullet x = x$ holds. Compare Mal'cev (1973), p. 67.
- ¹⁷ $\mathcal{U}$ could also be interpreted as truth in the interpretation frame and, correspondingly, $\mathcal{N}$ as falsity.
- ¹⁸ If the interpretation frame does not contain serious reasons against taking up the counsel.
- ¹⁹ This resembles, obviously, a truth condition.
- ^{19a} This corresponds to the procedure in Isard (1974). The approach developed in my article has been initiated by Isards analysis.
- ²⁰ This idea is attributed to Harris by Smaby in Smaby (1974).
- ²¹ More complicated changes analyzed by Smaby (1974) Sect. 4.
- ²² Indeed the early stages of language learning would probably be impossible without them.
- ²³ It is interesting to note that Gonda (1958) believes to have evidence that early stages of language development have just this categorial structure with respect to verb modification.

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PREJUDICES, PRESUPPOSITIONS AND THE THEORY OF COUNTERFACTUALS

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*Abstract.*⁰ Two theories of truth for counterfactual conditionals are developed. Both differ from current theories in that their explanations do not stop at the level of a comparative similarity relation of worlds. They differ from one another in that the first one traces comparative similarity, and with it counterfactual truth, back to the *beliefs* of a speaker, whereas the second one takes the *knowledge* of a speaker as its starting point. It is argued that the first theory is preferable to the second one, and that both these clear-cut 'coherence' theories are preferable to any, necessarily vague, 'correspondence' theory.

Turning, then, to questions of presupposition it is shown that a counterfactual conditional can be used appropriately only if its antecedent is believed to be false. This necessary condition for the conversational correctness of a counterfactual statement is discussed in detail, and an attempt is made to justify it in view of some maxims of conversation.

Logics are discussed in an appendix.

§ 0 Introduction

The following pages contain an essay on some of the pragmatic and some of the semantic peculiarities of some kinds of conditional sentences. To be more specific: I shall settle, formally, questions of presupposition and truth in connection with two conditional operators $\Box \rightarrow$, and $\Diamond \rightarrow$ to be read successively as:

If it were the case that...., then it would be the case that....

If it were the case that...., then it might be the case that....

I hope to formally settle these questions such that the result may be regarded as a set-theoretic characterization of the semantic and pragmatic behaviour of counterfactual conditionals in natural language.

In setting out my views, I shall adopt without scruples the method of *possible worlds*. Moreover, in comparing my views with competing ones, I shall

restrict myself to the theories of those who, like myself, have employed this method.¹

What are the truth conditions for statements 'If it were the case that A, then it would be the case that B'? Several² answers to this question have been offered in the past few years, yet none of them is completely satisfactory. Part of the problem is still to be solved: an important part, as some of the authors involved admit; a part which cannot be solved without falling into vagueness, as the others argue. To explicate this point I shall here compare the views of Stalnaker (1968) with those of Lewis (1973).

Loosely speaking³, we can say that both their accounts are alike in that they take a counterfactual $(A \Box \rightarrow B)$ to be true in a possible world w iff the consequent B is true in all worlds w' in which the antecedent A is true and *which in other respects resemble w as closely as possible*. Yet differences appear when we ask them for an elaboration of the italicized phrase.

Stalnaker takes for granted that exactly one such antecedent-world w' resembling w *in other respects* as closely as possible can be found, and he stresses the point that '*the context of utterance, the purpose of the assertion, and the beliefs of the speaker or his community*'⁴ may make a difference to the particular world w' which has this property. In other words, counterfactuals are *pragmatically ambiguous*. Unfortunately he does not specify *how* these contextual features make that difference to this world w' , but contents himself with specifying some formal constraints on the possible outcome.

I believe that Stalnaker is right on this point of pragmatic ambiguity, and I hope to supply full evidence for it in due course. Moreover, much of what follows can be seen as an attempt to bridge the gap between contextual features on the one hand, and that particular antecedent-world w' resembling w *in other respects* as closely as possible on the other. It will appear, however, that we must drop his assumption that there is always to be found exactly *one* such world w' . Actually, we cannot even be certain of finding one *set* of worlds w' in which the antecedent is true and which *in other respects* resemble w as closely as possible. We are up against several such sets, the members of which *in other respects* all resemble w as closely as possible, but different members of different such sets each *in their own other respects*. 'Each in their own other respects': perhaps we ought to stop talking in terms of resemblance as soon as this notion forces us to use this kind of language.

Lewis, for his part, is rather free and easy with the 'other respects' in

which the antecedent-worlds w' should resemble w as closely as possible. He simply advises us to look whether the consequent is true in all antecedent-worlds w' which are most similar, *overall*, to w , and introduces a comparative overall similarity relation between possible worlds in his formal set up to settle this affair. He admits that this notion is vague, but '*vague in a well-understood way....it is just the sort of vagueness that we must use to give a correct analysis of something that is itself undeniably vague*'⁵. In other words, counterfactuals are, in Lewis's view, *semantically vague* rather than pragmatically ambiguous. He admits that contextual features may be somewhat helpful in narrowing the range of this vagueness, but comparative similarity, and with it counterfactual truth, do not *wholly* depend on context. There are, indeed, only vague borderlines, but that does not mean there are no borderlines at all.

It is my purpose, however, to show that we can do without such a pre-established, vague relation of comparative overall similarity. Instead I shall take Popper's maxim '*Similarity presupposes the adoption of a point of view*'⁶ as my starting point, and show how something like a comparative similarity relation, though it be no comparative overall similarity relation, is *induced* in a set of possible worlds by what I shall call the prejudices and assumptions a speaker holds at a certain moment. I do of course realize that in doing so counterfactual truth will turn out to be speaker-dependent, and that I shall only barter vagueness for subjectivity. Nevertheless, my aim is to convince the reader that the latter is more '*natural*', and much to be preferred to the former.

§ 1 Preliminaries

Giving a set-theoretic description of a phenomenon in natural language is like drawing a cartoon: leave out everything that is not important, exaggerate the few things left, and you may end with the most striking characterization of what is going on.

The first thing to be retained in my cartoon is a non-empty set S of so-called *speakers*. A second set we cannot ill afford to do without is a non-empty set W of so-called (*possible*) *worlds*. Within our set-theoretical model these possible worlds will serve as the situation our speakers might discuss, hear of, think of, or come across in any other conceivable way. A special non-empty subset H of W will serve as the set of those situation that together make up the '*real*' *history*. And, although we shall neglect problems of time and tense as much as possible, we shall sometimes heuristically refer to members of H as '*moments* (of time)'. Our speakers are supposed to utter their sentences at some of these

moments, and to this purpose we introduce a non-empty subset $\mathcal{C}$ of $\mathcal{S} \times \mathcal{H}$ of so-called (*utterance*) *contexts*. In doing so we can take ordered couples $\langle A, \langle s, w \rangle \rangle$, where A is a sentence and $\langle s, w \rangle \in \mathcal{C}$, to represent *assertions*, i.e. utterances of a certain sentence by a certain speaker at a certain moment.

I want to stress that, from the point of view adopted here, questions like "What is a possible world?" and "Do possible worlds really exist?" are rather misleading. A possible world is a *set*, and you may take anything that is a set in virtue of, for instance, the Zermelo-Fraenkel axioms as a possible world. Thus questions about the essence and existence of possible worlds become questions about the essence and existence of sets. These are questions to be asked by people *discussing* set-theory, not by people like us who are *using* it. To put it differently: we are talking about possible worlds in connection with natural language in the same way as physicists talk about electron orbits in connection with atomic spectra. Both electron orbits and possible worlds are nothing but theoretical entities *in a mathematical model* constructed in order to explain some ill-understood phenomenon.

Now you could, of course, restate the first question, and ask: "What kind of ill-understood things are *modeled* by these theoretical entities called possible worlds?" But then you should not be surprised that I can only but repeat the phrase 'any situation one might discuss, hear of, think of, or come across in any other conceivable way'. And in answer to a rewording of the second question, I would say that I believe it is precisely one of these situations which really exists at this very moment.

Of course, we must constantly see to it that our possible worlds do not, in our theoretical frame, behave differently from their alleged sources. But thus far nothing has been mentioned about possible worlds which cannot be said about any situation anyone of us might conceive. I have nowhere stated that any of our speakers $s \in \mathcal{S}$ is capable of conceiving, let alone describing, any possible world $w \in \mathcal{W}$ completely. Moreover, some of our speakers may (partially) conceive of a particular situation, and yet choose the wrong words to describe it; they may think of something that they cannot put into words at all. And, confronted with a situation which they did not conceive of themselves, they may not only choose the wrong words for something they rightly think to be the case, but also wrongly estimate what in fact is going on.

So much for the notion of possible worlds. A more complicated notion is the notion of a proposition. It is easy enough to stipulate that we will call every subset of $\mathcal{W}$ a proposition, but to explain how these propositions are to

function within our formal cartoon, and how they are related to the 'propositions' philosophers talk about is a more difficult affair.

Remember the definition of an assertion: an assertion is a sentence uttered by a speaker $s \in S$ in a context $\langle s, w \rangle \in C$, in short, an ordered couple $\langle A, \langle s, w \rangle \rangle$. Let us call every triple $\langle A, \langle s, w \rangle, w' \rangle$ such that $\langle A, \langle s, w \rangle \rangle$ is an assertion and $w' \in W$ a *judgment*, and let us reserve the word *statement* for judgments $\langle A, \langle s, w \rangle, w' \rangle$ such that $w = w'$. Judgments are to be taken as assertions *about* a certain possible world, and statements are to be taken as judgments in which a speaker utters a sentence about his own world. We can now state our program thus: we want to define, recursively, what it means for certain judgments to be true. That is, we want to define the truth value of judgments $\langle A, \langle s, w \rangle, w' \rangle$, with A a (complex) sentence of a language we still have to specify, in terms of the truth values of judgments $\langle B, \langle s, w \rangle, w'' \rangle$, with B a (proper) component sentence of A ⁷.

Notice that within my formal scheme truth values are predicated of ordered triples: sentences/uttered in a certain context/about a certain situation. And notice that within natural language truth and falsity vary with these variables as well. Of course, I would agree if you remarked that *in a primary sense we are always talking about the situation in which we are talking*⁸, that you can say "that's true" or "that's false" as soon as I give you a sentence and the context in which this sentence is uttered. By way of example, take the sentence 'I am twenty-six years old', and yourself as the utterer at the moment of your reading this paper. I agree that it is 'natural' to take the resulting assertion as an assertion about the moment that you are reading this, and not as an assertion about a moment four years ago. But assertions about other situations are often made *implicitly*: if you were to claim that the (complex) sentence 'I was twenty-six four years ago', uttered by you at the very moment of your reading this paper (and 'naturally' about this moment as well), is true, then you would implicitly claim that the (simpler) sentence 'I am twenty-six', uttered by you at this moment about the moment four years ago, is true. Formulating truth conditions is a matter of making explicit what a statement implicitly claims to be the case. That is where assertions about other worlds enter the scene. That is why we are interested in truth conditions for judgments in general, and not only in truth conditions for statements.

We may now indicate how the above-mentioned *propositions* will function within our formal frame. I hope that it is clear that we will have amply fulfilled the desire for truth conditions for judgments $\langle A, \langle s, w \rangle, w' \rangle$ as soon as we have defined, for each assertion $\langle A, \langle s, w \rangle \rangle$, the *set of possible worlds* w''

such that the judgment $\langle A, \langle s, w \rangle, w' \rangle$ is true. If we make this our strategy, then sets of possible worlds are going to play a prominent role in our formal set-up, as we have to construct our truth definition in such a way that the set of possible worlds w' such that a (complex) judgment $\langle A, \langle s, w \rangle, w' \rangle$ is true can be defined in terms of *other* sets, each containing the possible worlds about which a (proper) component sentence of A can be truthfully asserted. Therefore, it becomes desirable to introduce a special notation ' $\llbracket A \rrbracket_{\langle s, w \rangle}$ ' for the set of worlds w' such that the judgment $\langle A, \langle s, w \rangle, w' \rangle$ is true. Read ' $\llbracket A \rrbracket_{\langle s, w \rangle}$ ' as '*the proposition expressed by the assertion $\langle A, \langle s, w \rangle \rangle$* '; then, instead of our previous clause 'the judgment $\langle A, \langle s, w \rangle, w' \rangle$ is true', you may write ' $w' \in \llbracket A \rrbracket_{\langle s, w \rangle}$ ', and read this as '*the proposition $\llbracket A \rrbracket_{\langle s, w \rangle}$ holds for w'* '.

The main reason for introducing the rather abstract notion of a proposition in addition to the much more familiar notion of a judgment is this: we can now talk about what an assertion expresses without reference to the assertion that expresses it. Propositions are to be understood as non-linguistic entities that may be expressed by many speakers at many moments, using many different sentences. Sometimes a speaker may not know *how* to express something which he nevertheless wants to put into words, and sometimes there may be no way of putting a proposition into words at all. Propositions, so understood, are very abstract entities indeed, exhibiting many of the properties traditionally ascribed to them. But notice that our propositions are not supposed to capture the meaning of an assertion; they only capture truth conditions. They represent the meaning of an assertion just as far as knowing the meaning of an assertion boils down to knowing the kind of conceivable situations about which the assertion can truly be made.

§ 2 Prejudices and Assumptions

Up to now our set-theoretical cartoon consists of speakers, possible worlds, a 'real' history, and a set of contexts. It is time to introduce the key notion of this article: we are going to supply our speakers with *opinions*. We introduce a function $\mathcal{O}$ that assigns to each context $\langle s, w \rangle$ and each possible world w' a set of propositions $\mathcal{O}_{\langle s, w \rangle}^{w'}$. If $p \in \mathcal{O}_{\langle s, w \rangle}^{w'}$ then we shall call p an opinion (belief, view) of the speaker s at the moment w on the world w' . A speaker may concurrently have different opinions on different worlds. Different speakers may simultaneously differ in their opinions on the same world. And the same speaker may have different opinions on the same world at different moments. I hope that this is adequate as an explanation of the different arguments of $\mathcal{O}$.

We don't suppose that our speakers have opinions about all possible worlds

$w' \in W$: it may be the case that $\emptyset_{\langle s, w \rangle}^{w'}$ is empty. On the other hand, we neither suppose our speakers to have opinions only about the world in which they are speaking, or only about the 'real' worlds $w' \in H$; they are entitled to hold views of their own on worlds described in fiction or depicted on the screen, to say nothing about the worlds they dream up themselves as well.

Let us for a moment concentrate on one context $\langle s, w \rangle$, one world w' , and the corresponding set $\emptyset_{\langle s, w \rangle}^{w'}$. Let $|\emptyset_{\langle s, w \rangle}^{w'}|$ denote the *intersection of* $\emptyset_{\langle s, w \rangle}^{w'}$ *within* W , i.e. the set of worlds $w'' \in W$ such that $w'' \models p$ for all $p \in \emptyset_{\langle s, w \rangle}^{w'}$. Notice that $|\emptyset_{\langle s, w \rangle}^{w'}| = W$ if $\emptyset_{\langle s, w \rangle}^{w'} = \emptyset$. We shall call the elements of $\emptyset_{\langle s, w \rangle}^{w'}$ *mutually incompatible* iff $|\emptyset_{\langle s, w \rangle}^{w'}| = \emptyset$.

There is a difference between on the one hand propositions p such that $|\emptyset_{\langle s, w \rangle}^{w'}| \subset p$ but $p \notin \emptyset_{\langle s, w \rangle}^{w'}$, and on the other hand propositions q such that $q \in |\emptyset_{\langle s, w \rangle}^{w'}|$. Both kinds of propositions hold for all $w'' \in |\emptyset_{\langle s, w \rangle}^{w'}|$, i.e. they hold for all worlds w'' that answer to the idea which s has formed of w' . But a proposition $q \in \emptyset_{\langle s, w \rangle}^{w'}$ is so to speak constitutive for this idea, and we may expect the s in question to present and defend it as a truth about w' , whereas it may take his opponents quite a while to show s that he does hold a proposition $p - |\emptyset_{\langle s, w \rangle}^{w'}| \subset p$ but $p \notin \emptyset_{\langle s, w \rangle}^{w'}$ - at least *implicitly* in virtue of the opinions that he *explicitly* defends. We shall call a proposition p such that $|\emptyset_{\langle s, w \rangle}^{w'}| \subset p$ an *implicit opinion* and reserve the phrase 'opinions' (rather than 'explicit opinions') for the elements $p \in \emptyset_{\langle s, w \rangle}^{w'}$.

Our speakers are not supposed to adhere to all their views in the same way. We shall split up every $\emptyset_{\langle s, w \rangle}^{w'}$ into two parts: *prejudices and assumptions*. Within our frame, prejudices will function as the opinions a speaker in a particular context is not willing to give up, come what may, when he is discussing matters pertaining to any of the 'real' worlds $w' \in H$, i.o.w., prejudices are to function as propositions a speaker considers to be *laws of nature*.⁹

In order to settle this, we can take a function P from $C \times W$ into the powerset of the powerset of W such that (i) $P_{\langle s, w \rangle}^{w'} = \emptyset$ if $w' \notin H$; (ii) $P_{\langle s, w \rangle}^{w'} = P_{\langle s, w \rangle}^{w''}$ if $w', w'' \in H$; and (iii) $P_{\langle s, w \rangle}^{w'} \subset \emptyset_{\langle s, w \rangle}^{w'}$.

The following remarks are in order: first, we take $P_{\langle s, w \rangle}^{w'} = \emptyset$ if $w' \notin H$ trusting that our speakers are willing to cast off their prejudices if they are confronted with "just fairy-tales". Secondly, all prejudices are opinions that a speaker in a certain context holds on all worlds $w' \in H$. But not *vice versa*: not all opinions that a speaker holds in a certain context about all real worlds $w' \in H$ have to be prejudices. The reason for this: I want prejudices to function in our cartoon as the laws of nature a speaker is *using* in a

certain context; but, aside from using them, it is a good habit to occasionally *test* your theories as well. In such a context you are trying to bring about a situation in which that law of nature does not hold. You have asked yourself "What would be the case, if this law were not to hold?", and in looking for an answer to that question you may have taken some of your other theories for granted, but not the one you are willing to test. On the other hand, it will do no harm if you nevertheless continue to *assume* that the law in question holds for all $w \in H$.

The reader may not appreciate my lumping together the most distinguished scientific theories with the vilest prejudices. I admit immediately that, from a *methodological* point of view, this is unfair, if not insulting. But, as stated before, I am interested in laws in use, and not in the question of how they came into use. I want each $P_{\langle s, w \rangle}^{w'}$ to function as the set of propositions that constitute a speaker's theoretical *field of view* at a certain moment. And then, from a *logical* point of view, there is no distinction to be made between a thorough scholar, willing to change the spectacles that fix *his* field of view as soon as we offer him better ones, and a narrow-minded what-do-you-call'em, who will keep wearing the very same blinkers for the rest of his life.

At this point we can put our considerations together, and state that our set-theoretical cartoon for its nonlinguistic part must consist of a so-called *frame*:

Def.1 A frame F is a sextuple $\langle W, S, H, C, O, P \rangle$ such that $W \neq \emptyset$; $S \neq \emptyset$; $\emptyset \neq H \subseteq W$; $\emptyset \neq C \subseteq S \times H$; O is a function; $\text{dom}(O) = C \times W$; $\text{ran}(O) \subseteq \text{pow}(\text{pow}(W))$; P is a function; $\text{dom}(P) = C \times W$; $\text{ran}(P) \subseteq \text{pow}(\text{pow}(W))$; for all $c \in C$ and $w \in H$: $P_c^w = \emptyset$; for all $c \in C$ and $w, w' \in H$: $P_c^w = P_c^{w'}$; for all $c \in C$ and $w \in W$: $P_c^w \subseteq O_c^w$.

The elements of W are called '(possible) worlds'; the elements of S 'speakers'; H is called 'history'; the elements of C 'contexts'; if $c = \langle s, w \rangle \in C$ and $w' \in W$ then the elements of $O_{\langle s, w \rangle}^{w'}$ are called 'opinions of s in $\langle s, w \rangle$ on w' '; the elements of every $P_{\langle s, w \rangle}^{w'}$ are called 'prejudices of s in $\langle s, w \rangle$ about w' '; the elements of every $(O_{\langle s, w \rangle}^{w'} \sim P_{\langle s, w \rangle}^{w'})$ are called 'assumptions of s in $\langle s, w \rangle$ about w' '. Subsets of W are called 'propositions'.

Our speakers are still in need of a *language*, and for our purpose any of the languages answering to the following definition will do:

Def.2 A language $\mathcal{L}$ is a fourtuple $\langle AT, UN, BI, SEN \rangle$ such that

- $AT \neq \emptyset$; the elements of AT are called 'atomic sentences'.
- UN contains seven elements: $\neg, \Box, \Diamond, \boxtimes, \oplus, \text{may}, \text{must}$; the elements of UN are called 'unary operators'.
- BI contains six so-called 'binary operators': $\&, \vee, \supset, \equiv, \Box \rightarrow, \text{and } \Diamond \rightarrow$.

AT, UN and BI are pairwise disjoint sets. Let $)$ and $($ be two sets distinct from the elements of $AT \cup UN \cup BI$. Let $\mathcal{L}$ be the set consisting of the finite concatenations of elements of $AT \cup UN \cup BI \cup \{ (,) \}$. (We shall freely indicate concatenation by juxtaposition.)

- SEN , the set of so-called 'sentences', is the smallest subset of $\mathcal{L}$ such that (i) $AT \subset SEN$; (ii) if $\Theta \in UN$ and $A \in SEN$, then $\Theta A \in SEN$; (iii) if $\Theta \in BI$ and $B, C \in SEN$, then $(B \Theta C) \in SEN$.

I have already indicated that we will construct our truth definition as a function mapping assertions on propositions. In definition 3 truth conditions are presented for sentences not containing any of our special conditional operators.

Def.3 Let $\mathbb{F}$ be a frame and $\mathcal{L}$ be a language. An *interpretation* of $\mathcal{L}$ into $\mathbb{F}$ is a function $\llbracket \cdot \rrbracket$, where $\text{dom}(\llbracket \cdot \rrbracket) = SEN \times \mathbb{C}$ and $\text{ran}(\llbracket \cdot \rrbracket) \subset \text{pow}(W)$, such that for every $A \in SEN$ and $\langle s, w \rangle \in \mathbb{C}$:

- if $A \in AT$ then $\llbracket A \rrbracket_{\langle s, w \rangle} = \llbracket A \rrbracket_{\langle s', w' \rangle}$ for every $\langle s', w' \rangle \in \mathbb{C}$
- if $A = \neg B$ then $w' \in \llbracket A \rrbracket_{\langle s, w \rangle}$ iff $w' \notin \llbracket B \rrbracket_{\langle s, w \rangle}$
- if $A = (B \& C)$ then $w' \in \llbracket A \rrbracket_{\langle s, w \rangle}$ iff $w' \in \llbracket B \rrbracket_{\langle s, w \rangle}$ and $w' \in \llbracket C \rrbracket_{\langle s, w \rangle}$
- if $A = (B \vee C)$ then $w' \in \llbracket A \rrbracket_{\langle s, w \rangle}$ iff $w' \in \llbracket B \rrbracket_{\langle s, w \rangle}$ or $w' \in \llbracket C \rrbracket_{\langle s, w \rangle}$
- if $A = (B \supset C)$ then $w' \in \llbracket A \rrbracket_{\langle s, w \rangle}$ iff $w' \notin \llbracket B \rrbracket_{\langle s, w \rangle}$ or $w' \in \llbracket C \rrbracket_{\langle s, w \rangle}$
- if $A = (B \equiv C)$ then $w' \in \llbracket A \rrbracket_{\langle s, w \rangle}$ iff $w' \in \llbracket B \rrbracket_{\langle s, w \rangle}$ iff $w' \in \llbracket C \rrbracket_{\langle s, w \rangle}$
- if $A = \Box B$ then $w' \in \llbracket A \rrbracket_{\langle s, w \rangle}$ iff $w'' \in \llbracket B \rrbracket_{\langle s, w \rangle}$ for every $w'' \in W$
- if $A = \Diamond B$ then $w' \in \llbracket A \rrbracket_{\langle s, w \rangle}$ iff $w'' \in \llbracket B \rrbracket_{\langle s, w \rangle}$ for some $w'' \in W$
- if $A = \boxtimes B$ then $w' \in \llbracket A \rrbracket_{\langle s, w \rangle}$ iff $\mathbb{P}_{\langle s, w \rangle}^{w'} \subset \llbracket B \rrbracket_{\langle s, w \rangle}$
- if $A = \oplus B$ then $w' \in \llbracket A \rrbracket_{\langle s, w \rangle}$ iff $\mathbb{P}_{\langle s, w \rangle}^{w'} \cap \llbracket B \rrbracket_{\langle s, w \rangle} \neq \emptyset$
- if $A = \text{must} B$ then $w' \in \llbracket A \rrbracket_{\langle s, w \rangle}$ iff $\emptyset \neq \mathbb{P}_{\langle s, w \rangle}^{w'} \subset \llbracket B \rrbracket_{\langle s, w \rangle}$
- if $A = \text{may} B$ then $w' \in \llbracket A \rrbracket_{\langle s, w \rangle}$ iff $\emptyset \neq \mathbb{P}_{\langle s, w \rangle}^{w'} \cap \llbracket B \rrbracket_{\langle s, w \rangle} \neq \emptyset$

I shall here only expound on the merits of the fourth and the last four lines of this definition. Hopefully, the reader is familiar with the remaining ones.

Let us take the fourth line first: it says that, given an atomic sentence A , all our speakers in all contexts express the same proposition by A . I must admit

that on this point our cartoon does give too rosy a picture of what is going on in reality. Discussions carried on in a natural language often end in a merely verbal dispute: a seeming difference in opinion turns out to be nothing but a disagreement on the meaning of some term or another. I want to avoid these things happening in our cartoon, as these kinds of discussions do not interest me here. The fourth line accounts for that distortion¹⁰.

The proposed truth conditions for *must*B - read: 'it must be the case that B' - and *may*B - read: 'it is maybe the case that B' - are basically the same as the ones proposed by Groenendijk and Stokhof (1975)¹¹. *may*B uttered by a speaker *s* in a context $\langle s, w \rangle$ about a world w' is true iff there is a world w'' for which (i) all the opinions of *s* in $\langle s, w \rangle$ on w' hold, and (ii) $\llbracket B \rrbracket_{\langle s, w \rangle}$ holds. *must*B uttered by a speaker *s* in a context $\langle s, w \rangle$ about a world w' is true iff $\llbracket B \rrbracket_{\langle s, w \rangle}$ holds for every w'' for which all the opinions of *s* in the context $\langle s, w \rangle$ on the world w' hold.

The truth condition for $\Diamond B$ is somewhat weaker than the one proposed for *may*B. It is therefore tempting to read $\Diamond B$ as 'it might be the case that B'. Notice that a judgment $\langle \Diamond B, \langle s, w \rangle, w' \rangle$ is true if there exists, in the light of the theories that *s* in $\langle s, w \rangle$ holds on w' , a possible world for which $\llbracket B \rrbracket_{\langle s, w \rangle}$ holds. If *s* happens to hold no theories on w' , for instance if $w' \notin H$, then $\langle \Diamond A, \langle s, w \rangle, w' \rangle$ is true if and only if $\langle \Diamond A, \langle s, w \rangle, w' \rangle$ is true: in the worlds of fiction everything *logically* possible might happen. Likewise: if we restrict ourselves to worlds $w' \in H$ then a judgment $\langle \Box B, \langle s, w \rangle, w' \rangle$ is true iff $\llbracket B \rrbracket_{\langle s, w \rangle}$ holds in all worlds w'' that are *physically* possible according to *s* in $\langle s, w \rangle$. But if $w' \notin H$ then $w' \in \llbracket \Box B \rrbracket_{\langle s, w \rangle}$ iff $w' \in \llbracket \Box B \rrbracket_{\langle s, w \rangle}$. I propose to read $\Box B$ as 'it should be the case that B' or equivalently(!) as 'it's a natural law that B', but I want in passing to note that most of us start showing off our learning with a simple 'It's an accomplished fact that....'

I can only think of one serious argument against the proposed truth conditions: I can imagine an opponent who rightly notes that judgments $\langle \textit{must}A, \langle s, w \rangle, w' \rangle$ and $\langle \Box A, \langle s, w \rangle, w' \rangle$ can be true, whereas *in fact* $\llbracket A \rrbracket_{\langle s, w \rangle}$ does not hold for w' , and that judgments $\langle \textit{may}A, \langle s, w \rangle, w' \rangle$ and $\langle \Diamond A, \langle s, w \rangle, w' \rangle$ can be false, whereas *in fact* $\llbracket A \rrbracket_{\langle s, w \rangle}$ does hold for w' ¹². More generally: opinions that do not *in fact* hold, mere beliefs, may make a difference to the truth value of *must*-, *may*-, $\Box$ - and $\Diamond$ -judgments. Our opponent is really worried by this, and he presents us with the following, puzzling case with respect to *must*-sentences (hopefully the reader can think of the analogues with respect to $\Box$ -, $\Diamond$ - and *may*-sentences): suppose that the statement $\langle \textit{must}A, \langle s, w \rangle, w \rangle$ is

true on behalf of prejudices and assumptions that do not in fact hold for w . Suppose, furthermore, that at a moment w' later than w s discovers that $\llbracket A \rrbracket_{\langle s, w \rangle}$ did not in fact hold for w . Don't you think that s in the context $\langle s, w' \rangle$ would conclude that his statement $\langle \text{must} A, \langle s, w \rangle, w \rangle$ was false after all?

My answer to this question runs as follows (and the reader may fill in my answer to the analogous questions): No! The only thing s has to conclude in the context $\langle s, w' \rangle$ is that the statement $\langle A, \langle s, w \rangle, w \rangle$ would have been false, and that the best thing he can now do is *change his mind* with respect to w . Then $\langle \text{must} A, \langle s, w' \rangle, w \rangle$ will become false, but s may still take $\langle \text{must} A, \langle s, w \rangle, w \rangle$ to have been true in that particular context $\langle s, w \rangle$. (Moreover, he still may truly say, at w' , with respect to w , that *it should have been* the case that A . See below.)

My opponent, however, takes the other horn of the dilemma; he advocates the following correction of our truth conditions: Let $*_0^{w'}_{\langle s, w \rangle}$ be the set of all $p \in *_0^{w'}_{\langle s, w \rangle}$ such that (i) $w' \in p$ and (ii) if $p \in P^{w'}_{\langle s, w \rangle}$ then $H \subset p$. Let $*_P^{w'}_{\langle s, w \rangle}$ be the set of all $p \in P^{w'}_{\langle s, w \rangle}$ such that $H \subset p$. Define an *interpretation* $*$ to be a function $\llbracket \cdot \rrbracket^*$ just like $\llbracket \cdot \rrbracket$, except for the last four lines in the definition of $\llbracket \cdot \rrbracket$, where every occurrence of ' $_0^{w'}_{\langle s, w \rangle}$ ' has to be replaced by an occurrence of ' $*_0^{w'}_{\langle s, w \rangle}$ ', and every occurrence of ' $P^{w'}_{\langle s, w \rangle}$ ' by an occurrence of ' $*_P^{w'}_{\langle s, w \rangle}$ '. In doing so it will never happen that $\langle \text{must} A, \langle s, w \rangle, w' \rangle$ or $\langle \boxtimes A, \langle s, w \rangle, w' \rangle$ are true, whereas in fact $\langle A, \langle s, w \rangle, w' \rangle$ is false, and that $\langle \text{may} A, \langle s, w \rangle, w' \rangle$ or $\langle \boxplus A, \langle s, w \rangle, w' \rangle$ are false, whereas in fact $\langle A, \langle s, w \rangle, w' \rangle$ is true: erroneous beliefs do not interfere in matters of truth and falsity any longer.

I admit, of course, that this is another way of solving the puzzle(s). But I wonder why my opponent has resorted to such a weighty manoeuvre; perhaps he has missed the first, somewhat subtler way of dealing with it by overlooking the fact that *must*-sentences (as well as $\boxtimes$ -, $\boxplus$ - and *may*-sentences) are pragmatically ambiguous. In any case, I am sure he has caused our cartoon to give a wrong picture of the logical behaviour of all the judgments at issue.

Firstly: According to my opponent a judgment $\langle A, \langle s, w \rangle, w' \rangle$ is true if $\langle \text{must} A, \langle s, w \rangle, w' \rangle$ is true. But, as Groenendijk and Stokhof (1975) rightly note: 'A statement like (i) *John must be at home* is weaker than (ii) *John is at home*.... (i) is used when, given a certain amount of information, it is almost certain that the situation described by (ii) does in fact occur. For instance, if someone⁴ has the information that John turns out the light before going out at night, and one evening he passes John's house and sees that the lights are on, then he will use (i).... (ii) on the other hand is used when someone has seen for himself that John is at home'¹³.

Secondly: According to my opponent statements $\langle \Box A, \langle s, w \rangle, w \rangle$ are true only if $H \subset \llbracket A \rrbracket_{\langle s, w \rangle}$, and the reader may consider it to be a point in his favour that statements 'it's a natural law that A' are true only if A can be truthfully asserted about all real worlds $w' \in H$. But in my opinion my opponent is missing the point about the lawfulness of lawful statements. A law *in use* is only a *bet* that a situation that does not obey this law will never occur. Our theories above all frame what we *expect* and do not *expect* of reality; they set out, as stated before, our *field of view*. Therefore, I take a statement 'It's a law that A' to be true if the speaker in question - rightly or wrongly - does not *reckon with* a situation for which $\llbracket A \rrbracket_{\langle s, w \rangle}$ does not hold. I want to account for the fact that our theories serve to guide us, and I think they do so quite independently of the question whether they are trustworthy or not. No doubt some of our theories are, from a methodological point of view, better justified than others. By all means, there are favourite horses in our race, and it is better to lay your bet on them than on the crippled ones. I even admit that within science a way of gambling has been developed that, if not profitable, at least reduces the loss to a minimum. Nevertheless, all kinds of bets are being laid out, both stupid and clever ones, and I would not give an adequate picture of this betting if I were to restrict myself to the clever bets or, even worse, to the winning ones. And that is what my opponent is doing: he is taking the winning bets to be the only real ones.

Let me leave this matter by giving my opponent a little puzzle in return: what are the truth conditions for statements like 'It should have been raining now' or 'They should have been arrived by now' or in general for judgments $\langle \textit{it should have been that } A, \langle s, w \rangle, w' \rangle$. To my mind these kinds of judgments are often true in contexts where the speaker is perfectly aware of the fact that $w' \notin \llbracket A \rrbracket_{\langle s, w \rangle}$. And in the spirit of definition 3 I can define:
 $w' \in \llbracket \textit{it should have been that } A \rrbracket_{\langle s, w \rangle}$ iff $|0_{\langle s, w' \rangle}| < \llbracket A \rrbracket_{\langle s, w \rangle}$ for some w'' earlier than w .¹⁴

However, if I place myself in my opponent's position, then I see no way of defining truth conditions for the judgments in question, and the reader does not have to go into the details of my proposal to see the problem: if not opinions that *did* not in fact hold, what else can determine the truth value of the statement 'It should have been raining now' at a moment when the speaker in question is perfectly aware of the fact that it does not rain? In my analysis this speaker, who truthfully states 'It should have been raining now' in the afternoon, is the same as the one who truthfully stated 'It must be raining this afternoon' in the morning. According to my opponent this speaker was wrong in the morning;

and it seems to me that my opponent must on the same ground - viz., that a judgment cannot owe its *truth* to an erroneous belief - conclude that this speaker is wrong in the afternoon as well. In that case I see no way in which judgments $\langle \textit{it should have been that } A, \langle s, w \rangle, w' \rangle$ can ever be true if they are made in the circumstances for which they seem to have been invented.

Meanwhile, the reader may disagree both with me and with my opponent. Perhaps he will blame me for letting truth depend on the beliefs a speaker holds at a certain time, whereas he will blame my opponent for letting truth depend on a speaker's knowledge: 'Why don't both of you just stick to the facts?'

I think my first opponent can meet this demand up to a certain point. He may admit that an assertion can express a law of nature, even if that law has not been discovered as yet; he may be willing to repair his truth definition such that laws would be laws independently of the question whether they are known to be laws or not: $w' \in \llbracket \Box A \rrbracket_{\langle s, w \rangle}$ iff $H \subset \llbracket A \rrbracket_{\langle s, w \rangle}$; likewise $w' \in \llbracket \Diamond A \rrbracket_{\langle s, w \rangle}$ iff $\llbracket A \rrbracket_{\langle s, w \rangle} \cap H \neq \emptyset$.¹⁵

For my part such a 'solution' is out of the question, as I do not believe that there exist such things as laws which are discovered first, and known afterwards. Laws are hypotheses. They are *made* and not discovered: lawfulness is a matter of *imputation*¹⁶. I have already criticized my opponent for underestimating the fact that we often impute this lawfulness to a proposition which does not deserve it. Now I must add that this second manoeuvre shows that he does not realize that even the propositions which deserve it, must get it in the first place. To continue our metaphor: There are winning horses in the race, but you are not going to be paid if you have not laid your bet on them.

In any case, there are no other concessions to be made. Not even for my opponent. For on which facts should the truth of statements 'it may be the case that A' and 'it must be the case that A' depend? On facts in other possible worlds? Which worlds? Worlds that resemble the actual world in some important respects? Which respects?

§ 3 Counterfactual 'Truth'

Let $\mathbb{F}$ be a frame and $\mathcal{L}$ be a language. Take $\langle s, w \rangle \in \mathbb{C}$. Take $A, B \in \text{AT}$. Let $w' \notin \llbracket A \rrbracket_{\langle s, w \rangle}$ and $w' \notin \llbracket B \rrbracket_{\langle s, w \rangle}$. Moreover, let $\llbracket \neg A \rrbracket_{\langle s, w \rangle} \in \mathcal{O}_{\langle s, w \rangle}^{w'}$ and $\llbracket \neg B \rrbracket_{\langle s, w \rangle} \in \mathcal{O}_{\langle s, w \rangle}^{w'}$. Assume $|\mathcal{O}_{\langle s, w \rangle}^{w'}| \neq \emptyset$.

I create this situation only to avoid any questions which may arise on pre-suppositions, now that I have this speaker s at this time w stating that B would have been the case at w' if A had been the case there: what are the sufficient and necessary conditions for this counterfactual judgment $\langle (A \Box \rightarrow B), \langle s, w \rangle, w' \rangle$ to

be true?

Let the following serve to guide us: $\langle (A \Box \rightarrow B), \langle s, w \rangle, w' \rangle$ is true iff the judgments $\langle B, \langle s, w \rangle, w' \rangle$ are true at all worlds w'' at which $\langle A, \langle s, w \rangle, w' \rangle$ is true, and which *in other respects resemble w' as closely as possible in the opinion of s at w* .

And this is our goal: to clarify the italicized phrase; how do things become similar for someone?¹⁷.

We first define in general:

Def.4 Let F be a frame and $p \in W$. A p -accommodating subset of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ is a set Q such that (i) $P_{\langle s, w \rangle}^{w'} \subset Q \subset \mathcal{O}_{\langle s, w \rangle}^{w'}$ and (ii) $|Q| \cap p \neq \emptyset$.

Imagine what an $[A]_{\langle s, w \rangle}$ -accommodating subset Q of the particular $\mathcal{O}_{\langle s, w \rangle}^{w'}$ of our example would be: a subset Q of the opinions of s in $\langle s, w \rangle$ on w' that includes all prejudices. Moreover, there are worlds w'' among the elements of $|Q|$ such that $\langle A, \langle s, w \rangle, w'' \rangle$ is true. Hence the worlds $w'' \in ([A]_{\langle s, w \rangle} \cap |\mathcal{O}_{\langle s, w \rangle}^{w'}|)$ are worlds at which $\langle A, \langle s, w \rangle, w'' \rangle$ is true and which resemble w' at least in some other respects in the opinion of s at w .

Notice that in general $\mathcal{O}_{\langle s, w \rangle}^{w'}$ has no p -accommodating subsets iff $|P_{\langle s, w \rangle}^{w'}| \cap p = \emptyset$, that is to say that in our example there are no worlds $w'' \in [A]_{\langle s, w \rangle}$ which are a bit like w' , if $[A]_{\langle s, w \rangle}$ is incompatible with the prejudices of s in $\langle s, w \rangle$ on w' ¹⁸.

But let our example be such that $|P_{\langle s, w \rangle}^{w'}| \cap [A]_{\langle s, w \rangle} \neq \emptyset$.

Def.5 Let F be a frame and $p \in W$. A p -accommodating subset M of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ is *maximal* iff there is no p -accommodating subset Q of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ such that $M \subset Q$ and not $Q \subset M$.

Imagine, with respect to our example, a maximal $[A]_{\langle s, w \rangle}$ -accommodating subset M of $\mathcal{O}_{\langle s, w \rangle}^{w'}$. What else can the worlds in $[A]_{\langle s, w \rangle} \cap |M|$ be but worlds at which $[A]_{\langle s, w \rangle}$ holds and which in other respects resemble w' as closely as possible in the opinion of s at w ? Every set $M \cup \{q\}$ - $q \in \mathcal{O}_{\langle s, w \rangle}^{w'}$, $q \notin M$ - is not an $[A]_{\langle s, w \rangle}$ -accommodating subset of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ any longer: the worlds in $|M \cup \{q\}|$ are too much like w' .

This, however, is not all there is to it. Firstly, it is very probable that there exist several maximal $[A]_{\langle s, w \rangle}$ -accommodating subsets of $\mathcal{O}_{\langle s, w \rangle}^{w'}$. The reader may easily verify this by taking $\mathcal{O}_{\langle s, w \rangle}^{w'} = \{p, q, r\}$; $P_{\langle s, w \rangle}^{w'} = \emptyset$; $p \cap q \cap r \neq \emptyset$; $(W \setminus p) \cap q \cap r = \emptyset$; $(W \setminus p) \cap q \neq \emptyset$; $(W \setminus p) \cap r \neq \emptyset$; $[A]_{\langle s, w \rangle} = W \setminus p$. Then both $\{q\}$ and $\{r\}$ are maximal $[A]_{\langle s, w \rangle}$ -accommodating subsets of $\mathcal{O}_{\langle s, w \rangle}^{w'}$. But on a more

informal level it must be clear, too, that this is very likely to happen. There may be several alternative ways in which to add more assumptions to a non-maximal $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subset of $\mathcal{O}_{\langle s, w \rangle}^{w'}$. Thus one may obtain several different maximal $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subsets of $\mathcal{O}_{\langle s, w \rangle}^{w'}$. The members of M , for each of these maximal $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subsets M , all 'in other respects' resemble w' as closely as possible, but different members of different M 's resemble w' 'in other respects' as closely as possible 'in different respects'. At this point every attempt to arrive at a comparative *overall* similarity relation in Lewis's sense must be abandoned: we should have to slur over the fact that a possible world w'' may in some respects be *more*, in some other respects *less* similar to a world w' than a world w'' ; they can be alike in that both are p -worlds resembling w' as closely as possible, and differ in that w'' is a q -world much more similar to w' than w'' .

Secondly¹⁹, the possibility is not excluded that there be *no* maximal $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subset of $\mathcal{O}_{\langle s, w \rangle}^{w'}$, even if we assume that there is some non-maximal $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subset Q . It might be possible that one can add assumption after assumption to Q without ever reaching a limit. Imagine a speaker s without prejudices who explicitly assumes for each natural number n that there exist more than n grains of sand. Let p be the proposition that there are finitely many grains of sand. This proposition can be accommodated within every finite subset of s 's assumptions, for there is bound to be a largest number n , such that the assumption that there are more than n grains of sand is an element of Q . On the other hand p cannot be accommodated within an infinite number of s 's assumptions; Then which set should be a maximal p -accommodating subset of s 's set of opinions?

If the reader wants to check formally that a p -accommodating subset does not always have a maximal extension, then he may choose a frame $\mathbb{F}$ such that $W = \omega + 1$; $\mathcal{O}_{\langle s, w \rangle}^{w'} = \{p_i : p_i \in \text{pow}(W) \text{ and } i < \omega \text{ and } p_i = \{j : i < j < \omega\}\}$; $\mathcal{P}_{\langle s, w \rangle}^{w'} = \emptyset$; $p = \{i : i < \omega\} = \omega$. It is easy to prove that $Q \subset \mathcal{O}_{\langle s, w \rangle}^{w'}$ accommodates p iff Q is a finite subset of $\mathcal{O}_{\langle s, w \rangle}^{w'}$.

There is a very natural way of avoiding the difficulties involved in this phenomenon: we can resign ourselves to what we shall call the *Finiteness Assumption*: every speaker in every context holds only a finite number of opinions on each world. It is obvious that this is a sufficient condition in order for every p -accommodating subset of every set of opinions to have a maximal extension.

We are now ready to give truth conditions for the counterfactual operators $\Box \rightarrow$ and $\Diamond \rightarrow$. In def. 6^F we restrict ourselves to the case that we can freely

utilize maximal accommodating subsets, i.e. to frames that satisfy the Finiteness Assumption:

Def. 6^F $w' \in \llbracket (A \Box \rightarrow B) \rrbracket_{\langle s, w \rangle}$ iff every maximal $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subset M of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ is such that $(\llbracket A \rrbracket_{\langle s, w \rangle} \cap |M|) \subset \llbracket B \rrbracket_{\langle s, w \rangle}$
 $w' \in \llbracket (A \Diamond \rightarrow B) \rrbracket_{\langle s, w \rangle}$ iff some maximal $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subset M of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ is such that $(\llbracket A \rrbracket_{\langle s, w \rangle} \cap |M|) \cap \llbracket B \rrbracket_{\langle s, w \rangle} \neq \emptyset$

Amplification: Substituting 'some' for 'every' in the first line of this definition would allow for the truth of both $\langle (A \Box \rightarrow B), \langle s, w \rangle, w' \rangle$ and $\langle (A \Diamond \rightarrow B), \langle s, w \rangle, w' \rangle$, even in case $\llbracket A \rrbracket_{\langle s, w \rangle} \cap |\mathcal{P}_{\langle s, w \rangle}^{w'}| \neq \emptyset$. Substituting 'every' for 'some' in the third line would destroy the equivalence of $\langle (A \Box \rightarrow B), \langle s, w \rangle, w' \rangle$ and $\langle \neg(A \Diamond \rightarrow B), \langle s, w \rangle, w' \rangle$.

Without the Finiteness Assumption, the formulation of the truth conditions becomes more complicated, but the idea remains the same: $w' \in \llbracket (A \Box \rightarrow B) \rrbracket_{\langle s, w \rangle}$ if one can add assumptions to every $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subset Q of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ up to a point where one gets an $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subset N such that $(\llbracket A \rrbracket_{\langle s, w \rangle} \cap |N|) \subset \llbracket B \rrbracket_{\langle s, w \rangle}$. That one may go on adding more and more assumptions to N , still keeping $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subsets N' , is of minor importance since every such $|N'|$ is a subset of $|N|$.

If, on the other hand, there exists some $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subset Q of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ such that you never reach that point, whatever assumptions you add to Q , and notwithstanding the fact that you can go on adding more and more assumptions and still keep $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subsets of $\mathcal{O}_{\langle s, w \rangle}^{w'}$, then $w' \notin \llbracket (A \Box \rightarrow B) \rrbracket_{\langle s, w \rangle}$. Again it is of minor importance that with the Finiteness Assumption you need only concern yourself with the maximal $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subsets of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ which you must necessarily get in this way.

We define with respect to the general case:

Def. 6^G $w' \in \llbracket (A \Box \rightarrow B) \rrbracket_{\langle s, w \rangle}$ iff every $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subset Q of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ is a subset of some $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subset N of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ such that $(\llbracket A \rrbracket_{\langle s, w \rangle} \cap |N|) \subset \llbracket B \rrbracket_{\langle s, w \rangle}$
 $w' \in \llbracket (A \Diamond \rightarrow B) \rrbracket_{\langle s, w \rangle}$ iff some $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subset Q of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ is such that $(\llbracket A \rrbracket_{\langle s, w \rangle} \cap |N|) \cap \llbracket B \rrbracket_{\langle s, w \rangle} \neq \emptyset$ for every $\llbracket A \rrbracket_{\langle s, w \rangle}$ -accommodating subset N of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ of which Q is a subset.

A final explanatory remark: Compare the wording of the truth condition for judgments $\langle (A \Diamond \rightarrow B), \langle s, w \rangle, w' \rangle$ with the phrase ' $w' \in \llbracket (A \Diamond \rightarrow B) \rrbracket_{\langle s, w \rangle}$ iff some

$[A]_{\langle s, w \rangle}$ -accommodating subset Q of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ is such that $([A]_{\langle s, w \rangle} \cap |Q|) \cap [B]_{\langle s, w \rangle} \neq \emptyset$. This would be too weak: adding more assumptions to such a Q might give an $[A]_{\langle s, w \rangle}$ -accommodating subset N such that $([A]_{\langle s, w \rangle} \cap |N|) \subset (w \sim [B]_{\langle s, w \rangle})$. This would allow for the truth of both $\langle (A \boxdot \rightarrow B), \langle s, w \rangle, w' \rangle$ and $\langle (A \boxdot \rightarrow \neg B), \langle s, w \rangle, w' \rangle$.

I cannot hope that my final explanatory remark will have been a final one in defence of these truth conditions as well. Indeed, I may expect the same kind of severe criticism I met in § 2. Once again this opponent is proposing to replace, throughout def. 4 - def. 6^G, the occurrences of ' $\mathcal{O}_{\langle s, w \rangle}^{w'}$ ' by occurrences of ' $\mathcal{O}_{\langle s, w \rangle}^{*w'}$ '; the occurrences of ' $\mathcal{P}_{\langle s, w \rangle}^{w'}$ ' by occurrences of ' $\mathcal{P}_{\langle s, w \rangle}^{*w'}$ '; and the occurrences of ' $[[]]$ ' by occurrences of ' $[[]]^*$ '. He is still worried about the fact that prejudices and assumptions which in fact do not hold play a role in our truth conditions. And what a role! Any phantasm, utterly unfounded but nevertheless figuring in a speaker's stock of opinions, may make a difference to the truth value of his counterfactual judgments. To give a simple example: a statement $\langle (A \boxdot \rightarrow B), \langle s, w \rangle, w' \rangle$ may owe its truth simply and solely to the prejudice $[(A \supset B)]_{\langle s, w \rangle}$, which in fact does not hold for some $w' \in H$. Once more my opponent argues that even the speaker s of this example would himself conclude, after a falsification of this theory $[(A \supset B)]_{\langle s, w \rangle}$ of his, that the statement at issue was false. And again the reader finds me replying that the only conclusion to draw for s , after a falsification, is that he must drop this theory $[(A \supset B)]_{\langle s, w \rangle}$. Then a judgment $\langle (A \boxdot \rightarrow B), \langle s, w' \rangle, w' \rangle$, made next moment w' , will probably become false - only probably: s may in the meantime have gotten, rightly or wrongly some further prejudices and assumptions about w -, but there is nothing paradoxical in still reckoning $\langle (A \boxdot \rightarrow B), \langle s, w \rangle, w' \rangle$ among the true statements that have been made in that particular context $\langle s, w \rangle$.

Both this opponent, to whom I shall henceforth refer as my ^{*}opponent with his ^{*}definitions, and myself may expect to encounter a second opponent - we have already met him at the end of § 2 in the person of the reader - who will accuse both of us of advocating a kind of coherence theory of truth for counterfactual conditionals; and that, according to him, is no theory of truth at all. In any adequate (correspondence) theory of truth a true counterfactual statement would owe its truth to the facts, and not to the accidental knowledge - or even worse, to the accidental beliefs - that the utterer of that statement happens to have about these facts.

(It is worth noting how seriously the three of us differ in opinion, not only in theory, but also in practice. The following puzzle may serve as an illustration:

Three persons are involved: Mr. A, Mr. B and a conjurer. Not such a very good conjurer actually, for he accidentally murdered his wife on the stage, sawing her in two. Mr. A has just heard this on the radio.

Mr. B attended the show, but he seems not to have noticed what happened. 'This final trick, marvellous!' he says to Mr. A and (1) *'If you had seen it, you would not have believed your eyes'*.

Mr. A is puzzled by this statement; he has been in the juggling business himself, you know, and he knows all about the sawing trick, so that he *agrees* with Mr. B. On the other hand, if he tells Mr. B about this juggling career of his, then Mr. B will probably change his mind and say: *'O, well, then you might have believed your eyes of course'*. And then they would *disagree*, until the moment when he tells Mr. B what he has heard on the radio. Then Mr. B must change his mind again, and say: (3) *'If you had seen it, you would not have believed your eyes'*.

Question: Assume that both my *opponent and myself, as well as our common adversary, agree that statement (3), if stated in the circumstances as described, would be true. What, then, would be the truth value of the statements (1) and (2) according to each of us?)

How do we answer this second opponent? How do we convince him that this wish for a correspondence theory of truth for counterfactuals cannot be realized? Neither I nor my *opponent (if I may speak on his behalf) know of any decisive argument in our favour. Nevertheless, our adversary's position is all but enviable. For what we can point out is that the correspondence theory which he is looking for cannot in any case be based on a comparative similarity relation of worlds. However, his only alternative seems to be to explain counterfactual truth in terms of such a relation, and to deny that this relation is linked up with either the knowledge or the beliefs of any speaker whatsoever. In other words, he seems to be obliged to revert to a pre-established comparative similarity-relation fixed by factual similarities and dissimilarities.

Any attempt to develop a correspondence theory along these lines is doomed to failure. This can be shown by my *opponent. After all, within his theory counterfactual truth, and with it comparative similarity, are being judged in the light of facts, though it be only in the light of the facts known to a speaker. As a consequence our common adversary can only reproach him for not taking unknown facts into account. Another consequence is that this adversary must be able to indicate which *additional* facts should be reckoned with. Are all additional facts relevant?

Let me illustrate this question by means of an example. Suppose a particular

judgment $\langle (A \sqsupset B), \langle s, w \rangle, w' \rangle$ is false according to my $*$ opponent, but true by the standards of our adversary (compare statement (1) of the above puzzle). Here my $*$ opponent will be able to select an $\llbracket A \rrbracket_{\langle s, w \rangle}^*$ -accommodating subset Q of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ which cannot be extended (by facts known to s) to an $\llbracket A \rrbracket^*$ -accommodating subset N of $\mathcal{O}_{\langle s, w \rangle}^{w'}$ such that $(\llbracket A \rrbracket_{\langle s, w \rangle}^* \cap |N|) \subset \llbracket B \rrbracket_{\langle s, w \rangle}^*$. That is, there are, for all s knows about w' , no $\llbracket B \rrbracket_{\langle s, w \rangle}^*$ -worlds in $(\llbracket A \rrbracket_{\langle s, w \rangle}^* \cap |Q|)$ which resemble w' more than the $\llbracket \neg B \rrbracket_{\langle s, w \rangle}^*$ -worlds in it do.

Our common adversary, for his part, cannot deny that the worlds of $(\llbracket A \rrbracket_{\langle s, w \rangle}^* \cap |Q|)$ all are worlds which in fact resemble w' in some respects: the propositions $p \in Q$, which hold for w' , hold also for these worlds. Furthermore, he must admit that all the $\llbracket A \rrbracket_{\langle s, w \rangle}^*$ -worlds which in fact resemble w' in more respects than these Q -respects are elements of $(\llbracket A \rrbracket_{\langle s, w \rangle}^* \cap |Q|)$ as well. So we must hope with him that there are at least some $\llbracket B \rrbracket_{\langle s, w \rangle}^*$ -worlds among the elements of $(\llbracket A \rrbracket_{\langle s, w \rangle}^* \cap |Q|)$; otherwise he cannot defend the truth of $\langle (A \sqsupset B), \langle s, w \rangle, w' \rangle$ at all. And if there are $\llbracket B \rrbracket_{\langle s, w \rangle}^*$ -worlds in $(\llbracket A \rrbracket_{\langle s, w \rangle}^* \cap |Q|)$, then he must be able to defend the proposition that some of these $\llbracket B \rrbracket_{\langle s, w \rangle}^*$ -worlds do in fact resemble w' more than the $\llbracket \neg B \rrbracket_{\langle s, w \rangle}^*$ -worlds in $(\llbracket A \rrbracket_{\langle s, w \rangle}^* \cap |Q|)$. In this case we may expect him to tell us that we should see past the end of s 's nose, and he, in turn, may expect to be asked *how far* we should see past s 's nose. Has he himself arrived at his conclusion by taking *all* facts in w' into account and by *exhaustively* comparing the $\llbracket B \rrbracket_{\langle s, w \rangle}^*$ -worlds in $(\llbracket A \rrbracket_{\langle s, w \rangle}^* \cap |Q|)$ with the $\llbracket \neg B \rrbracket_{\langle s, w \rangle}^*$ -worlds in it? To put it differently: if our adversary wants his fixed comparative similarity relation to be more than a hollow phrase, then he must be able to point out, in advance, the respects in which the possible worlds are to be compared with each other, and give some reason why the respects which he neglects are to be neglected.

Let us look at the consequences of the most natural answer to this question: compare the worlds in all respects; all facts are equally relevant. The point is that my $*$ opponent can easily simulate a situation in which all facts are taken into account. We may consider an omniscient speaker s who at a certain moment w happens to know everything there is to know about all worlds $w' \in W$:

Let $\mathbb{P}$ be such that $\mathcal{O}_{\langle s, w \rangle}^{w'} = \{p : p \in \text{pow}(W) \text{ and } w' \in p\}$ for all $w' \in W$; Take $\mathbb{P}_{\langle s, w \rangle}^{w'} = \emptyset$ iff $w' \notin H$, and $\mathbb{P}_{\langle s, w \rangle}^{w'} = \{p : p \in \text{pow}(W) \text{ and } H \subset p\}$ iff $w' \in H$.²⁰ It is easy to prove that on this condition:

$w' \in \llbracket (A \sqsupset B) \rrbracket_{\langle s, w \rangle}^*$ iff $w' \in \llbracket ((A \supset B) \ \& \ (\neg A \supset \Box (A \supset B))) \rrbracket_{\langle s, w \rangle}^*$.

And it is easy to see why this result entails that the most natural answer

to our question is wrong. If it were right, then the logic of counterfactual statements $\langle (A \Box \rightarrow B), \langle s, w \rangle, w \rangle$ would boil down to the logic of statements $\langle ((A \supset B) \ \& \ (\neg A \supset \Box(A \supset B))), \langle s, w \rangle, w \rangle$. It would be valid, for example, to conclude that a statement $\langle ((A \ \& \ C) \Box \rightarrow B), \langle s, w \rangle, w \rangle$ is true, given the truth of $\langle \neg A, \langle s, w \rangle, w \rangle$ and $\langle (A \Box \rightarrow B), \langle s, w \rangle, w \rangle$. This, however, cannot be our adversary's intention.²¹

It should be clear now that our adversary finds himself in a rather precarious situation. On the one hand he reproaches my *opponent for only reckoning with the facts known to a speaker. On the other hand he must admit that taking all facts into account would cause our cartoon to give a wrong picture of the logic of counterfactual conditionals. Hence he must neglect some facts himself, and draw a line somewhere in between. But whether he draws this line vaguely or precisely, he cannot exclude the possibility of a speaker's wanting, on the grounds of his knowledge, to take more facts into account than he is actually supposed to do.

It is time to assess the pros and cons. I hope that the above argument has convinced the reader that any correspondence theory of truth for counterfactuals based on a pre-established comparative similarity relation of worlds is an absurdity, however vaguely one may define that relation. I doubt whether I have succeeded in persuading him to move directly into accepting the point of view recorded in the definitions 4-6G. He may prefer the less risky step to the standpoint of my *opponent and refuse to make any further concessions until some convincing argument forces him to do so. I must admit that such an argument has not been given. What makes me incline to my "own" point of view is the belief that counterfactuals fall into the category of *may-*, *might-*, *might have been-* and *must-*, *should-*, *should have been-*sentences. And I still flatter myself with the hope that I have refuted my *opponent at least when we discussed the semantic properties of these sentences.

§ 4 'Counterfactual' Presuppositions

At the outset of the preceding section I called upon the reader not to raise questions concerning presuppositional matters until further notice. I doubt whether he has managed to comply with that request, since both my *opponent and myself may certainly have provoked such questions through having

intimated how they are *not* to be answered. Our truth conditions leave no room for a counterfactual judgment to be neither true nor false. Hence we cannot trace back the oddity of, for example, the sentence '*It would not have been for the common good, if I had resigned*', stated by Nixon the day after his resignation, to something like a truth value gap. And we have no intention of doing so: questions of presupposition are not to be answered within semantics, but within pragmatics; their solution does not lie in a theory of truth, but in a theory of conversation. The oddity of the above statement must be attributed to the fact that Nixon, in stating this sentence, would have broken a general rule of conversation.

One cannot utter any sentence at any time about any situation; judgments can be *conversationally out of place*, whether they are true or not. Having made this trifling observation - after all $7+5=12$ - we might ask for the criteria by which it can be determined whether or not a judgment is conversationally out of place. We might try to find these criteria in some *general rules of conversation* - better: some principles of rational co-operative behaviour - which the participants in a conversation should observe in order that their conversation be for all of them as fruitful and to the point as possible. Then, having found these criteria, we might carry on and try to stake out for every kind of sentence the circumstances in which it can be used correctly.

Recently both linguists and logicians have begun to fill in the details of this program, and in particular Kempson²² and Stalnaker²³, both inspired by Grice's 'Logic and Conversation'²⁴, have broken a lance for the idea that "*the phenomena often incorporated into semantics under an umbrella label of presupposition can naturally be explained within (such F.V.) a framework which depends on a logically prior system of linguistic conventions*"²⁵.

I hope to illustrate the fertility of this idea below. More specifically: I shall curtail the speakers figuring in our formal cartoon in their liberty of using $(A \sqsubset \rightarrow B)$ - and $(A \circ \rightarrow B)$ -judgments. I shall supply some evidence in favour of the claim that the restrictions imposed on these speakers apply to ourselves as well. And I shall show - or at least try to - how these restrictions can be justified in view of some general rules of conversation.

Remember the definition of an *implicit opinion*: a proposition p is an implicit opinion of s at w on w' if and only if $|0_{\langle s, w \rangle}^{w'}| < p$. Using this concept we can distinguish nine kinds of circumstances - they are mutually exclusive

iff $|0_{\langle s, w \rangle}^{w'}| \neq \emptyset$ - in which a judgment $\langle (A \Box \rightarrow B), \langle s, w \rangle, w' \rangle$ or $\langle (A \Diamond \rightarrow B), \langle s, w \rangle, w' \rangle$ can be made (It is optional to read ' $\Box$ ' (*) as either $\Box$ or $\Box$ (*)):

- C1. $\Box_{\langle s, w \rangle}^{(*)}$ and $\Box_{\langle s, w \rangle}^{(*)}$ are implicit opinions of s at w on w' .
- C2. $\Box_{\langle s, w \rangle}^{(*)}$ and $\Box_{\langle s, w \rangle}^{(*)}$ are implicit opinions of s at w on w' .
- C3. $\Box_{\langle s, w \rangle}^{(*)}$ is an implicit opinion of s at w on w' , and neither $\Box_{\langle s, w \rangle}^{(*)}$ nor $\Box_{\langle s, w \rangle}^{(*)}$ are implicit opinions of s at w on w' .
- C4. $\Box_{\langle s, w \rangle}^{(*)}$ and $\Box_{\langle s, w \rangle}^{(*)}$ are implicit opinions of s at w on w' .
- C5. $\Box_{\langle s, w \rangle}^{(*)}$ and $\Box_{\langle s, w \rangle}^{(*)}$ are implicit opinions of s at w on w' .
- C6. $\Box_{\langle s, w \rangle}^{(*)}$ is an implicit opinion of s at w on w' , and neither $\Box_{\langle s, w \rangle}^{(*)}$ nor $\Box_{\langle s, w \rangle}^{(*)}$ are implicit opinions of s at w on w' .
- C7. Neither $\Box_{\langle s, w \rangle}^{(*)}$ nor $\Box_{\langle s, w \rangle}^{(*)}$ are implicit opinions of s at w on w' , and $\Box_{\langle s, w \rangle}^{(*)}$ is an implicit opinion of s at w on w' .
- C8. Neither $\Box_{\langle s, w \rangle}^{(*)}$ nor $\Box_{\langle s, w \rangle}^{(*)}$ are implicit opinions of s at w on w' , and $\Box_{\langle s, w \rangle}^{(*)}$ is an implicit opinion of s at w on w' .
- C9. Neither $\Box_{\langle s, w \rangle}^{(*)}$ nor $\Box_{\langle s, w \rangle}^{(*)}$, and neither $\Box_{\langle s, w \rangle}^{(*)}$ nor $\Box_{\langle s, w \rangle}^{(*)}$ are implicit opinions of s at w on w' .

The remainder of this section, then, will be devoted to a discussion of the following stipulation:

- A judgment $\langle (A \Box \rightarrow B), \langle s, w \rangle, w' \rangle$ or $\langle (A \Diamond \rightarrow B), \langle s, w \rangle, w' \rangle$ is conversationally correct only if it is made in the circumstances described in C4, C5 and C6.

Let it be understood that the above stipulation is meant to frame only a *necessary* condition for the correctness of the conditional judgments at issue.

We shall call every necessary condition for the correctness of a judgment a *presupposition* of that judgment. Thus, a counterfactual judgment

$\langle (A \Box \rightarrow B), \langle s, w \rangle, w' \rangle$ carries *at least* the presupposition that $\Box_{\langle s, w \rangle}^{(*)}$ is an implicit opinion of s at w on w' . But this is not the only condition which must be satisfied: the judgment $\langle (A \Box \rightarrow B), \langle s, w \rangle, w' \rangle$ must also be regarded as incorrect if, for instance, even the speaker himself does not believe that he is speaking the truth.²⁶

Is there any evidence in favour of the claim that a judgment '*if it were*

the case that A, then it would be the case that B' is conversationally out of place if made in the circumstances C1, C2, C3, C7, C8 and C9? I hope the reader will answer this question in the affirmative after he has allowed himself to take part in the following experiment. First I should like him to examine what his reactions would be to each of the following sequences of statements

- (C1) *I am in love with you, darling, and I want to marry you. And if I were in love with you, then I would like to marry you.*
- (C2) *I visited Paris last week, but I did not see the Eiffel Tower. And I would have seen the Eiffel Tower, if I had visited Paris last week.*
- (C3) *Maybe I passed; maybe not. I haven't got the result yet. Anyway, I have done my utmost. And if I had done my utmost, then I would have passed.*
- (C7) *Maybe we have met before; maybe not. But I know your husband quite well. And if we had met before, then I would know your husband quite well.*
- (C8) *We may have met before; I don't remember. And if we had met before, I would remember.*
- (C9) *I may have borrowed your car; I don't remember. And I may have crashed it too. I really don't know. But if I had not borrowed it then I would not have crashed it.*

The reader, playing the part of the addressee, may have listened very willingly to the first part of each of these sequences (trusting that the utterer is telling at least something that he believes himself). But then, I hope, the subsequent counterfactual must have confused him and made him doubtful of either his own eyes or the sanity of the utterer. If I am right here, then the first part of our experiment has been successful.

The utterers of the above statements have been so kind as to indicate the relevant circumstances previous to uttering the relevant - irrelevant actually - counterfactual. In such cases the alleged incorrectness is quite obvious. However, I must show, too, that the counterfactual statements in question would have been incorrect if the speakers had simply concealed these circumstances, or if the relevant beliefs had not been explicit ones. To settle this, I must ask the reader to fill the part of the speaker: just believe what is stated in the first part of each of these sequences and try to utter, then, the subsequent counterfactual; or utter the counterfactual in question and "realize", then,

what you are actually believing.

These examples in favour of our claim that a counterfactual judgment is incorrect if it is made in circumstances C1, C2, C3, C7, C8, C9 - I assume that the second part of our experiment has been successful too - can of course at most challenge the reader to search for counter-examples. I have some arguments in store, however, which are bound to thwart his attempt to find these. But first I shall show that a counterfactual judgment can be correct if it is made in the circumstances C4, C5 and C6.

It has been argued, traditionally, that counterfactuals presuppose the falsehood of both the antecedent and the consequent. The following examples serve the purpose of showing that this view is based on a confusion of the notions of truth and falsity with the notions of correctness and incorrectness.

(C5) *If Santa Claus did not exist, we would get no Christmas presents.*

To my mind, this sentence can be perfectly correct, if at least it is uttered by a child which happens to believe that Santa Claus exists. Things are different, however, if its father utters the same sentence. Then the resulting statement is conversationally incorrect indeed. The difference is that the child in question is honest, whereas its father is only pretending that he believes in the existence of Santa Claus.

Of course, there still is *something* wrong with the statement of this child, since in uttering this statement correctly it is giving evidence of holding an erroneous belief. This, however, is quite another thing. You can only conclude that this child actually holds this belief if you *first* take for granted that it is not trying to cheat you.

Supporters of the traditional view do not draw the above distinctions. They accuse both this mistaken child and its dishonest father of the same offense. Consequently, they cannot accuse anyone dissimulating an erroneous belief of any offense whatsoever.²⁷

That a counterfactual judgment does not presuppose the falsity of its consequent - and not even that its consequent is believed to be false - may appear from the following example:

(C6) *Do you love me? You would love me, wouldn't you, if I only were a bit like Elvis Presley. But do you love me, anyhow?*

I think there is nothing wrong with this sequence of sentences if indeed the utterer is not merely asking for the sake of asking.

The case C4 requires some special attention.

(C4) *John did not attend the show; nor did Mary or Peter. John would have gone if Mary had gone. But if Mary had taken Peter along, then he would not have gone.*

The third statement in the above sequence is a counterfactual judgment made in circumstances C4 - if indeed the utterer believes what he has stated in the first sentence of this sequence - and there is no fault to be found with its correctness. Hence a counterfactual judgment made in the circumstances C4 can be correct. The reader will have noticed, however, that our example is rather complicated. Indeed, we get into trouble if we try a simpler one. Consider:

Neither John nor Mary attended the show. And if Mary had gone to it, then John would not have gone to it.

To my mind, the second statement in this sequence is incorrect. It is not so much a counterfactual conditional as a so-called semifactual conditional that is due here:

Neither John nor Mary attended the show. And if Mary had gone to it, then John would still not have gone to it.

A semifactual conditional can be obtained from a counterfactual by inserting 'still' in the consequent and (sometimes) 'even' in the antecedent. Semifactuals are incorrect in the circumstances C1, C2, C3, C7, C8, C9, just as counterfactuals are. It should be noted that these semifactual conditionals can be used appropriately also in other circumstances than C4:

Neither John nor Mary nor Peter attended the show. John would have gone to it if Mary had gone. And he would still have gone to it, even if Mary had taken Peter along.

I consider semifactuals to form a special class of counterfactuals: in matters of truth they behave like counterfactuals, and in the first instance they behave like counterfactuals in matters of presupposition too. That a more subtle look will allow us to articulate some differences is beyond doubt.

Evidence in favour of our claim that a might-counterfactual is always conversationally out of place in the circumstances C1, C2, C3, C7, C8, C9, and sometimes conversationally correct in the circumstances C4, C5 and C6 can be furnished in the same way. We leave it to the reader to adapt the examples given for (would-)counterfactuals.

We now pass on to the last subject of this section: An attempt to show that the incorrectness of judgments $\langle (A \square \rightarrow B), \langle s, w \rangle, w' \rangle$ and $\langle (A \Diamond \rightarrow B), \langle s, w \rangle, w' \rangle$ made in the circumstances C1, C2, C3, C7, C8 and C9 can be explained in view of some maxims of conversation (To prevent disappointment, I must ask the reader to read the foregoing sentence once again, emphasizing the word 'attempt').

Consider a judgment $\langle (A \square \rightarrow B), \langle s, w \rangle, w' \rangle$ or $\langle (A \Diamond \rightarrow B), \langle s, w \rangle, w' \rangle$ made in circumstances such that $[A]_{\langle s, w \rangle}^{(*)} \cap [0]_{\langle s, w \rangle}^{w'} \neq \emptyset$ - this applies to all the circumstances C1, C2, C3, C7, C8 and C9 (if $[0]_{\langle s, w \rangle}^{w'} \neq \emptyset$ ²⁸). Notice that under this condition $[0]_{\langle s, w \rangle}^{w'}$ - or $[0]_{\langle s, w \rangle}^{w'}$ if you prefer the *definitions - is an extension of every $[A]_{\langle s, w \rangle}^{(*)}$ -accommodating subset $\mathcal{A}$ of $[0]_{\langle s, w \rangle}^{w'}$. Therefore $w' \in [(A \square \rightarrow B)]_{\langle s, w \rangle}^{(*)}$ iff $([A]_{\langle s, w \rangle}^{(*)} \cap [0]_{\langle s, w \rangle}^{w'}) \subset [B]_{\langle s, w \rangle}^{(*)}$, and $w' \in [(A \Diamond \rightarrow B)]_{\langle s, w \rangle}^{(*)}$ iff $([A]_{\langle s, w \rangle}^{(*)} \cap [0]_{\langle s, w \rangle}^{w'}) \cap [B]_{\langle s, w \rangle}^{(*)} \neq \emptyset$. This means that $w' \in [(A \square \rightarrow B)]_{\langle s, w \rangle}^{(*)}$ iff $w' \in [must(A \supset B)]_{\langle s, w \rangle}^{(*)}$ and $w' \in [(A \Diamond \rightarrow B)]_{\langle s, w \rangle}^{(*)}$ iff $w' \in [may(A \& B)]_{\langle s, w \rangle}^{(*)}$.

In other words, if a *counterfactual* conditional 'If it were the case that A, then it would be the case that B' is stated in circumstances in which its antecedent is not believed to be false, then it is true iff the corresponding *indicative* conditional 'If it is the case that A, then it must be the case that B' is true. Likewise: A subjunctive conditional 'If it were the case that A, then it might be the case that B' is true in these circumstances iff the corresponding *indicative* statement 'maybe it is the case that A and B' is true. Hence, a speaker who has uttered such a subjunctive sentence in such circumstances, *might* just as well have uttered the corresponding indicative sentence. And he *should* have uttered this corresponding indicative sentence, if indeed it was not his aim to mislead his discussion-partner.²⁹

There is no need for a speaker s to make a judgment $\langle (A \square \rightarrow B), \langle s, w \rangle, w' \rangle$ if $[A]_{\langle s, w \rangle}^{(*)} \cap [0]_{\langle s, w \rangle}^{w'} \neq \emptyset$. There is no need for him to use the subjunctive mood if the proposition expressed in the antecedent of this counterfactual is compatible with his opinions on w' . For in this case he does not have to give up any of his opinions on w' in order to enable himself to imagine that $[A]_{\langle s, w \rangle}^{(*)}$ holds for w' . The addressee, however, hearing the phrase 'If it were the case that', will assume that the speaker does have to give up some of his opinions. For if he hears the subjunctive mood instead of the indicative one, then he will think that the speaker in order to make his point needs to use that mood. Therefore, it is misleading to use the subjunctive mood when the indicative one would serve just as well.

I think it is a rule for rational co-operative behaviour that we should only make use of a certain provision in our language if its application is indeed really necessary for our purpose. That is why I think that a counterfactual judgment is only correct if it is made in circumstances in which the antecedent is believed to be false. Granted, my formulation of this rule leaves much to be desired where clarity is concerned. Nevertheless, we would do better to search for a more precise formulation than to deny that we should take heed of it.

One additional observation pertaining to subjunctive conditionals should be made. It concerns the question whether there exists a second kind of subjunctive conditionals which behaves differently in matters of truth from the counterfactuals we have studied. It has been argued several times that this question must be answered in the affirmative. Lewis, for instance, entitled his book 'Counterfactuals' rather than 'Subjunctive Conditionals' for the following reason:

'The title 'Subjunctive Conditionals' would not have delineated my subject properly There are subjunctive conditionals pertaining to the future like '*If our ground troops entered Laos next year, there would be trouble*' that appear to have the truth condition of indicative conditionals rather than of the counterfactual conditionals I shall be considering.'³⁰

Two remarks are in order: Firstly, we agree with Lewis that a subjunctive conditional may appear to have the truth condition of an indicative conditional. We have seen above that a conversationally incorrect counterfactual judgment has this property.

Secondly, we would disagree with Lewis, however, if he were to claim that such a subjunctive conditional might be conversationally correct. We would argue that even a subjunctive conditional pertaining to the future carries the presupposition that its antecedent is believed to be false. Compare:

- *Our ground troops may enter Laos next year; if they do, there will be trouble.*
- *Our ground troops will not enter Laos next year; if they did, there would be trouble.*
- *Our ground troops may enter Laos next year; if they did, there would be trouble.*

Once again I must ask the reader to fill the part of the speaker: believe what is stated in the first sentence of each of the above sequences and utter the second one. If in doing so you meet some difficulties as to the third sequence, then you may endorse our conclusion that those 'other' subjunctive conditional judgments which appear to have the truth condition of indicative conditionals are

just counterfactual conditional judgments, made in circumstances appropriate to the use of only indicative ones.

§ 5 Appendix

Let $\mathcal{L}$ be a language answering to def. 2. If matters of logic are of interest to us here, then the first thing for us to do is to define what it means for a sentence C of $\mathcal{L}$ to be valid. We are faced with several alternatives. In the first place we must distinguish between a notion of validity*, based on the *definitions of my *opponent, and a notion of validity, based on my 'own' definition.³¹ Secondly, we must realize that there is a distinction to be made between the logic of judgments and the logic of statements, and between the logic of assertions about historical worlds and the logic of assertions about 'just' imaginary worlds.

Def.7. Let C be a sentence of .

C is valid₁ iff $w \in [C]_{\langle s, w \rangle}$ for every F , $[]$, $\langle s, w \rangle \in C$, and $w \in W$

C is valid₂ iff $w \in [C]_{\langle s, w \rangle}$ for every F , $[]$, $\langle s, w \rangle \in C$, and $w \in H$

C is valid₃ iff $w \in [C]_{\langle s, w \rangle}$ for every F , $[]$, $\langle s, w \rangle \in C$, and $w \in W \sim H$

C is valid₄ iff $w \in [C]_{\langle s, w \rangle}$ for every F , $[]$, and $\langle s, w \rangle \in C$

C is valid₁* iff $w \in [C]_{\langle s, w \rangle}^*$ for every F , $[]^*$, $\langle s, w \rangle \in C$, and $w \in W$

C is valid₂* iff $w \in [C]_{\langle s, w \rangle}^*$ for every F , $[]^*$, $\langle s, w \rangle \in C$, and $w \in H$

C is valid₃* iff $w \in [C]_{\langle s, w \rangle}^*$ for every F , $[]^*$, $\langle s, w \rangle \in C$, and $w \in W \sim H$

C is valid₄* iff $w \in [C]_{\langle s, w \rangle}^*$ for every F , $[]^*$, and $\langle s, w \rangle \in C$

The following observations should be made:

- If a sentence is valid₁ then it is valid₁* ($i \in \{1, 2, 3, 4\}$)
- There are sentences which are valid₁*, but not valid₁ ($i \in \{1, 2, 3, 4\}$)
Example: Take $A \in AT$, and consider the sentence $(\Box A \supset A)$.
- A sentence is valid₂ iff valid₄, and valid₂* iff valid₄*
- If a sentence is valid₁, then it is valid₂ and valid₃
If a sentence is valid₁*, then it is valid₂* and valid₃*
- There are sentences which are valid₂ and valid₂*, but neither valid₃ nor valid₃*
Example: Take $A \in AT$, and consider $(\Diamond A \supset \Box \Diamond A)$.
- There are sentences which are valid₃ and valid₃*, but neither valid₂ nor valid₂*
Example: Take $A \in AT$ and consider $(\Box A \supset \Box A)$.

It may have occurred to the reader that the notions of validity₁, validity₂

and validity_3 - and the notions of validity_1^* , validity_2^* and validity_3^* - yield different logics simply as a result of the requirement, recorded in definition 1, that within every frame F , $P_{\langle s, w \rangle}^{w'} = \emptyset$ if $w \notin H$, and $P_{\langle s, w \rangle}^{w'} = P_{\langle s, w \rangle}^{w'}$ if $w \in H$. Let us for a moment drop this requirement and call every sextuple answering to this new definition 1 an *imperfect frame*. Let us define eight new notions of validity - ${}^0\text{validity}_1$, ${}^0\text{validity}_1^*$, ${}^0\text{validity}_2$, etc. - just as we did the old notions, but then relative to the class of imperfect frames. Indeed, it appears that a sentence is ${}^0\text{valid}_i$ iff ${}^0\text{valid}_j$, and ${}^0\text{valid}_i^*$ iff ${}^0\text{valid}_j^*$ ($i, j \in \{1, 2, 3, 4\}$). Notice furthermore that every ${}^0\text{valid}_i$ sentence is valid_i and that every ${}^0\text{valid}_i^*$ sentence is valid_i^* ($i \in \{1, 2, 3, 4\}$).

We shall now specify a logic L_0 for $\mathcal{L}$ which is correct and complete with respect to the notions of ${}^0\text{validity}_i$ ($i \in \{1, 2, 3, 4\}$).

L_0 is the smallest subset of SEN which meets the following conditions:

i) L_0 contains the following *axioms*:

- All truth functional tautologies.
- All sentences $(\Diamond A \equiv \neg \Box \neg A)$; $(\Box(A \supset B) \supset (\Box A \supset \Box B))$; $(\Box A \supset A)$; $(\Diamond A \supset \Box \Diamond A)$.
- All sentences $(\Box A \supset \Box A)$; $(\Diamond A \equiv \neg \Box \neg A)$; $(\Box(A \supset B) \supset (\Box A \supset \Box B))$.
- All sentences $(\Box A \supset \text{must} A)$; $(\text{may} A \equiv \neg \text{must} \neg A)$; $(\text{must}(A \supset B) \supset (\text{must} A \supset \text{must} B))$.
- All sentences $((A \Diamond \rightarrow B) \equiv \neg(A \Box \rightarrow \neg B))$;
 $((A \Box \rightarrow (B \supset C)) \supset ((A \Box \rightarrow B) \supset (A \Box \rightarrow C)))$;
 $((A \Box \rightarrow B) \& (B \Box \rightarrow A) \supset ((A \Box \rightarrow C) \supset (B \Box \rightarrow C)))$;
 $(\Diamond A \supset ((A \Box \rightarrow B) \supset (A \Diamond \rightarrow B)))$;
 $(\Box(A \supset B) \supset (A \Box \rightarrow B))$;
 $((A \Box \rightarrow B) \supset \text{must}(A \supset B))$;
 $(\text{may} A \supset (\text{must}(A \supset B) \supset (A \Box \rightarrow B)))$.

ii) if $A \in L_0$ and $(A \supset B) \in L_0$, then $B \in L_0$. (I.o.w., L_0 is closed under *Modus Ponens*.)

iii) if $A \in L_0$ then $\Box A \in L_0$. (I.o.w., L_0 is closed under *the Rule of Necessitation*.)

We omit the proof of the *theorem* that $A \in L_0$ iff A is ${}^0\text{valid}_i$ ($i \in \{1, 2, 3, 4\}$).

It is easy to extend L_0 to a logic L_0^* which is correct and complete with respect to the notions of ${}^0\text{validity}_i^*$ ($i \in \{1, 2, 3, 4\}$).

L_0^* is the smallest subset of SEN which meets the following conditions:

i) L_0^* contains the following *axioms*:

- All axioms of L_0 .
- All sentences $(\Box A \supset A)$; $(\text{must} A \supset A)$.

- ii) if $A \in L_0^*$ and $(A \supset B) \in L_0^*$, then $B \in L_0^*$.
- iii) if $A \in L_0^*$ then $\Box A \in L_0^*$.

We omit the proof of the *theorem* that $A \in L_0^*$ iff A is $^0\text{valid}_1^*$.

Let us compare L_0 and L_0^* , and especially their counterfactual fragments, with Lewis's 'official logic of counterfactuals', his system VC.³²

A cursory look yields the following differences:

- The sentences $((A \ \& \ B) \supset (A \Box \rightarrow B))$, which figure as axioms within VC, are not all provable within L_0^* . The sentences $(\text{must}(A \ \& \ B) \supset (A \Box \rightarrow B))$, all provable within L_0^* , can be regarded as their (weaker) substitutes. All other axioms of VC are provable within L_0^* .
- Some of the VC-axioms $((A \Box \rightarrow B) \supset (A \supset B))$ are not provable within L_0 . The L_0 -axioms $((A \Box \rightarrow B) \supset \text{must}(A \supset B))$ can be regarded as their (weaker) substitutes. Besides, within L_0 not all sentences $\text{must}(A \ \& \ B) \supset (A \Box \rightarrow B)$ are provable; here we can only offer the still weaker $(\text{may}(C \vee \neg C) \supset (\text{must}(A \ \& \ B) \supset (A \Box \rightarrow B)))$ as alternatives to the VC-axioms $((A \ \& \ B) \supset (A \Box \rightarrow B))$. The remaining axioms of VC are all provable within L_0 .

Problems arise if we try to extend L_0 and L_0^* to logics L_1, L_2, L_3 and L_1^*, L_2^*, L_3^* correct and complete with respect to the notions $\text{validity}_1, \text{validity}_2, \text{validity}_3$ and $\text{validity}_1^*, \text{validity}_2^*, \text{validity}_3^*$ respectively. To mention some of them: All sentences $(\Diamond A \supset \Box \Diamond A)$ are valid^* and valid_2 , but such is not the case with all sentences $\Box(\Diamond A \supset \Box \Diamond A)$. Hence L_2^* and L_2 are not closed under the Rule of Necessitation. Likewise; all sentences $(\Box A \supset \Box A)$ are valid_3 and valid_3^* , but such is not the case with all sentences $\Box(\Box A \supset \Box A)$. Hence L_3^* and L_3 are not closed under the Rule of Necessitation either.

I have not yet overcome all the difficulties arising from these phenomena. Therefore I cannot but conclude this article with some conjectures.

Let L^* be the smallest subset of SEN which meets the following conditions:

- i) $L_1^{(*)}$ contains the following *axioms*:
 - All axioms of $L_0^{(*)}$
 - All sentences $((\Diamond A \supset \Box \Diamond A) \vee (\Box B \supset \Box B))$
- ii) if $A \in L_1^{(*)}$ and $(A \supset B) \in L_1^{(*)}$, then $B \in L_1^{(*)}$
- iii) if $A \in L_1^{(*)}$, then $\Box A \in L_1^{(*)}$

(The reader will have understood that he is supposed to read the foregoing definition at least twice: reading $L_1^{(*)}$ and $L_0^{(*)}$ as L_1 and L_0 the first time, and as L_1^* and L_0^* the second time.)

Conjecture: $A \in L_1^{(*)}$ iff A is valid₁^(*).

Let $L_2^{(*)}$ be the smallest subset of SEN which meets the following conditions:

i) $L_2^{(*)}$ contains the following *axioms*:

- All axioms of $L_1^{(*)}$

- All sentences $(\Diamond A \supset \Box \Diamond A)$

ii) if $A \in L_2^{(*)}$ and $(A \supset B) \in L_2^{(*)}$, then $B \in L_2^{(*)}$

iii) if $A \in L_1^{(*)}$, then $\Box A \in L_2^{(*)}$

Conjecture: $A \in L_2^{(*)}$ iff A is valid₂^(*) ($A \in L_2^{(*)}$ iff A is valid₄^(*)).

Let $L_3^{(*)}$ be the smallest subset of SEN which meets the following conditions:

i) $L_3^{(*)}$ contains the following *axioms*:

- All axioms of $L_1^{(*)}$

- All sentences $(\Box A \supset \Box A)$

ii) if $A \in L_3^{(*)}$ and $(A \supset B) \in L_3^{(*)}$, then $B \in L_3^{(*)}$

iii) if $A \in L_1^{(*)}$, then $\Box A \in L_3^{(*)}$

Conjecture: $A \in L_3^{(*)}$ iff A is valid₃^(*).

Notes

⁰ I am indebted to E.C.W. Krabbe and J.B.M. van Rijen for their helpful criticism, to M.J. Petry and J. Vrieze for correcting the English, and to C.J.J. de Ruiter for typing the manuscript.

¹ The reader will notice, however, that my approach is akin to Rescher's. Some of his views, expressed by himself in proof-theoretical terms, will re-emerge here, but then framed in the language of model theory. See especially Rescher (1964).

² See Åqvist (1973), Gabbay (1972), Lewis (1971), Lewis (1973), Nute (1975a), Nute (1975b), Stalnaker (1968), and Stalnaker & Thomason (1970).

³ I disregard divergencies as to details (reckoning the Limit Assumption among them).

⁴ Stalnaker (1968), p. 109.

⁵ Lewis (1972), p. 91.

⁶ Popper (1972), p. 421.

⁷ Of course, it is nothing but a working hypothesis that such a truth definition is possible at all. Cf. note 14.

⁸ Thomason (1974), p. 67.

⁹ I am dividing each $\mathcal{O}_{\langle s, w \rangle}^{w'}$ into two: prejudices, i.e. opinions a speaker is not willing to abandon, come what may, and assumptions, i.e. opinions a speaker is willing to give up if indeed he is forced to do so. Some refinements come to mind: we might introduce a partial ordering of each set of assumptions in order to account for the fact that a speaker may be less willing to give up his assumption p than his assumption q . Introducing these partial orderings of each $\mathcal{O}_{\langle s, w \rangle}^{w'} \sim \mathcal{P}_{\langle s, w \rangle}^{w'}$, however, would only complicate the discussion in §3, whereas it would in the end make no difference whatever to the logic of counterfactuals.

¹⁰ It must be clear, however, that our cartoon does not distort reality to such an extent that $\llbracket A \rrbracket_{\langle s, w \rangle} = \llbracket A \rrbracket_{\langle s', w' \rangle}$ for every $A \in \text{SEN}$ and $\langle s, w \rangle, \langle s', w' \rangle \in \mathcal{C}$ (*must*, *may*, $\boxtimes$ and $\boxdot$ behave like indexical expressions).

¹¹ See Groenendijk & Stokhof (1975). Their account differs from mine in two respects: $\mathcal{O}_{\langle s, w \rangle}^{w'}$ is only defined for $w' = w$, and $\mathcal{O}_{\langle s, w \rangle}^{w'}$ is a set of sentences (rather than propositions). Consequently, they can only attribute truth values to those *may*- and *must*-statements, in which *may* and *must* do not occur in iteration.

¹² Groenendijk & Stokhof (1975), p. 69.

¹³ Take note of the fact that there is nothing strange in the following

cases: $\langle \text{must}A, \langle s, w \rangle, w' \rangle$ is false, whereas in fact $w' \in \llbracket A \rrbracket_{\langle s, w \rangle}$
 $\langle \text{may}A, \langle s, w \rangle, w' \rangle$ is true, whereas in fact $w' \notin \llbracket A \rrbracket_{\langle s, w \rangle}$
 $\langle \text{must}A, \langle s, w \rangle, w' \rangle$ is true, and in fact $w' \in \llbracket A \rrbracket_{\langle s, w \rangle}$
 $\langle \text{may}A, \langle s, w \rangle, w' \rangle$ is true, and in fact $w' \in \llbracket A \rrbracket_{\langle s, w \rangle}$
 $\langle \text{must}A, \langle s, w \rangle, w' \rangle$ is false, and in fact $w' \notin \llbracket A \rrbracket_{\langle s, w \rangle}$
 $\langle \text{may}A, \langle s, w \rangle, w' \rangle$ is false, and in fact $w' \notin \llbracket A \rrbracket_{\langle s, w \rangle}$

¹⁴ Notice the ambiguities in 'It should have been raining yesterday'.

Notice furthermore that the proposed truth condition for *should have been* is not in accord with our working hypothesis that the proposition expressed by a sentence A /uttered in a context $\langle s, w \rangle$ can be defined in terms of the propositions expressed by the component sentences B /uttered in the same context $\langle s, w \rangle$.

¹⁵ This, presumably, would be the strategy of Åqvist, Stalnaker and Thomason. Cf. Åqvist (1973), p. 4.

¹⁶ For further discussion see Rescher (1962).

¹⁷ I owe this formulation of the problem to a conversation with N. Stemmer.

¹⁸ Reactions to counterfactual statements form good clues to determine someone's prejudices. If the addressee replies with something like 'If ifs and ans were pots and pans, there would be no use of tinkers', then you have detected one.

¹⁹ Readers familiar with Lewis's theory may compare the subsequent remarks with his observations in connection with the Limit Assumption. See Lewis (1973), p. 19-21. The examples were suggested by E.C.W. Krabbe.

²⁰ The particular choice of $P_{\langle s, w \rangle}^{w'}$ is not essential to our argument.

²¹ This inference pattern is discussed more fully in e.g. Lewis (1973). Its invalidity should be obvious from the following example (borrowed from Lewis):
If the USA threw its weapons into the sea tomorrow, there would be war. Hence, if the USA and the other nuclear powers all threw their weapons into the sea tomorrow, there would be war.

²² See Kempson (1976).

²³ See Stalnaker (1973).

²⁴ See Grice (1975). This is the first publication of his William James Lectures at Harvard 1968.

²⁵ Kempson (1975), p. 25.

²⁶ This in view of the following maxim of conversation: *'Be sincere! Do not try to convince your partner of something which you do not believe yourself.'*

Formally: a judgment $\langle A, \langle s, w \rangle, w' \rangle$ is conversationally incorrect if

$[A]_{\langle s, w \rangle}^{(*)} \notin \mathcal{O}_{\langle s, w \rangle}^{w'}$: Let us furthermore agree that every judgment is conversationally incorrect if $|\mathcal{O}_{\langle s, w \rangle}^{w'}| = \emptyset$. I think we are entitled to stipulate this in virtue of the following maxim: *See to it that your opinions are mutually compatible!*

²⁷ Consider a sentence 'If John had not killed him, who else would have done it?' stated by someone who, though he erroneously believes that John is not the murderer, wants nevertheless to witness against him.

²⁸ $\langle (A \Box \rightarrow B), \langle s, w \rangle, w' \rangle$ and $\langle (A \Diamond \rightarrow B), \langle s, w \rangle, w' \rangle$ are in any case incorrect if $|\mathcal{O}_{\langle s, w \rangle}^{w'}| = \emptyset$. We assume therefore that $|\mathcal{O}_{\langle s, w \rangle}^{w'}| \neq \emptyset$.

²⁹ I do not want to say that such an incorrect counterfactual judgment becomes automatically correct if it is changed into the corresponding indicative judgment. Indeed, I think that even the judgments $\langle \text{must}(A \supset B), \langle s, w \rangle, w' \rangle$ are always incorrect if stated in the circumstances C2, C3 and C4. My *opponent can prove this on account of the maxims mentioned in footnote ²⁶. We leave it to the reader to check this.

³⁰ Lewis (1974), p. 4.

³¹ Throughout this section I shall refer to def. 6^G and *def. 6^G, and not to def. 6^F and *def. 6^F.

³² See Lewis (1973), p. 132-134.

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OPERATORS AND ARGUMENTS IN NATURAL LANGUAGES

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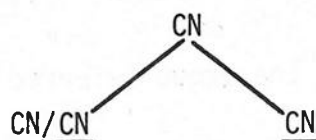
It is to Frege's credit that logical study of language disposed of the notions of logical subject and predicate. In Begriffsschrift (§3) Frege stated: "A distinction of subject and predicate finds no place in my way of representing a judgment". He replaced both notions by the notion of argument and function, expressing a hope (in the preface to Begriffsschrift) "I believe that the replacement of the concept subject and predicate by argument and function is going to approve itself with the time". The simplest application of Fregean apparatus in logic is to take a name (or rather its "semantic value") as argument and the proposition as the corresponding value of certain linguistic functions (operators), namely predicative ones. The same linguistic function can apply to different names and in this case we have the same predication made about different objects named by the different names.

This Fregean idea combined with Lesniewski - Ajdukiewicz notion of the categorial grammar found the full development in the Montague type approach to the study of natural languages. It seems to me however that the notion of logical subject carries some intuitions which render better our comprehension of various semantic phenomena in natural languages. The aim of this paper is not to reintroduce this notion to formal studies in natural languages, but to make a proposal how to replace it, in some sense, by the notion of presupposition which can be regarded as a generalisation of the notion of the logical subject.

I will try to show that there are different but interconnected types of arguments to which a linguistic function can apply, giving different but interconnected results. These arguments are what usually has been called presupposition and assertion.¹⁾

Let me begin by giving some examples which show that anything which can be regarded as a linguistic function can in fact apply to different semantic parts of the argument. For this I will use the generalisation of major grammatical relations which follows from the categorial grammar and interpret these relations in a function - argument way. Then I will point out for every grammatical relation represented in this way, the argument ambiguity of the corresponding function (operator). In what follows I will assume that the common noun orphan has as a presupposed feature child and as asserted feature not having parents. Similarly student presupposes human being and asserts being enrolled at an university or college. I take as usual t to mean a sentence, I - term phrase, IV - a verb phrase and CN - common noun phrase.

Let us begin by the relation adjective : noun : CN/CN



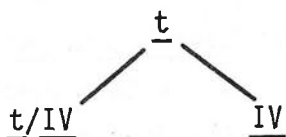
My examples are old student and bald student.

The noun phrase old student is ambiguous meaning either and old person who is a student, or someone, possibly young who has been studying for a long time.

The noun phrase bald student does not display this ambiguity. Notice that the first reading, which I call catagorematic, arises when the adjective old applies to the presupposed feature human. The second reading - syncategorematic - is the reading in which the adjective old does not apply to the presupposed but only to the asserted feature of the noun student.

The adjective bald is (purely) catagorematic adjective and the adjective new for instance is purely syncategorematic; the adjective old is non-catagorematic, since it can have either reading.

The second grammatical relation we are going to look at is the one we have between subject and predicate:



As an example illustrating of what is going when this relation occurs take the following French sentence (French because there is no difference between continuous and simple tense which is relevant here):

(1) Les orphelins mangent beaucoup

This sentence is ambiguous. It can mean - eventive reading - the orphans are eating much, or generic reading, orphans eat much. Notice that in the case of the generic reading (1), or rather its English equivalent, does not entail (2):

(2) Children eat much

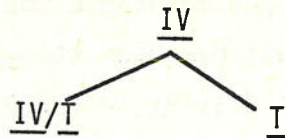
And (2) is obtained when the predicate is applied to the presupposed feature of

the NP orphan. But in the eventive reading (1) entails (3):

(3) The children are eating much

(Of course in (3) as well as in (1) the group referred to by the or les must be suitable specified.)

As the next relation take Verb-Object relation with an example in (4):



(4) Steve is looking for a student

The object NP in (4) has two readings, referential and non-referential. One can see that only at the referential interpretation of the object noun (4) entails (5):

(5) Steve is looking for a human being

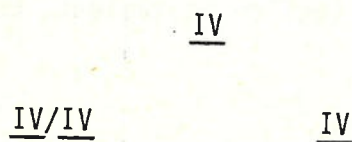
Notice that to have the phenomenon in question it is not necessary to have as an IV-phrase a so-called intensional verb (look for, own, want, need, etc.). The same can be true of any other transitive verb; in this case we have an object-genericness as in (6). In the generic reading (6) does not entail (7):

(6) Steve aime les orphelins

(7) Steve loves children

Thus in the same manner as in (4) on non-referential reading there is no particular student for which Steve is looking, in (6) on the generic reading there are no particular orphans which Steve loves.

As next relation let us take adverbial modification: adverb - verb phrase:

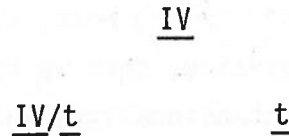


As an illustration let us have a look at (8):

(8) Steve climbed high

In many languages sentences corresponding to (8) (its translations) are ambiguous. They can mean either that Steve was somewhere high when climbed or that Steve made a big distance by climbing. Notice that on the second reading, of adverbial intentionality, we do not have as an entailment the fact that Steve made some particular movements of hands and feet while being high. Consequently this different application of the adverb gives rise to quite similar phenomenon as those discussed in connection with other grammatical relations.

One can see that the same arises at the sentential level. Only in this case one should take into consideration presuppositions of correspondingly different categories. Look for instance at the relation of subordination or the relation verb - sentential complement:

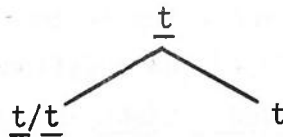


This is the classical case of opacity. Thus the sentence (9) does not entail (10) on the opaque reading:

(9) Steve believes that the orphan he met is leftist

(10) Steve believes that he met an orphan

We still have the same with sentential adverbs:



This is also somewhat classical case of the modality de re and de dicto

(11) It is necessary that the girl who is a leftist is not a leftist

In the de re reading we do not have as a consequence a sentence saying that it is necessary for some girl to be a leftist.

For the de dicto reading this implication holds.

Note that by this means we can speak not only about referential opacity as it is

usually the case but about opacity in general; an operator is opaque (intensional in general) if it can apply either to the assertion of its argument or to the assertion and to the presupposition. For instance (12) is ambiguous in the same way as every previous example:

(12) Steve thinks that Jo danced as well

It can mean that Steve thinks that Jo danced (without doing "anything" else) or that he thinks that Jo danced and did "something" else.

Probably one could discover the same phenomena looking at conjunctions; they also may apply to the assertion of the argument or to the assertion and presupposition. I will not, however, continue this presentation of various cases. Instead I will make some comments about the results to which the above examples lead. We have seen that an operator, of any syntactic category, can apply, in an intuitive sense, to the assertion and presupposition of the argument; when an operator applies to the assertion and not to the presupposition, then we have to do with the general case of intensionality (generalised intensionality) which includes all the classical cases such as syncategorematicity, opacity of the verbs of propositional attitude and of some intensional transitive verbs. This generalisation includes also some less discussed cases of intensionality such as genericness (subject and object genericness) and the intensionality of some adverbs. As we have seen these phenomena can arise at any syntactic "point" of the sentence of any syntactic complexity. It means that one should classify expressions of natural languages depending on whether they apply to one or another part of the semantic content.

Probably some other possibilities should also be taken into consideration: there are operators which can apply to the negation of the assertion and others, which may give as a result an expression which is equivalent to the negation of the assertion of the whole sentence or to the negation of the presupposition of the whole sentence. For instance alleged student is a human being which is not a student. Karttunen in his works on implicative etc. verbs proposed such a classification for the operators of the IV category (Karttunen 1973). Some other, more exhaustive classification may be in order (Zuber 1975). Furthermore, a description which associates lexical presuppositions with any class of operators is also necessary (for the so-called factive verbs see Zuber 1976). Only in this case one can try to give a recursive definition of the presupposition useful for the treatment of cases similar to the ones illustrated by the above examples. In Karttunen and Peters 1975 one can find an attempt to define recursively the notion of implicature (which in many cases covers the notion of presupposition).

Their procedure may be very well adapted to at least some problems discussed here. But this is not what I intend to do here. My aim now will be to show the profit that can be derived from the above considerations for the construction of a logical approach to the study of natural language - an approach such as Montague's in which various tools of formal semantics are used.

Note first the advantages of the above analysis of intensionality. It treats - granted for the moment that the notion of presupposition and assertion is clear enough - phenomena often considered as apparently disparate, in a rather unified way. Recall that there does not seem to exist a "simple" and unified treatment of intensionality (cf. Partee 1974). In particular generic sentences (readings) are not usually considered as belonging to the same class of phenomena as other cases of intensionality.²⁾

Furthermore, all those phenomena are due to the content ambiguity, as our intuition tells us, they are due to the fact that linguistic operators can vary their semantic scope, whereas syntactically it is still the same argument, the same string (of symbols) which serves as a scope. One could say that the ambiguity is not linear or "horizontal" but "vertical".

From this last fact follows an empirical advantage of the proposal here put forth. The two readings in question, intensional and non-intensional, can be expressed by expressions which are very close to the surface of the ambiguous sentences. In particular it is not necessary in this approach to make application of various, rather artificial, syntactic transformations having for effect a very important change of order (and often of the stock) of various logical elements (quantifiers, variables, etc.). One can easily check that in all above examples no lexical item changes its place during the disambiguation.

Of course all the above discussion presupposes a suitable and well-defined notion of presupposition and assertion and apparently this is far from being the case. We have, however, very strong intuitions concerning these notions, at least as strong, I believe, as those concerning the notion of intension or extension.

In the remainder of this paper I would like to show how these intuitions can help us to make some changes in formal semantics as used in Montague type grammar.

The problem is roughly the following: is it really without importance from the semantic point of view what category we take as a functor and what as its argument? Since Frege, and Montague's treatments of term phrases and quantifiers continue this line, there is no difference if we take a predicate as a functor and the subject as argument or the subject as a functor and the predicate as the argument. From an empirical point of view, however, both possibilities do not seem to be equally preferred; our intuition strongly suggests that in most normal cases it

is rather the predicate which is a functor and the subject the argument. Indeed the following criterion to distinguish the subject from the predicate has often been proposed: only the predicate in a sentence undergoes the elementary operations such as denying, questioning, etc. It is clearly not a subject we negate when negating a sentence in which it occurs. There is on the other hand an interdependence between what is negated (questioned etc.) and the selectional restrictions (presuppositions) of what is not negated (cf. Zuber 1972). It is the predicate which is negated because subject's presupposed features select the presupposed features of the predicate and cannot be negated as such.³⁾ In other words, the subject is an argument and the predicate the operator applying to this argument because it is the subject which chooses the semantic presupposed feature of the predicate. And generalising this we can say that from two expressions between which a grammatical relation holds, one should consider as the argument the expression which chooses (selects) the semantic features of the other expression. Thus in (13)

(13) This student is old

the adjective old is an operator and the noun phrase this student is its argument, for this sentence means that This student is a human being (and not old as a student) i.e. the feature human is imposed on the predicate old by the subject. Now the inversion of the situation is possible. Two expressions of the same category can have different selection restrictions and, a priori, each of them can impose its own selection restrictions on the other; in this case we can have two different readings. We can see this somewhat differently. Given a category mistake, as in (14)

(14) Tables are prime

one can say that there is a mistake because of "tables" (for it is not tables which are prime) or because of "prime" (it is not prime that tables are). Let me now apply this analysis to some of the above examples. Take first the adjectival modification. The noun phrase old student has two (non-equivalent) negations: negating either the adjective or the noun. When we negate the adjective, then it is considered as the operator on which the presupposed feature human of the noun student is imposed and consequently the noun student is its argument; we get the categorematic reading. When it is the noun student which is negated then it can be replaced by any other noun which does not have as a pre-

supposed feature human but which refers to something which can be old or not old, for the feature human is not a presupposed feature of the adjective old; the adjective is to be considered as the argument and the noun as the operator and we get the syncategorematic reading. More formally the extension of the NP old student can be either the result of the application of a function (old) to the extension of the noun student: old'(student') - categorematic reading, or the result of the application of another function (student) to the extension of the adjective old (anything which is old, in any sense, not only human beings): student'(old) - syncategorematic reading.

Similar considerations are valid with respect to generic sentences for instance. The two following functions are relevant in the determination of the two readings of (1): eat much'(orphans') and orphans'(eat much'). Notice that this analysis permits us to understand why the negation of the generic reading of (15) is false and the negation of the eventive reading may be true:

(15) Les chiens aboient

The corresponding (translations of surface) negations would be: Dogs do not bark and The dogs are not barking.

As far as I can see any other case of the type discussed above can be analysed in the same way. Of course it is possible that in details some supplementary aspects should be taken into account. For instance in the case of genericness one should think about tenses, articles, grammatical cases, plurals, etc. A priori, however, all of these have an ambiguous status: semantically they can be either arguments or operators.

More precisely I hope that all above discussion has furnished an empirical basis for the following modification of the semantic part of the Montague type grammar: if a is a semantic type corresponding to the category A and b the type corresponding to the syntactic category B, then to the category A/B (and A//B) correspond two types: <b,a> and <a,b>.

It is clear that this proposal, to be taken seriously, necessitates some, probably non-trivial, changes in the corresponding higher order logic. I will not, however, enter into the technicalities of this topic.

My last remark will be concerned with quantifiers. We were preoccupied till now by the possibility of inverting the role of argument and operator given two expressions between which certain grammatical relation holds. Thus we need something which can be taken as an "inverse" of a quantifier. I would like to propose considering the words like only, also, even etc. for this role. Two reasons at

least support this suggestion. First there is an equivalence (with qualifications) between All A are B and Only are A and between Also A is B and Some B are A etc. What is interesting here is the switching between subject and predicate expressions with the change of quantifiers into only or also.

Furthermore, one can observe that no noun phrase which is under the scope of such a word as only, also, even etc. can serve as a grammatical antecedent for the pronoun of laziness. Thus (16) and (17) are not equivalent:

(16) Only Steve washes himself

(17) Only Steve washes Steve

This non-equivalence can be explained by the presuppositional properties of only, also, etc. (cf. Zuber 1975 a).

Of course here even more than in the previous part, a more formal development is in order.

Footnotes

- 1) I am quite aware of the fact that the distinction presupposition - assertion has been often criticised. As far as I can see this criticism is not an absolute criticism of the distinction as such but a criticism of some particular analyses. Furthermore, what follows can be considered in some sense a defense of this distinction.
- 2) It is worth-while to mention that in many papers Montague discusses many examples which are in simple tense but interprets as if they were in progressive tense. It clearly means that Montague does not find the generic - non-generic distinction relevant for the logical study of natural languages.
- 3) I am disregarding here proper names and quantifier phrases. Later I will say a few words about quantifiers. Concerning proper names one can observe that they do not have any particular selection restrictions on the one hand and that they do not display the referential - non-referential ambiguity on the other hand. We can consequently disregard them.

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