CRAIGE ROBERTS

MODAL SUBORDINATION AND PRONOMINAL ANAPHORA IN DISCOURSE*

Modal subordination is a phenomenon which stems from the relationships between propositions in a discourse. It is reflected in two kinds of related problems, which are illustrated in the discourses in (1)–(4):

(1) The birds will get hungry (this winter).

(2)a. If Edna forgets to fill the birdfeeder, she will feel very bad.

 b. The birds will get hungry.

(3)a. If John bought <u>a book</u>, he'll be home reading <u>it</u> by now.

 b. # <u>It</u>'s a murder mystery.[1]

(4)a. If John bought <u>a book</u>, he'll be home reading <u>it</u> by now.

 b. <u>It</u>'ll be a murder mystery.

The first type of problem involves the effect of context on the inferences which we may draw from a given sentence. In (1), for example, a proposition is asserted. But the same sentence in the context of the discourse in (2) seems more likely not to be asserted, but only to be asserted as following from the antecedent of (2a). The birds need not actually get hungry for the whole discourse to be true, so long as Edna is filling the birdfeeder so that the proposition expressed by the antecedent of the conditional isn't true. The other type of problem involves anaphora, where the apparent antecedent is a quantified expression and the anaphor is not within its scope under standard assumptions about quantifier scope. In (3a) and (4a) we see an example of the classical 'donkey' sentences of Geach (1962), which have posed problems for theories of anaphora be-

[1] Intended anaphoric relations are indicated by underlining antecedent and anaphor, The symbol '#' here and below indicates that the sentence is infelicitous in this context.

CRAIGE ROBERTS

cause the indefinite noun phrase *a book* serves as antecedent for a pronoun outside its scope, in the consequent. The discourse theories of Hans Kamp (1981) and Irene Heim (1982) provide an account of the felicity of anaphora in examples of this type. However, they do not account for several facts about the potential for anaphora in succeeding sentences. The discourse in (3) is infelicitous. (b) is only interpretable as an independent assertion in this context, and the discourse is infelicitous because we have no available antecedent for the pronoun *it*. But the syntactically similar discourse (4) is felicitous. (4b) may be interpreted as a sort of continuation of the conditional in (a), as if it were coordinated with the consequent. I will show that the facts about inference and anaphora which are displayed in (2) and (4) are the consequences of a phenomenon I call **modal subordination**. Note that this notion of subordination is not the traditional syntactic notion. For example, in (4a), although the antecedent clause is syntactically subordinate, the main, or consequent clause is modally subordinate to it in discourse. This will become clear below.

I will develop a formal theory of examples such as (1)–(4) as an extension of Kamp's (1981) Discourse Representation Theory. In Section 1, I will relate the notion of the mood of a sentence to a theory of modality in model theoretic semantics and show how this is relevant for modal subordination. In Section 2, I will argue that in order to account for the anaphoric phenomena, we need a theory of discourse which provides discourse referents intermediate between syntactic noun phrases (NPs) and their model theoretic interpretation; I will sketch informally the way in which I propose to account for modal subordination by extending Discourse Representation Theory to include modality. In Section 3, I will consider cases of modal subordination where the modality is not epistemic, and I will present a formal theory which accounts for both the epistemic and non-epistemic cases. In Section 4, I will discuss how we might extend the analysis of subordination in discourse to cover cases involving non-modal operators, and in Section 5, I will summarize my conclusions.

1. MOOD, MODALITY, AND MODAL SUBORDINATION

Before we can discuss the relation between mood and modality, we must consider what it means to make an assertion in a discourse. Following Robert Stalnaker (1979), I will characterize this notion in a possible worlds semantic framework.[2] Because we as individuals are not omniscient and

---

[2] Heim (1982) discusses the relevance of Stalnaker's theory of assertions for her theory of discourse, What is new here is the discussion of the relationship of mood and modality to what is asserted.

do not know everything about the world in which we live, we do not know which of the possible ways that things may be, or possible worlds, is the actual world. However, as participants in a conversation, we assume a set of propositions about the way the world is; these may be introduced explicitly in the course of the conversation and mutually agreed upon, or they may be implicit presuppositions which it is assumed that all participants share. These explicit and implicit assumptions Stalnaker calls the **common ground** of the conversation, and this is enough to rule out quite a few possible worlds, those in which any of the propositions in the common ground are false. The larger the common ground in a given conversation, the smaller the set of possible worlds compatible with all the propositions presupposed, that is, the closer we come to being able to fully characterize the actual world. The set of possible worlds compatible with the common ground of a conversation is called the **context set**. These are the remaining candidates for the actual world. Given this framework, Stalnaker characterizes assertions as follows (1979, p. 323):

> To make an assertion is to reduce the context set in a particular way, provided that there are no objections from the other participants in the conversation. The particular way in which the context set is reduced is that all of the possible situations incompatible with what is said are eliminated. To put it in a slightly different way, the essential effect of an assertion is to change the presuppositions of the participants in the conversation by adding the content of what is asserted to what is presupposed. This effect is avoided only if the assertion is rejected.

So, every time we accept some assertion about the actual world[3] we come closer to being able to completely characterize that world, and the context set of remaining possibilities becomes smaller. For example, suppose you and I are discussing the poet Lorine Niedecker. You mention that she was born near Lake Koshkonong in southern Wisconsin in 1903, a fact which I already knew. This fact is then in our common ground, and the context set determined by that common ground contains no worlds in which Lorine Niedecker was not a poet, or in which she was born in Tulsa, Oklahoma. But if this is all the information we share about Lorine Niedecker, there will be worlds in the context set where she never left Lake Koshkonong, worlds where she left there at age 20 and rarely returned, worlds where she had children, worlds where she did not, and so forth. If I tell you that Lorine Niedecker left her birthplace for only a few years in the late forties and that she never had children, and if you

---

[3] For simplicity, I will assume throughout this paper that the world which we attempt to characterize in discourse is always the actual world. However, it is often the case that we assert propositions to be true not of the actual world but of some fictional or fantasy world, as in a novel, a play, children's play, etc.

accept what I say as true, then we add these propositions to our common ground. We now eliminate from the context set all worlds incompatible with this information.

This characterization of the notion of common ground and the discussion in Stalnaker's work from which it is drawn tend to suggest that the common ground is epistemic in character and is shared by all participants. However, things are somewhat more complex than this. In actual practice, there may be as many versions of the common ground of a given conversation as there are participants. This is because we typically have different ideas about what propositions are implicitly presupposed, as well as failing to communicate or understand properly those propositions which are explicitly presupposed or asserted. We may even deliberately mislead a hearer into thinking we share certain assumptions, so that the conversation proceeds on the basis of what one of us believes to be false premises. In any case, each of the participants in a conversation adopts a certain fiction which is crucial for effective communication: that the common ground as he or she knows it is in fact common to all the participants. Many restrictions on what constitutes felicitous discourse are designed to make sure that in crucial respects our common grounds do match. Some of these restrictions are rhetorical in nature, concerned with more or less conscious strategies for the presentation and flow of information and the development of argumentation; but some seem to be more deeply integrated into linguistic rule systems such as that governing anaphora. We will consider how such restrictions affect discourse anaphora in the following section.

Let us assume that Stalnaker's characterization of what it is to make an assertion is essentially correct. It remains to clarify when a particular utterance is an assertion. Even if we rule out of consideration utterances which clearly function as questions, commands, or other non-assertive speech acts, not all declarative sentences uttered in a discourse are asserted to be true, as we have seen in (2b). It is the **mood** of an utterance which tells us whether or not it is asserted. The sense of *mood* which interests us here is what Jespersen (1965) calls **notional mood**. This does not concern a grammatical feature of verbs, but rather describes a feature of sentence use: it relates to the speaker's commitment to the truth of a sentence in the actual world. If a speaker indicates by conventional means that a sentence or clause is to be interpreted as true in the actual world, we say that the sentence or clause was uttered in the **factual mood**. Utterances in the factual mood are asserted, in Stalnaker's sense. Sentences in the indicative grammatical mood, such as (1), are generally interpreted as factual where there is no context to suggest otherwise. But if a clause, such as the antecedent of a conditional, expresses a hypothetical assumption, or

if there is otherwise some question about the actual truth of the clause, we say that it is uttered in a **nonfactual mood**. Nonfactual mood is expressed by a variety of conventional means. The subjunctive grammatical mood is one means; for example, I have been told (Roger Higgins, p.c.) that in German journalistic style the subjunctive may be used in main clauses to indicate that the proposition expressed is hearsay, and that the writer does not necessarily subscribe to its truth. Other, unrelated languages use similar morphological devices, for example Japanese (Karina Wilkinson, p.c.) and Finnish (Anne Vainikka, p.c.). Nonfactual mood may also be indicated by expressions like *suppose that...*, or *if...then....* It may involve the use of modal auxiliaries like *would* or *could*, or adverbials like *probably*, *supposedly*, etc. And nonfactual mood may also be suggested by the sequence of tenses in a discourse; below we will consider how this works in examples such as (2).

I propose that in a possible worlds semantic framework, mood should be interpreted in terms of modality. If we make a hypothetical supposition, in a nonfactual mood. we are not committing ourselves to its truth in the actual world. But for the purpose of exploring the consequences if that supposition were in fact true, we temporarily add it to our common ground. This temporarily eliminates some possible worlds in the original context set – those in which the hypothetical assumption is not true. Since we do not necessarily know whether our assumption holds true, the reduced context set which results may or may not include the actual world, that is it may or may not be **realistic**.[4]

In order to express this formally, I will adopt a theory of modality in natural language which has been proposed by Angelika Kratzer (1977, 1979, 1980, 1981) and is compatible with Stalnaker's functional characterization of assertion. Kratzer points out that the force of modal operators such as *necessarily*, *possibly*, *would*, and the like in natural language is not absolute, as are the necessity and possibility operators in modal logic, but is relativized to a contextually determined set of propositions. In Kratzer (1980), there are two sets of propositions involved in such relativization, given by two functions which she calls the **modal base**, and the **ordering source**. In this section, I will simplify the informal discussion of Kratzer's theory by only considering the relativization of the force of modal operators to a single set of propositions, those in the common ground; for the examples under consideration, the common ground will play the role of the propositions given by Kratzer's modal base. Later, in Section 3, we will see more complex examples where the common ground

---

[4] This is an extension of Kratzer's (1980) sense of *realistic*.

CRAIGE ROBERTS

and the set of propositions given by the modal base are not the same, and we will consider the importance of the ordering source in characterizing non-epistemic modality and counterfactuals.

As an example of how the relativization of modal force works in Kratzer's theory, consider (6):

(6)   Ella might lift that refrigerator.

Here, the modal force of *might* is that of possibility. If we translate this utterance into a sentence of a modal predicate calculus and then interpret it in the standard fashion, it means roughly, "there exists at least one member of the set of all possible worlds in which Ella lifts that refrigerator". Now, if we assume that this set of possible worlds contains not just those situations which we regard as reasonable in the actual world, but all possibilities, including, for example, a world in which ordinary women such as Ella easily lift two ton trucks, the utterance is then trivially true. It would come as no surprise that in that world such women also lift refrigerators. But this flies in the face of our intuitions about the proposition, which seems much stronger than this.

In ordinary conversation, a hearer is likely to assume that the person uttering (6) is making a claim in view of what is physically possible and normal in the actual world. Following Kratzer, we will relativize the modal force of (6) to the set of possible worlds where the actual facts about this sort of thing are all true. In general, speakers tend to assume that the common ground of a given discourse includes a set of propositions which we might characterize as "what is physically possible" (or, more properly in a doxastic common ground, "what we in common assume about what is physically possible". Thus, in a lay conversation, speakers do not generally assume that the common ground includes propositions about quarks or the ultimate nature of light.) This determines a context set which does not contain all possible worlds, and in particular, won't contain worlds where ordinary women easily lift two-ton trucks. Relativizing the modal force of (6) to this context set, the proposition has truth conditions which are closer to our intuitions about its meaning: it will be true in case there is a possible world in which the actual facts about human strength, gravity, etc. are true, and in that world, Ella lifts that refrigerator.

This relativization of the modal force to a narrowed context set is very similar to domain selection in quantification. For example, if a speaker says "Everyone seems happy", he doesn't usually mean that absolutely all individuals whatsoever seem happy, but only those in a suitably narrowed domain; for example, 'those individuals in this room', or the like. We

often are not explicit about how to select this domain, assuming that our hearers will guess what we intend from the context. Similarly, we often assume that our hearers will understand how we intend to restrict the context set of possible worlds over which modal operators range. This was the case in the refrigerator example just discussed.

Sometimes, though, a speaker is more explicit about at least some of the propositions which she wants the hearer to add to their shared common ground. Consider again example (2):

(2)a.   If Edna forgets to fill the birdfeeder, she will feel very bad.
    b.   The birds will get hungry.

It has been noted by several authors (including Kratzer (1980) and Heim (1982)) that conditional sentences often have modal force, either explicit, as when the consequent contains a modal auxiliary such as *might*, or implicit, in which case the modal force is that of necessity.[5] The antecedent clause is hypothetically added to the common ground, narrowing the context set against which the modal force is evaluated. (2a) is an indicative conditional without overt modal operators. Because of the future tense in the consequent, we are not tempted to interpret the present tense in the antecedent as a generic present, quantifying over times when Edna forgets; rather it is interpreted as a prediction about what will happen, given what we know about the world, if the antecedent is true. Thus, we interpret the conditional as having necessary modal force. In order to interpret (2a), we temporarily add the proposition expressed by its antecedent, *Edna forgets to fill the birdfeeder*, to the common ground of the conversation up to that point. Felicity conditions on the utterance of a conditional are such that we do not generally utter a conditional such as (2a) in a

---

[5] Actually, *if*-clauses may serve to modify various operators, not just modals. Farkas and Sugioka (1983) point out examples like the following:

(i)   Mary is usually friendly, if she's not in a hurry.
(ii)   All cats like to use scratching posts, if they haven't had their claws removed.

In (i), the operator is a temporal adverb of quantification; in (ii), a universal quantifier. Often, conditionals without any explicit operator seem to have a modal flavor. However, this is not always the case. Steve Berman (p.c.) points out that the following example seems to involve quantification over times or events:

(iii)   If Edna forgets to fill the birdfeeder, she feels bad. The birds get hungry.

Such examples may involve situations, however these are to be defined, See Section 4 for further discussion. In all the cases which interest us in this section, treating the *if*-clause as modifier of a modal operator presents no problem.

context where we already know the truth of the antecedent in the actual world. Thus, adding the antecedent to the preceding common ground determines a hypothetical context set of possible worlds which may or may not contain the actual world, that is, which may or may not be realistic. The modal force of the conditional is then relativized to the hypothetical context set: we only consider those worlds where Edna forgets to fill the feeder. The whole conditional is then true if the consequent, *she will feel very bad*, is true in each of these possible worlds. Thus, the consequent is modally subordinate to the antecedent, in that it is only asserted relative to the truth of the antecedent.

As I already noted, we may interpret (2b) as being in a nonfactual mood. The key to this possibility lies in the interpretation of its tense. As Partee (1973, 1984) has discussed, the interpretation of tense has much in common with the interpretation of anaphora, in that whatever the tense of a sentence, it may only be interpreted with respect to an implicit or explicit **reference time**, a notion stemming from Reichenbach (1947). While the reference time of a given event, state or process may be introduced by an initial adverbial, it is often given by the context in which the sentence occurs. This is the case with the determination of the reference time for the verb in (1), *the birds will get hungry (this winter)*. With no prior relevant context, we take the reference time to be simultaneous with the event of uttering (1), called the **speech time**, so that the event of the birds getting hungry is future relative to the speech time; the temporal adverbial *this winter* further specifies the location of this future time. Without the temporal adverbial, we know only that there will be some future time at which it will be true that the birds have gotten hungry.

However, the same sentence occurs in a different context in (2). The reference time of the nonfactual antecedent of (2a) is most likely that of some future time which the participants have been discussing, a time when the feeder is supposed to be filled. The consequent is then interpreted as future with respect to its reference time, the latter given by the antecedent, in keeping with the plausible implication that the state referred to in the consequent will result from the event referred to in the antecedent. Now consider the interpretation of (2b) in this context. Since we have already been talking about Edna, and since Gricean conversational principles (Grice 1967) require that we generally seek to determine the relevance of a proposition to its context in discourse, we consider how (2b) may be related to (2a). In this case, the sequence of tenses and the plausibility of narrative continuity suggest that the reference time of (2b) is given by (2a); more precisely, that (2b) has the same reference time as the consequent of (2a), that which is given by the antecedent.

However, note that although the entire conditional in (2a) is factual (that is, its truth is a condition on membership in the context set of worlds which are candidates for actuality), neither the antecedent nor the consequent by themselves are factual. This means that the event denoted by the antecedent may not occur in the actual world. We are likely to view (2b) as a consequence of the antecedent (and possibly the consequent of (2a) as a consequence of (2b)). But we don't have actual effects of non-actual causes. That is, since the consequent of (2a) and (2b) take the antecedent as giving their reference time, they must be non-factual as well. In terms of the account I am proposing, this means that although (2b) contains no overt modal operators, it is to be interpreted against a possibly non-realistic common ground which includes the antecedent of the preceding conditional. If we do this, we get an interpretation like "If Edna forgets to fill the birdfeeder, she will feel very bad and the birds will get hungry". This seems to give the right truth conditions.

In this informal discussion of the relationship of mood to reference time, there are a number of important questions which remain unexamined. For example, I have not discussed here what I mean formally by *reference time*. Is it an interval or an event? Why does taking a non-factual clause α as giving the reference time for a clause β entail that β is non-factual as well? In the formal theory presented in Section 3, I will have nothing to say about times or the temporal relations between sentences. However, I believe that this type of example may be used to argue for a particular kind of theory of the relationship between temporal reference and subordination in discourse, and this will be one of the central arguments of Roberts (forthcoming). What is important here is that if we take (2b) as interpreted against a partially nonfactual common ground which includes the proposition denoted by the antecedent of (2a), we can explain the inference problem discussed in the introduction.

There is another way of interpreting (2b) in this context, a factual interpretation where the future time referred to by its tense is existentially quantified: "there is some future time when the birds will get hungry". This is an assertion, factual in mood. We take it to be a fact of life that the birds will get hungry in any case. On this interpretation, (2b) is only indirectly relevant to the utterance of the preceding conditional, and I take it that this is why the nonfactual interpretation is preferred, since we generally seem to prefer the most relevant interpretation of an utterance with respect to its immediately preceding context.

This discussion of examples (1) and (2) suggests that the notion of mood in conjunction with a theory of modality along the lines suggested by Kratzer can provide an account of the inferential properties of discourses

with intersentential modal subordination. Now we will turn to consider the relevance of anaphora for a theory of modal subordination.

2. MODAL SUBORDINATION AND CONSTRAINTS ON ANAPHORA

2.1. *The Insertion Approach*

To account for the facts about anaphora illustrated in examples (3) and (4), the Stalnaker–Kratzer approach I have just sketched will not alone suffice. This is because this approach by itself has no provision for describing structural relations between NPs above the sentential level; hence, we do not have the means to discuss formal constraints on anaphora in discourse. Irene Heim's File Change Semantics (1982) and Hans Kamp's Discourse Representation Theory (1981) were initially developed to deal with problems in anaphora, and extending them to include the theory of modality I have just described will provide us with the basis of a theory of anaphora in modal subordination. In what follows, I will use Discourse Representation Structures (DRSes) to illustrate the theory; however, a very similar theory may be developed using Heim's Files.

Both discourse theories utilize variable-like **discourse referents** to serve as intermediate representations of syntactic noun phrases on the DRS (or File) level.[6]

For Kamp, the relative location of two discourse referents in the DRS determines whether one of these may serve as antecedent to the other.[7] If a clause is in a factual mood, it is mapped onto the top level of the DRS. Consider the DRS for the simple sentence *John bought a book* in (7):

(7)

$$\begin{array}{|ll|} \hline x & y \\ \text{John}(x) \\ \text{book}(y) \\ \text{bought}(x, y) \\ \hline \end{array}$$

---

[6] Other researchers before Kamp and Heim had realized the need for something intermediate between syntactic NPs and their real world denotations. For example, see Karttunen (1976), from whom the term *discourse referent* is borrowed, and Webber (1978).

[7] Chierchia and Rooth (1984) point out that this is really a matter of the scope of the operators involved in the interpretation of the DRSes and not of configurationality. However, we can ignore this point here.

Kamp proposes an algorithm for mapping from sentential syntactic structures onto DRSes. In Roberts (1985, 1986) I proposed a different approach, which permits us to retain the insights of the Binding theory of the Government and Binding framework of Chomsky (1981) and associates. For our purposes here, the important feature which these approaches share is that each NP in a discourse will be mapped onto a discourse referent in the DRS. Both the content of the original NP and the content of anything predicated of that NP in the sentence are then entered as conditions on its discourse referent. In the case of (7), each NP in the original sentence is correlated with a distinct discourse referent, *John* with x, and *a book* with y. The proper name *John* and the common noun *book* have become conditions on the discourse referents correlated with their respective NPs, and a further condition specifies that the relation *bought* holds between x and y.

The resulting DRS is still an uninterpreted formal structure, logically syntactic in Carnap's sense. To interpret this structure, we use another algorithm to **embed** it in a truth conditional model. Formally, an embedding is a function from discourse referents onto individuals in the model, such that the individual which a given discourse referent r is mapped onto displays each property corresponding to a condition on r. A DRS, and thus, indirectly, the discourse which induced it, is true in a model iff there is an embedding of the DRS in the model. Note the metalanguage existential quantification over embeddings. Although indefinite and definite NPs aren't treated as inherently quantificational in this theory, this meta-language quantification has the truth conditional effect of existentially quantifying over all of the discourse referents on the top level of a representation. (7) may be interpreted in a model as asserting that there is an individual to which x may be mapped, *John*, and an individual to which y may be mapped, which is a book, such that the individual corresponding to x bought the individual corresponding to y.

Universally quantified NPs induce a more complex DRS. Compare Kamp's representation for the generic interpretation of sentences such as (8), in (9):

(8)   Every farmer who owns *a donkey* beats *it*.

(9)

| $x \quad y$		w
farmer(x)	$\Rightarrow$	beat(x, w)
donkey(y)		
owned(x, y)		$w = y$
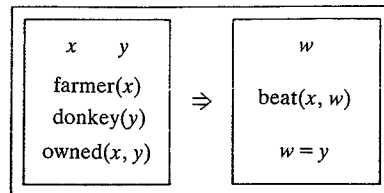
Here, the symbol between the antecedent and consequent boxes is reminiscent of the symbol for the material conditional. The lefthand subordinate box contains the representation of all the material in the common noun of the subject, here the noun *farmer* and the relative clause which modifies it, including the representation for the NP *a donkey* within that relative clause. The righthand subordinate box represents the material predicated of that subject. In such a representation, the righthand box is said to be **subordinate** to the lefthand box. When we introduce a discourse referent for a pronoun, such as *w* in the righthand box in (9), we must indicate an antecedent for the pronoun, or else the resulting DRS will be ill-formed. To find an antecedent, we locate an **accessible** discourse referent, that is, one which is on the same or a superordinate level of structure as the pronoun's discourse referent. In (9), the discourse referent for the pronoun, *w*, may take any accessible discourse referent as its antecedent; here, we have selected the discourse referent for *a donkey*, *y*. This is symbolized by equating *w* with *y*. The extensional embedding conditions for such a representation specify that for any embedding of the antecedent box there must be an extension of that embedding to provide an embedding of the consequent box as well. Thus, any farmer/donkey pair which stands in the *own* relation must stand in the *beat* relation as well. Again, this metalanguage universal quantification explains the seemingly universal force of the indefinite in the relative clause without treating that NP itself as inherently universally quantified.

If a clause is in a non-factual mood, the common ground against which it is interpreted is not realistic. Entities which are introduced with an indefinite NP in that section of discourse may not actually exist. So the clause is mapped onto a subordinate level of the DRS, reminiscent of the way in which hypothetical assumptions are indented in a proof. Consider the sentence which occurs in (3a) and again in (4a):

(3)a.   If John bought <u>a book</u> he'll be home reading <u>it</u> by now.

This is another example of modal subordination in a conditional sentence, as with example (2a), but here anaphora is involved. As before, although the entire conditional is asserted, neither the antecedent 'nor the consequent is factual in mood. Because the antecedent is not factual, it must be entered into the DRS on a level subordinate to the top level, as in the DRS in (10):[8]

---

[8] Kamp does not use the symbol □ in his representation of sentences like (3), using instead the symbol ⇒, as in (9). He doesn't consider modality in his account.

(10)

$x \quad y$		$z \quad w$
John(x)	$\Box$	reading(z, w)
book(y)		$z = x$
bought(x, y)		$w = y$
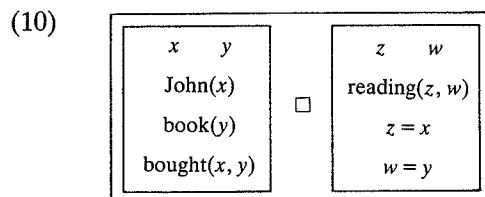
Here, the representations of the antecedent and consequent are each in a box which is subordinate to the top level. The lefthand box, representing the antecedent, is as in (7). The righthand box represents the consequent; as in the example with a universal quantifier in (9), the righthand box, that representing the consequent, is subordinate to the lefthand, or antecedent, box. (Note again how this notion of subordination differs from the syntactic one.) We enter discourse referents for the pronouns in the consequent of (3a) on the appropriate level of the DRS, z for *he* and w for *it* in the righthand box. These may then take the accessible discourse referents for *John* and *a book*, x and y, as their antecedents.
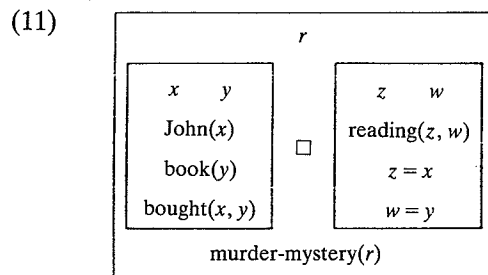
The symbol $\Box$ in (10) is mnemonic for the necessity operator. In interpreting the DRS, the antecedent box will serve as a restriction on the necessity operator, in much the same way as in Kratzer's theory. In terms of the formal theory in Section 3, its truth conditions can be paraphrased as "For all worlds in which there is an individual John x, and a book y, and x bought y, then $z(=x)$ is reading $w(=y)$". As an assertion, this utterance instructs the participants in the discourse to reduce the context set as follows: "Consider all worlds in the present context set. (These are all candidates for the actual world. That is, they are all worlds in which all the presuppositions in our common ground so far are true.) Now consider only those worlds in that set where there is an individual John, x, and there is a book, y, and x bought y. In each of those worlds, you should find that there is an individual $z(=x)$ and an individual $w(=y)$ and that z is reading w. If not, discard that world from the context set." We see that the notion of modal subordination which we expressed using Kratzer's theory of modality in the birdfeeder example translates readily into Kamp's configurational subordination. Just as in that example, after I have modified the original context set, containing candidates for the actual world, by the hypothetical addition of the antecedent of the conditional to the common ground, I no longer know whether the resulting context set contains the actual world. We haven't asserted the antecedent, but only assumed it temporarily. So we have only temporarily assumed the existence of the entities referred to in the antecedent. Since the

consequent is subordinate to the antecedent, we may continue to assume the existence of those referents, and their discourse referents may serve as antecedents for anaphors in the consequent.

Now consider (3b):

(3)a.　　If John bought <u>a book</u>, he'll be home reading <u>it</u> by now.

　　b.　#<u>It</u>'s a murder mystery.

There is no overt modal in (3b), and no plausible dependency relation between the reference time of its simple present tense and the conditional present of the consequent of (3a). Hence, we are not tempted to interpret the two clauses as in the same, nonfactual mood, and there is no evidence of modal subordination. Further, a conditional such as (3a) is only felicitous where we do not know the truth of its antecedent, and in this case, this entails not knowing whether John bought a book. But (3b) seems to be about some actual thing which is a murder mystery. Since (3b) appears to be in the factual mood, we enter it on the top level of the DRS, assigning a discourse referent r to the pronoun *it*, and adding the condition *murder-mystery* (r), as shown in (11):

(11)

$$
\boxed{
\begin{array}{c}
r \\[4pt]
\boxed{
\begin{array}{c}
x \quad y \\
\text{John}(x) \\
\text{book}(y) \\
\text{bought}(x, y)
\end{array}
}
\quad \square \quad
\boxed{
\begin{array}{c}
z \quad w \\
\text{reading}(z, w) \\
z = x \\
w = y
\end{array}
} \\[6pt]
\text{murder-mystery}(r)
\end{array}
}
$$

But now the discourse referent for *a book*, y, is in a box which is subordinate to r, and so y is not an accessible antecedent for r. The discourse is not felicitous unless there is another discourse referent in prior discourse which would be a plausible antecedent for the pronoun, or where the pronoun is deictic.[9]

(4b), on the other hand, contains the same modal auxiliary *will* as the consequent of the preceding conditional sentence, and it is readily interpreted as an extension of the nonfactual mood:

---

[9] These two cases may be the same from the point of view of discourse theory. For some discussion, see Heim (1982).

(4)a.   If John bought <u>a book</u>, he'll be home reading <u>it</u> by now.

   b.   <u>It</u>'ll be a murder mystery.

One way to represent the resulting modal subordination would be to simply add the representation of (4b) to the consequent box of the DRS (10), as in (12):

(12)

x y		z w r
John(x)	□	reading(z, w)
book(y)		$z = w$
bought(x, y)		$w = y$
		murder-mystery(r)
		$r = y$
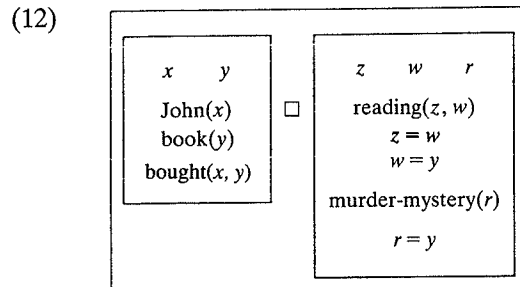
Here, a new discourse referent r has been added to the consequent of (10), along with the condition *murder-mystery* on r, and r has been equated with the accessible discourse referent y. Let us call this way of representing modal subordination the **insertion approach**. In this example, the result gives us the correct truth conditions. (12) would be interpreted as "In all worlds where there is a book which the individual named John bought, you will find that John is reading the book and that it is a murder mystery". As an assertion, the conditional is an instruction to remove from the context set determined by the prior common ground any worlds in which the antecedent is true and the consequent false.

2.2. *The Accommodation of the Missing Antecedent Approach*

There are a number of examples which show that the insertion approach is inadequate. (13) illustrates a problem pointed out by Fred Landman (p.c.):

(13)a.   A <u>thief</u> might break into the house.

    b.   <u>He</u> would take the silver.

In (13a), *might* leads us to interpret the material in its scope as nonfactual. Uttering this sentence does not commit the speaker to the existence of an event in the actual world. Rather, it asserts that among the candidates for the way things are, the possible worlds in the present context set, there is at least one where a thief breaks into the house. Just as in Kratzer's theory of modality, *might* will be interpreted as the possibility operator in modal logic, relativized to the context set. The DRS of (13a) is shown

in (14):

(14)

$$\Diamond \quad \boxed{\begin{array}{c} x \\ \text{thief}(x) \\ \text{break-into-the-house}(x) \end{array}}$$
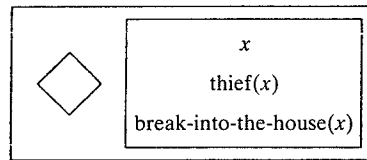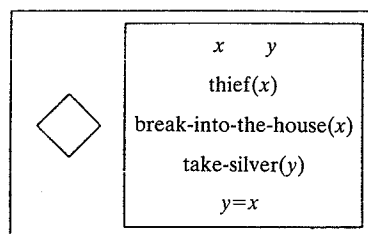
The modal *might* is translated by the diamond operator on the left. The nonfactuality of the remainder of (13a) is expressed by entering its representation on a subordinate level of the DRS, the box on the right in (14). The modal force here is possibility, indicated in the DRS by the diamond operator. We might utter (13) in a situation where all the participants in the discourse already have certain assumptions, such as "Given that there has been a lot of theft in this neighborhood", and "Given that this house has poor security". These propositions in our common ground, rather than propositions denoted by any nonfactual clauses, might alone serve to relativize the force of the modal. Because the hypothetical common ground is realistic in such a case, I have not included a subordinate box to the left of the diamond operator, though in other contexts this might be necessary, as in "If you left a Mercedes parked out front, a thief might break into the house".

In this example, I think the most natural sense of possibility is that of future possibility. An adequate embedding algorithm for this DRS will require us to examine each world in the context set to determine whether among the possible futures which branch out from the present moment in that world there exists at least one in which the box on the right in (14) may be truthfully embedded. If this is so, the world is retained in the context set after the utterance of (13a). If not, it is removed. Informally, its truth conditions might be paraphrased, "There exists some possible future in which a thief breaks into the house".

Now, if we try to represent (13b) by inserting material into the righthand box in (14), as in (15), we will get the wrong truth conditions:
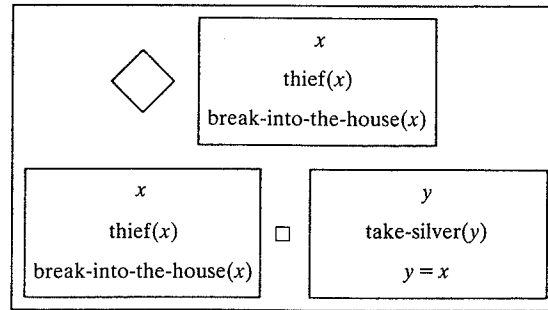
(15)

$$\Diamond \quad \boxed{\begin{array}{c} x \quad y \\ \text{thief}(x) \\ \text{break-into-the-house}(x) \\ \text{take-silver}(y) \\ y = x \end{array}}$$

Here, I have added a discourse referent, y for *he*, and the appropriate condition *take-silver* on y, equating y with the accessible antecedent x. The model theoretic interpretation of this DRS could be paraphrased, "It's possible that a thief will break into the house and take the silver". But this is not our understanding of (13). In uttering this discourse, I don't simply assert that a thief *might* take the silver. I'm saying something stronger: "It's possible that a thief will break into the house, and *if he does*, he will undoubtedly take the silver". The problem, of course, is that (13b) has a different modal force than (13a). *Might* in (13a) has the force of possibility; whereas, *would* in (13b) has the force of necessity. Instead of inserting the non-factual (13b) under the scope of the possibility operator in (13a), we must treat the modal auxiliary *would* as indicating that (13b) is a modally subordinated clause which is, like the consequent of a conditional, in need of an antecedent. The approach I suggest, which I will call the **accommodation of the missing antecedent** approach to modal subordination, is the pragmatic **accommodation** of a contextually given hypothetical common ground to be the antecedent of the modally subordinated clause. I use the term *accommodation* in an extension of David Lewis' (1979) sense, where to accommodate a presupposition is basically to add it to our common ground because without that presupposition, we cannot assign a truth value to an utterance, i.e., cannot make sense of it. Here is Lewis' definition:

> If at time t something is said that requires presupposition P to be acceptable, and if P is not presupposed just before t, then – *ceteris paribus* and within certain limits – presupposition P comes into existence at t. (p. 340)

Stalnaker (1979) identifies the set of propositions in the common ground of a discourse as the presuppositions of that discourse. We do not always introduce such presuppositions explicitly. Rather, we often assume that we share certain knowledge about the world with other members of the discourse, that is, we presuppose the propositions expressing that knowledge. In discussing (13), for example, I said that it would be felicitously uttered where the participants in the discourse already had certain assumptions about the actual world which made it probable. But these assumptions might not have been explicitly introduced into the discourse. Perhaps we've both lived in this neighborhood all our lives. I know there are thieves out there and you know it too, so we don't need to say it. It is presupposed. That is, in a Kratzer-type theory where we relativize the force of a natural language modal element to some context set, the propositions which determine that context set may be implicit in whole or in

part. So, when we encounter the modal *would* in (13b), we may assume that certain relevant assumptions should be added, at least hypothetically, to our common ground. To illustrate how accommodation works in modal subordination, consider the DRS for (13) in (16):

(16)

```
┌──────────────────────────────────────────────────────┐
│                         ┌─────────────────────────┐    │
│                         │            x            │    │
│         ◇               │         thief(x)        │    │
│                         │   break-into-the-house(x)│   │
│                         └─────────────────────────┘    │
│  ┌─────────────────────┐     ┌─────────────────────┐  │
│  │          x          │     │          y          │  │
│  │       thief(x)       │  □  │     take-silver(y)   │  │
│  │ break-into-the-house(x)│   │        y = x         │  │
│  └─────────────────────┘     └─────────────────────┘  │
└──────────────────────────────────────────────────────┘
```
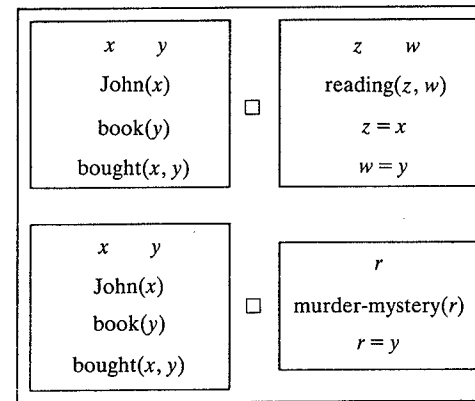
The upper portion of (16) contains the representation of (13a) which we saw in (14). The diamond possibility operator is intended to have scope only over this top box. The lower portion contains the representation for (13b). The necessary modal force of *would* induces the form for the representation of necessity which we have seen above. (13b) itself is represented in the righthand, or consequent box, while in the lefthand box we have accommodated the contextually available representation of the proposition *a thief breaks in* as a hypothetical common ground, narrowing the context set over which the necessary force of *would* will range. Notice that this accommodation is very naturally licensed by our assumptions of the relevance of (13b) to its context. This representation now gives the correct truth conditions when interpreted in a model. That is, something like "Given what we already know in common about the actual world, it is possible that a thief will break into the house. In all such worlds where a thief breaks into the house, he takes the silver".

In general, then, the antecedent of conditional sentences serves as an explicit hypothetical addition to the common ground against which the consequent is to be evaluated. In sentences which are not conditional in form, modal subordination involves the pragmatic accommodation of a contextually salient proposition (or propositions) to serve as antecedent for the nonfactual clause.

I propose that we generalize this treatment of modal subordination via accommodation to examples such as (4), replacing the representation in (12), involving insertion, with that shown in (17):

(17)

$$
\boxed{
\begin{array}{ccc}
\boxed{
\begin{array}{l}
x \quad y \\[4pt]
\mathrm{John}(x) \\[4pt]
\mathrm{book}(y) \\[4pt]
\mathrm{bought}(x, y)
\end{array}
}
&
\Box
&
\boxed{
\begin{array}{l}
z \quad w \\[4pt]
\mathrm{reading}(z, w) \\[4pt]
z = x \\[4pt]
w = y
\end{array}
} \\[40pt]
\boxed{
\begin{array}{l}
x \quad y \\[4pt]
\mathrm{John}(x) \\[4pt]
\mathrm{book}(y) \\[4pt]
\mathrm{bought}(x, y)
\end{array}
}
&
\Box
&
\boxed{
\begin{array}{c}
r \\[4pt]
\mathrm{murder\text{-}mystery}(r) \\[4pt]
r = y
\end{array}
}
\end{array}
}
$$

Here we have taken the preceding antecedent box as our accommodated hypothetical common ground for the representation of (4b). The interpretation of (17) might be paraphrased, "In all worlds where there is a book which the individual named John bought, you will find that John is reading the book. And in every world in which there is a book which the individual named John bought, the book is a murder mystery". One motivation for treating (4) in this way is that it gives a more compositional account of the mapping from sentences to DRSes, in that here the modal auxiliary in (4b) is treated as itself inducing a modal operator, the lower instance of $\Box$. An open question is whether we should treat modally subordinate sentences without overt modal operators, such as (2b), as inserted into the prior representation of material under the scope of a modal, such as the representation of (2a), or as containing an implicit modal operator themselves, for which we then accommodate relativizing material as we have done in (17). In what follows, I will assume for simplicity that all the examples of modal subordination involve accommodation.

There is one worry about the use of accommodation: It is a very powerful device. What prevents us from simply accommodating an appropriate common ground, including a potential anaphoric antecedent, in every case where we have a pronoun in discourse with no apparent antecedent. If this were possible, we would have no account of the infelicity of examples such as (3b). We seem to need constraints on the power of accommodation. One which is already clear from prior discussion is that modal subordination, and thus the accommodation which it triggers, requires nonfactual mood. Further, it must be plausible that the modally subordinate utterance has a hypothetical common ground suggested by the immediately preceding context. The examples which we have examined

so far occur after a conditional or contain an explicit modal operator such as *would* or *might* to trigger the subordination. Another type of example involves *or*, the disjunction operator. (18) is due to Barbara Partee:[10]

(18)   Either there's no bathroom in this house or it's in a funny place.

Here we find no overt modal in the second conjunct, yet the quantified noun phrase *no bathroom* appears to serve as a sort of antecedent for a pronoun, *it*, which is outside its scope under standard assumptions about quantifier scope.

On pragmatic grounds, we may assume that neither disjunct of a disjunction is asserted, and hence that both are nonfactual. We have seen above that any sentence uttered in a nonfactual mood may justify the accommodation of a hypothetical common ground. Further, we have also noted that relevance to context often dictates the choice of such an accommodated common ground. We often take disjuncts to be alternative answers to the same topic of discussion. In (18), we may naturally assume that that topic is whether there is a bathroom in the house. The first disjunct entertains a negative answer to that question, so it seems perfectly natural to assume that the second disjunct pertains to the possibility of a positive answer to that same question. Thus, the accommodation of the portion of the representation of the first disjunct which is under the scope of the negation operator may be seen as the most natural means of providing an antecedent for the second disjunct, and hence for the pronoun *it* within it.[11] We may then build a DRS for (18) such as (19).

(19)

---
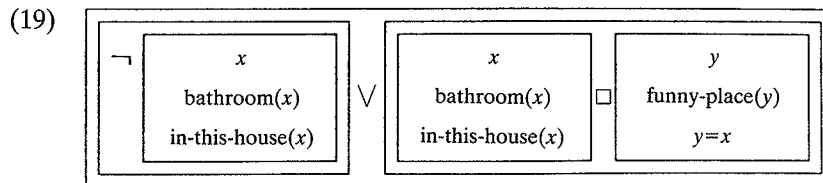
[10] This is very similar to a sentence in Evans (1977):

(i)   Either John does not own a donkey, or he keeps it very quiet.

[11] Higginbotham (p.c.) also points out that this procedure can be iterated for multiple disjunction operations, as in (i):

(i)   Either there's no bathroom in this house, or it's in a funny place, or I just failed to spot it.

where the logical form would be (ii):

Here, the symbol preceding the lefthand box recalls the negation symbol in the predicate calculus;[12] it is intended to have scope only over that box. The negation and the lefthand box together represent the first disjunct in (16). A box under the scope of the negation symbol may be properly embedded only in a model where it is not the case that the box itself may be properly embedded. The symbol following the lefthand box recalls the disjunction symbol. The embedding algorithm will take the disjunction symbol as an instruction that every proper embedding of the entire DRS must be a proper embedding of at least one of the disjuncts as well. Thus, the DRS in (19) would receive an interpretation along the lines of "Either it is not the case that there is a bathroom in this house, or, if there is a bathroom in this house, it's in a funny place".

With respect to the representation of the first disjunct as a negated existential sentence, rather than the logically equivalent form with the negation under the scope of a universal quantifier, note that this is partly justified by generally recognized properties of sentences of the form *there is ...*, which do not generally permit universally quantified NPs after the copula. Also, James Higginbotham (p.c.) points out that though (20) is logically equivalent to (18), (20) does not appear to license the anaphora we find in (18):

(20)   # Either every bathroom does not belong to this house, or it's in a funny place.

This follows from the general algorithm for mapping from sentences with universally quantified NPs onto DRSes, as we saw, e.g., in (8), (9) above. Using this algorithm, the first disjunct in (20) would map onto the DRS in (21):[13]

(21)
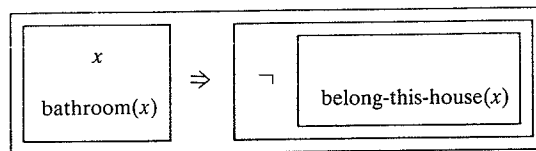
(ii) $\neg P \vee (\neg\neg P \to Q) \vee (\neg\neg P \wedge \neg Q \to R)$

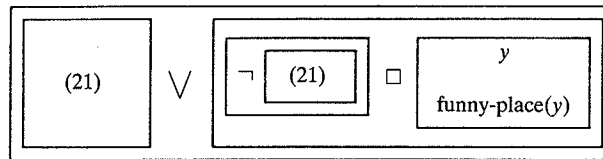which is logically equivalent to (iii):

(iii) $\neg P \vee Q \vee R$.

[12] I borrow this treatment of negation in DRSes from M, Carlson (1982).
[13] Here, the universal quantifier induces the standard box-splitting of Kamp's treatment, as exemplified also in (9) above.

If we then represent the second disjunct as we have done for (18) in (19), we would derive (22):

(22)

$$\boxed{\;\boxed{(21)}\quad\bigvee\quad\boxed{\;\neg\;\boxed{(21)}\;}\;\Box\;\boxed{\begin{array}{c} y \\ \text{funny-place}(y) \end{array}}\;}$$

(In (22), *(21)* refers to the entire DRS in (21) above.) Here, the discourse referent for *every bathroom*, x, is in a subordinate box within the sub-DRS (21), which is itself under the scope of a negation, so x is not an accessible antecedent to the discourse referent for *it*, y; the box in which y occurs is only subordinate to the top level of the DRS (21). That is, the more complex logical structure of the first disjunct does not provide us with an appropriate representation to be accommodated as antecedent of the second disjunct, and so anaphora seems infelicitous.

The derivation of the DRS for (18) in (19) is not intended to be algorithmic. That is, it is not always the case that where we have disjunction we accommodate the negation of the first disjunct as antecedent for the second. For example, consider Steve Berman's (p.c.) (23):

(23)   Either there's <u>a bathroom</u> on the first floor, or <u>it</u>'s on the second floor.

Here, accommodating the negation of the first disjunct would not achieve the desired results. The discourse referent for *a bathroom* would be under the scope of a negation operator, and hence not accessible to it. However, (23) seems most felicitous when there is no intonational pitch accent on *bathroom*. (Compare this with (18), which always has a pitch accent on *bathroom*, and may even have a phrase boundary after it.) This may be taken as a signal that the speaker presupposes there is a bathroom, and it is this conventionally indicated presupposition which licenses the hearer to introduce a representation for *there's a bathroom* on the highest level of the DRS, providing a discourse antecedent for *it*.[14] I assume that relevant contextually supplied and conversationally implicated material, as well as accommodated material, may be introduced into the same DRS

---

[14] See Pierrehumbert (1980) and Selkirk (1983) for discussion of the phonology of pitch accent placement, and Ladd (1980), Selkirk (1983) for discussion of the relationship of 'old information', including presupposition, to lack of pitch accent.

as the explicit text. See Kadmon (1987), for independent arguments to this effect.

The contrast between (18) and (20) points to an important constraint on the type of accommodation we have been using when anaphora is involved: it requires the explicit prior representation of potential antecedent discourse referents. We may not simply infer their existence. Heim (1982, Chap. III) discusses the accommodation of antecedents for definite noun phrases and shows that it is constrained by the requirement that new file cards introduced under this type of accommodation must be cross-referenced to some pre-existing file card. But she claims in Section 5.3 that antecedents for pronouns cannot generally be accommodated in this fashion, due to their relative lack of descriptive content. The examples under discussion here provide further evidence for this claim. In these cases, we do not accommodate antecedents for pronouns directly; rather, it is the independently required accommodation of appropriate hypothetical common grounds for nonfactual utterances which supplies pronominal antecedents. Though independently motivated, this type of accommodation may not serve to introduce previously unmentioned discourse referents, new file cards in Heim's terms, to serve as antecedents for pronouns. Although we may infer the first disjunct of (18) from the logically equivalent first disjunct of (20), (20) still may not license the same anaphoric relations as (18).

In the formal theory developed here, where accommodation takes place at the DRS level of representation, the requirement under consideration might be expressed as a stipulation that if the accommodated material includes the antecedent of a pronoun in the modally subordinate clause, that material must be borrowed from a prior representation. But I think that careful consideration will show, as Heim's discussion suggests, that in fact the requirement follows from Gricean cooperative principles for conversation and hence should not be regarded as a stipulation. That is, since pronouns have no descriptive content, the speaker must take great pains to make sure that their intended antecedent discourse referent is in the common ground of the conversation. Introducing a discourse referent through an explicit utterance is the surest way to guarantee this.

This same constraint on accommodation is shown clearly by another example due to Barbara Partee, (24):

(24)a.   Nine of the ten marbles are in the bag.
    b. # It's under the couch.

Here, although (24a) conversationally implicates that there exists a tenth marble which is not in the bag, we may not accommodate this information

directly into the DRS, for if we did we would have a potential antecedent for *it* in (24b), and (24b) seems infelicitous precisely because there is no available antecedent for *it*. Notice, however, that (24b) seems more felicitous after a long pause, especially if after uttering (24a) the speaker notices that the hearer is looking for something. A solution to this problem was suggested by Lyn Frazier (p.c.). She points out that in order to infer that there is one marble which is not in the bag the hearer must perform a mathematical calculation: she must subtract nine from ten. Even though this calculation seems quite trivial to us, it introduces a factor which was not involved in the previous examples, a nonlinguistic operation. Notice also that in previous examples the accommodated information was simply copied from portions of a pre-existing DRS. This would not be the case here, where the representation for (22a) does not involve a discourse referent for a single marble, but only plural referents for the groups of nine and ten marbles. We cannot automatically assume that the hearer has performed the necessary calculation. However, as Heim (1982) discusses, once it is clear that some entity is salient in the context for all participants in a discourse, as is the case with deixis, for example, we may accommodate a discourse referent for that entity. In the case where the speaker of (24a) notices the hearer looking for something, the speaker may assume that the hearer has performed the calculation, has realized that there is a missing marble, and is looking for it. In our terms, the speaker may assume that there is a discourse referent for the missing marble in the common ground, which then may serve as antecedent for the utterance of a pronoun such as *it* in (24b).

The account proposed for this example should suffice as well for the contrast in anaphoric potential of the following sentences from Isard (1975):

(25)   First square 19 and then cube it.
(26)   First take the square of 19 and then cube it.

For most speakers, in (25) where the square of 19 has not been explicitly mentioned as such, *it* may only refer to 19, while in (26), *it* may either refer to 19 or to the referent of the NP *the square of 19*.

There is a further point which I would like to note: The phenomenon of anaphora licensed by modal subordination provides an independent argument for a level of discourse representation intermediate between syntactic representation and model theoretic interpretation. Cases such as Landman's (13) and Partee's (18) show that pragmatic accommodation is required, so that neither a syntactic representation such as S-Structure in Government and Binding theory, nor a simple transform of S-Structure

such as LF, would suffice to explain the data. An approach which posits operators with discourse scope in an extended version of LF, such as the one that Heim explores in a preliminary way in Chapter II of Heim (1982), would run into the same problems with mixed modals as the insertion approach considered earlier. On the other hand, given the assumptions we have made here about the form of a grammar and its interpretation, we may not explain modal subordination in terms of direct interpretation in a model. Standard models fail to provide discourse referents, which we have seen to be crucial to this account. In addition, consider the discourse in (27):

> (27)a.   *One of the 10 marbles* is out of the bag.
>   b.   *It*'s under the couch.

If we assume that (24a) conversationally implicates that one marble is *not* in the bag and that (27a) implicates that nine marbles *are* in the bag, then (24a) and (27a) will be true in exactly the same worlds. Yet unlike (24a), (27a) provides an antecedent for *it* in the (b) sentence, and the discourse is felicitous. Hence, I believe that the phenomenon I have described here argues for an intermediate level of Discourse Representation.

3. The interpretation of DRSes involving modality

In this section I will present a formal theory of the interpretation of DRSes involving modality. In the examples of modal subordination which were considered in Sections 1 and 2 above, the explicit or implicit hypothetical extensions of the common ground which provided the antecedents for anaphora were all live possibilities in the discourse up to that point: that is, they were doxastically plausible given the common ground of the participants (at least, given the common ground which the participants as a group assume they share, though one or more may have had evidence to the contrary). But many utterances denote propositions which contradict 'the facts', i.e., are incompatible with propositions in the common ground of the conversation. In Section 3.1, I will briefly consider a few examples of this type in order to illustrate what is involved in incorporating non-epistemic modals into a general account of modal subordination.[15] The discussion of these examples is intended to motivate some of the complexities of the formal theory which follows, in Section 3.2.

---

[15] In incorporating non-epistemic modality into this account of modal subordination, I benefited from closely related work by Irene Heim (1985) on modality and propositional attitudes in File Change Semantics.

3.1. *Subordination with Non-Epistemic Modality and Counterfactuals*

Consider the following examples:

(28)a. If I had brought <u>a book</u> with me to Georgia, I could have read <u>it</u> on the plane.

  b. I would probably have finished <u>it</u> by now.

(29)a. You should eat <u>a bagel</u>.

  b. <u>It</u> would fill you up.

(28a) may be uttered in a context in which I did not bring a book with me to Georgia, and in which this fact is part of the common ground shared by the participants in the discourse. The addition of the antecedent of (28a) to this common ground, then, would leave us with the empty context set. Given the interpretive principles we have discussed so far, this would make the whole conditional vacuously true, since in all the worlds in this empty context set, the consequent would be true. But the conditional seems to be much more informative than this, so that the truth conditions thus derived are too weak. The modal auxiliary *should* in (29a) has the force of necessity. Its utterance in a given context should not be taken as a suggestion by the speaker to remove all worlds from the context set in which the hearer does not eat a bagel, i.e., as the assertion that it is impossible in this context that the hearer not eat a bagel. Rather, it is a suggestion that it would be ideal in some sense if she ate a bagel, though we generally acknowledge that ideals will not necessarily be realized. So, (28b) and (29b) seem to be parallel to the examples involving anaphora licensed by modal subordination, yet the account I sketched above using the common ground to relativize modal force is not adequate for these cases.

Kratzer (see references) develops compelling arguments for a unified theory of modals with conditionals, including counterfactuals. And we have just seen that modal subordination seems to be possible in non-epistemic conditionals. In both epistemic and non-epistemic cases, the speaker first establishes a set of worlds (possibly not including the actual world) in which some individual *a* is said to exist. So long as we continue to talk about those worlds, we may continue to assume *a*'s existence and to refer anaphorically to the discourse referent with which *a* was originally introduced into the conversation. Given this parallel, we would like to find a more general approach to modal subordination which can account for (28) and (29) as well as the cases already discussed.

As I mentioned in Section 1, Kratzer relativizes the modal force of a modal or conditional using two distinct functions, each of which is a

function from possible worlds to sets of propositions. The first is called the *modal base*; the modal base may be epistemic (or doxastic), as in the case of most of the examples of modal subordination we examined above, or circumstantial (facts, of course, need not be known). In the cases of epistemic modality we have considered, the modal base assigns to each world in the context set of the conversation at that point exactly those propositions which are in the common ground, so that the intersection of the propositions assigned to a given world by the modal base equals the context set. What this means is that the usual accessibility relation of modal logic will hold in such cases between just those worlds which are in the context set. However, this is not the case in the non-epistemic examples, so we need some more general terminology. Given a world w and a modal base m, I will use the expression **derived context set for** w to describe the intersection of the propositions in $m(w)$, i.e., $\cap m(w)$.[16]

The other function used to relativize modal force is the *ordering source*. The propositions assigned to a given world w by an ordering source o, $o(w)$, reflect what would be true under (possibly counterfactual) ideal circumstances. These propositions are used to induce an ordering on the worlds in the derived context set for w given by the modal base: only those worlds in $\cap m(w)$ which also come closest[17] to realizing the ideal given by $o(w)$ will be in the domain of the modal operator involved. A world w' is **closer** to the ideal given by $o(w)$ than a world w'' if more of the propositions in $o(w)$ are true in w' than in w''.

Kratzer (1980) argues that we interpret counterfactuals using a particular type of modal base and ordering source. The modal base assigns the empty set of propositions to each world w in the context set of the conversation at that point. Following the general rule for interpreting conditionals, we take the union of $m(w)$ with the proposition expressed by the antecedent, call this union $m^+(w)$. Then with the special type of modal base used for counterfactuals, the derived context set $\cap m^+(w)$ is the set of worlds in which the antecedent is true, whether or not those worlds were in the original context set of the conversation at the point at which the conditional was uttered. But the modal operator may not range over all the worlds in $\cap m^+(w)$; rather, it only ranges over those worlds in the derived context set which come closest to the ideal expressed by

---

[16] I borrow the term *derived context set* from Stalnaker (1985), following Heim (1985).

[17] Actually, there may be no 'closest' set of worlds; cf, Lewis (1973) for discussion. Kratzer (1980) takes this into account in her formal definition of the ordering source. I will ignore this complication in the informal discussion in the interest of conveying the basic intuition more clearly. However, it will be incorporated into the formal theory which follows.

the ordering source. For counterfactuals, we use an ordering source which is **totally realistic**, that is, one which assigns to any world w just those propositions which are true in w; hence the set of worlds in the intersection of $o(w)$ equals w. We use this ordering to consider only those worlds where the antecedent is true and which are most like w in all other respects.

For example, consider the set of all those worlds in which the antecedent of (28a) is true, i.e., in which I did bring a book; in the discourse context described above where I didn't bring a book, this set will be disjoint from the context set, and in fact, the derived context set will be the same for each world in the original context set. We then impose an order on worlds in the set, using the totally realistic ordering source o. So, for any world w in the original context set, we only consider those worlds in $\cap m^+(w)$ which are most like w. In order for the whole conditional to be true in w, the consequent must be true in each such world. If the consequent is false in any of these most ideal worlds in $m^+(w)$, then w is eliminated from the original context set. Otherwise, it is retained. The domain of the modal in (28b) is then restricted using the derived context set and ideal of (28a), where we already know that for any world w in the context set it is true in all the most ideal worlds in its derived context set that I brought a book and read it on the plane. This will be reflected in the DRS for (28b) by the accommodation of the DRS for the antecedent of (28a), as in the epistemic examples we have considered.

In (29a), *should* is deontic; imagine that the common ground in this case includes propositions such as the fact that the hearer is hungry, that bagels are readily available here, and that eating a bagel will satisfy the hunger. However, it may also include the fact that the hearer is anorexic and refuses to eat anything. That is, in all of the worlds in the corresponding context set, the hearer will not eat a bagel. Let us assume that the modal base used in interpreting the modal in (29a) assigns to each world in the context set w a subset of the propositions in the common ground; for example, the propositions that the hearer is hungry, that bagels are available, etc., but not the fact that the hearer is anorexic. This modal base will determine a derived context set which is a superset of the context set at that point in the conversation. Assume further that for each world w in the original context set, the ordering source, o, characterizes what are considered good nutritional practices in w; for example, it might assign to w the proposition that someone who is hungry will do something to satisfy the hunger. We can call the worlds in the derived context set $\cap m(w)$ which come closest to $o(w)$, **the nutritional ideal for** w. The speaker's assertion amounts to an instruction to discard any worlds w from the

context set whose nutritional ideal includes a world in which the hearer doesn't eat a bagel, whether she will in fact do so in w or not. We might paraphrase this interpretation of (29a) as, "In view of the fact that you're hungry, that bagels are available and would satisfy the hunger, and that one who is hungry would ideally do something to satisfy the hunger, you should eat a bagel".

Note that for any given world w, $m(w)$ need not include all the propositions which were in the common ground prior to uttering (29), and in particular not the propositions that the hearer is anorexic and will refuse to eat anything. Hence, we can extend (29a) as in (30), without contradiction:

(30)   You should eat a bagel, but you won't.

The second conjunct in (30) is factual in mood. Unlike the first conjunct, in interpreting it we take into account all we know about the actual world, including the hearer's anorexia, etc.

The material in (29a) which is under the scope of the modal, "you eat a bagel", is nonfactual; that is, the modal *should* signals that we must consider the truth of "you eat a bagel" in each world in the possibly nonrealistic nutritional ideal of w, for each w in the context set. *Would* in (29b) then continues the nonfactual mood; we need to relativize its modal force to some contextually salient set of propositions. In this context, the paraphrase which most plausibly captures this relativization is "if you ate a bagel, it would fill you up". Since the antecedent of this conditional is at least implausible, given what we know about anorexia, we interpret (29b) as if it were the antecedent of a counterfactual. Now the modal base is empty, and the ordering source is totally realistic, as in (28). That is, for each world w in the context set, we consider all worlds in which the hearer ate a bagel which are closest to the ideal, that is, to the way things actually are in w. If the bagel fills the hearer up in all those ideal worlds, then (29b) is true in w, and it is retained in the context set which results. Otherwise, it is eliminated.

In translating this intuitive analysis into DRS terms, we need to make a decision about the role of a modal base and ordering source in deriving such representations. Heretofore, we have assumed that we relativize modal operators both to material in the DRS to their left and also to material in superordinate DRSes. But the non-epistemic examples show that this would not give the correct results in all cases, since they may involve a non-realistic modal base or ordering source; a modal base m is non-realistic if for some w it is not the case that $w \in m(w)$. Further, a modal base or ordering source may assign a different set of propositions to each world in the context set, so that we cannot simply introduce a

single set of relativizing propositions into the DRS to the left of the modal
operator. And more than one modal base or ordering source may play a
role in the interpretation of a single discourse. We saw an example of this
in the analysis of (29); the ordering source for (29a) assigned to each
world its nutritional ideal, while for the counterfactual-like (29b) the
ordering source was totally realistic. This suggests that we must assign a
modal base and an ordering source to each modal operator independently.
The formal theory in the next section will have nothing to say about how
hearers know which modal base and ordering source are relevant for the
interpretation of a given modal, but only about how this information is
used in interpretation; the question of selection involves pragmatic ques-
tions which go beyond the purview of semantic theory.

Heim (1985) discusses cases involving what I have called modal subordi-
nation, but also a parallel phenomenon in cases involving propositional
attitudes, treating the latter as essentially modal in character. She also
uses Kratzer's theory of modality, including the modal base and ordering
source. Though her theory and this one are quite similar in approach and
predictions, I do not believe that they are exactly alike in the type of
anaphoric relationships they permit in discourse; however, since her ac-
count has not been published, I will not compare it with my proposal in
detail.

3.2. *A Formal Theory of DRSes With Modality*

Given this informal discussion of the interpretation of non-epistemic mo-
dals, we turn now to consider a formal theory of Discourse Representation
Structures which include modality.[18] In this paper, I will not present a
general theory of the mapping from syntactic structures onto DRSes. See
the proposal in Roberts (1986) of DRS construction for sentences without
modals; see also Heim (1982) for a somewhat different approach within
File Change Semantics. As we have seen, examples involving modal subor-
dination raise new questions about the non-trivial way in which pragmatic
factors enter into DRS construction. Heim (1982), Partee (1984), and
Kadmon (1987) discuss other types of examples where non-syntactic
input is crucial in constructing appropriate files or DRSes. However, in
order to respect the constraint on accommodation discussed at the end
of Section 2, we must stipulate that discourse referents may only be

---

[18] In developing this, I benefited from Landman (1987), which lays out the main parameters
to be considered in formalizing Discourse Representation Theory, and develops several
versions of a simpler, extensional form of the theory.

accommodated when (a) they are to serve as the antecedent of a definite description (as discussed by Heim (1982)), (b) they are licensed by deixis or other clear contextual factors (also discussed by Heim), or (c) they are borrowed from the prior representation of explicitly uttered NPs.

Syntax

DRL, the language of discourse representation structures (DRSes), is based on a set VAR of variables, a set of n-place predicates (for all n), and the relation symbols $\neg$, $\bigvee$, $\Rightarrow$, $\Box$, and $\Diamond$. DRL is the set of all DRSes, where DRSes are defined as follows:

A **DRS** K is a pair $\langle X_K, C_K \rangle$, where X_K, **the local domain** of K, is a finite set of variables and C_K, **the set of conditions** in K, is a finite set of conditions.

Conditions are all and only the following:

(1)   If P is an n-place predicate and $x_{i_1}, \ldots, x_{i_n}$ are variables, then $P(x_{i_1}, \ldots, x_{i_n})$ is a(n atomic) condition.
(2)   If K_i is a DRS, then $\neg K_i$ is a condition.
(3)   If K_i and K_j are DRSes, then $K_i \bigvee K_j$ is a condition.
(4)   If K_i and K_j are DRSes, then $K_i \Rightarrow K_j$ is a condition.
(5)   If K_i and K_j are DRSes, then $K_i \Box K_j$ is a condition.
(6)   If K_i and K_j are DRSes, then $K_i \Diamond K_j$ is a condition.

The following syntactic notions may be defined on (occurrences of) DRSes:

$\leqslant$, **is accessible from**, is the smallest partial order on DRSes such that for any DRS K, if $\neg K_i \in K$, or $K_i \Rightarrow K_j \in C_K$, or $K_i \Box K_j \in C_K$, or $K_i \Diamond K_j \in C_K$, then $K \leqslant K_i$ and $K_i \leqslant K_j$; and if $K_i \bigvee K_j \in C_K$, then $K \leqslant K_i$ and $K \leqslant K_j$.

The **accessible domain** of K_i, $\mathbf{A}_{K_i}$, is the set of all variables in (local) domains of DRSes accessible from K_i: $\mathbf{A}_{K_i} = \bigcup_{K \leqslant K_i} \mathbf{X}_K$.
   We then impose the following condition on DRSes:

No free variables: if x occurs in an atomic condition in C_K then $x \in A_K$.

Semantics

A **model** $\mathcal{M}$ for DRL is a structure $\langle W, A, \iota \rangle$, where W is a set of possible worlds, A is a non-empty set of individuals, and ι is the interpretation function mapping pairs of an n-place predicate and world into $pow(A^n)$.

CRAIGE ROBERTS

An **assignment function**, f, is a total function from VAR to A.

Given two assignment functions, f and g, f **varies from** g **at most with respect to** X, $f\langle X\rangle g$, iff $\forall y[\neg(y \in X) \rightarrow f(y) = g(y)]$.

A **proposition** is a set of possible worlds.
A **modal base** or **ordering source** is a function from possible worlds to sets of propositions.

The **truth of a DRS with respect to a world and an assignment function** is defined recursively, as follows:

> For all worlds w, u, v, w', u', assignment funtions f, g, h, modal bases m, ordering sources o, models $\mathcal{M}$, DRSes K, K_i, K_j, sets of conditions C, n-place predicates P, and variables x:

1. $\langle w, f\rangle \models_{\mathcal{M}} K$ iff $\forall c \in C_K(\langle w, f\rangle | \Vdash_{\mathcal{M}} c)$
2. (a) $\langle w, f\rangle \Vdash_{\mathcal{M}} P(x_{i_1}, \ldots, x_{i_n})$ iff $\langle f(x_{i_1}), \ldots, f(x_{i_n})\rangle \in \iota(P)(w)$
   (b) $\langle w, f\rangle \Vdash_{\mathcal{M}} (\neg K_i)$ iff $\neg \exists g[g\langle X_{K_i}\rangle f \ \& \ \langle w, g\rangle \models_{\mathcal{M}} K_i]$
   (c) $\langle w, f\rangle \Vdash_{\mathcal{M}} (K_i \vee K_j)$ iff $[\exists g(g\langle X_{K_i}\rangle f \ \& \ \langle w, g\rangle \models_{\mathcal{M}} K_i)$
   $\bigvee \exists g(g\langle X_{K_j}\rangle f \ \& \ \langle w, g\rangle \models_{\mathcal{M}} K_j)]$
   (d) $\langle w, f\rangle \Vdash_{\mathcal{M}} (K_i \Rightarrow K_j)$ iff $\forall g[g\langle X_{K_i}\rangle f \ \& \ \langle w, g\rangle \models_{\mathcal{M}} K_i \rightarrow$
   $\exists h(h\langle X_{K_j}\rangle g \ \& \ \langle w, h\rangle \models_{\mathcal{M}} K_j)]$
   (e) $\langle w, f\rangle \Vdash_{\mathcal{M}} (K_i \square_{m,o} K_j)$ iff
   $\forall u, g[g\langle X_{K_i}\rangle f \ \& \ u \in \cap[m(w) \cup \{\{v: \langle v, g\rangle \models_{\mathcal{M}} K_i\}\}] \rightarrow$
   $\exists w'(w' \in \cap[m(w) \cup \{\{v: \langle v, g\rangle \models_{\mathcal{M}} K_i\}\}] \ \& \ w' \leqslant_{o(w)} u \ \&$
   $[\forall u'[u' \in \cap[m(w) \cup \{\{v: \langle v, g\rangle \models_{\mathcal{M}} K_i\}\}] \ \& \ u' \leqslant_{o(w)} w' \rightarrow$
   $\exists h(h\langle X_{K_j}\rangle g \ \& \ \langle u', h\rangle \models_{\mathcal{M}} K_j)])]$
   (f) $\langle w, f\rangle \Vdash_{\mathcal{M}} (K_i \diamond_{m,o} K_j)$ iff
   it is not the case that $\langle w, f\rangle \Vdash_{\mathcal{M}} (K_i \square_{m,o} \neg K_j)$
3. K is **true** in a world w iff $\exists f(\langle w, f\rangle \models_{\mathcal{M}} K)$.
4. The **context set** determined by K is the set of worlds where K is true.

The first clause of the recursive definition of the truth conditions for a DRS K tells us that K is **embeddable**, or is **verified** in a model relative to a world and an assignment function iff all the conditions in K are **satisfied** relative to those same elements. This notion of satisfaction is then defined in the second clause. Clauses (2a) through (2d) are fairly simple and require no special comment. The complexity of clause (2e), which is intended to reproduce in DRS terms the truth conditions for conditional necessity in Kratzer (1980), is necessitated by the fact that in the derived context set, $\cap[m(w) \cup \{\{v: \langle v, g\rangle \models_{\mathcal{M}} K_i\}\}]$ (which is the formal specification

of the $m^+(w)$ of the previous section), there may be no set of worlds 'closest' to w under the ordering induced by $o(w)$. Instead, we require that there be some world w' in the derived context set such that all worlds u' in the context set which are at least as close to the ideal as w' are such that K_j is embeddable in them. If we were only considering epistemic examples, where the ordering source is generally irrelevant, we could simplify this clause considerably, ignoring the ordering source as follows:

(2e') $\langle w, f \rangle \Vdash_{\mathcal{M}} (K_i \, \Box_m \, K_j)$ iff
$\forall u, g[g \langle X_{K_i} \rangle f \ \& \ u \in \cap[m(w) \cup \{\{v: \langle v, g \rangle \vDash_{\mathcal{M}} K_i\}\}] \rightarrow$
$\exists h(h \langle X_{K_j} \rangle g \ \& \ \langle u, h \rangle \vDash_{\mathcal{M}} K_j)]$

Since in the epistemic examples $u \in \cap m(w)$ iff u is in the context set prior to interpreting the condition, this clause amounts to saying that the conditional is true iff in all worlds in the context set in which the antecedent is true (i.e., worlds in the hypothetical context set), the consequent is true as well. Now we can see that the clause for the material conditional, (2d), just gives truth conditions for a subcase of (2e') where the modal base is what Kratzer calls totally realistic, that is, where for any w, the only world in $m(w)$ is w itself.

4. GENERALIZED SUBORDINATION IN DISCOURSE

The examples of subordination in discourse which we have examined so far all involve modality in some form or other. However, there are examples displaying anaphoric phenomena very much like those considered above, but where the subordination appears to involve only nonmodal operators. In this section, I will present a few such cases and discuss informally how they may be related to modal subordination.

Karttunen (1976) noticed cases like (31):

(31)a. Harvey courts a girl at every convention.
    b. She always comes to the banquet with him.
    c. The girl is usually very pretty.

Subordination in (31) is induced by adverbs of quantification (Lewis 1975): *at every convention* in (a) establishes a limited set of cases or situations which are contextually salient and serve to restrict the domain of *always* in (b) and *usually* in (c).

Something similar seems to license the anaphoric relation between the definites and the preceding indefinites in (32), from Stenning (1978):

(32)a.   In each room, there was [a cat]$_i$ and [a goldfish]$_j$.
   b.   [The goldfish]$_j$ dived.
   c.   [The cat]$_i$ caught [it]$_j$.

Here, the adverbial *in each room* quantifies over locations, and (b) and (c) are implicitly offered as instantiating the situation in such a location.

Temporal parallels were noted in Sells (1985). His example (29b) is given in (33):

(33)a.   A train leaves every hour for Boston.
   b.   It always stops in New Haven.

The relevant reading of (33a) is that in which *a train* is under the scope of the temporal quantifier *every hour*. Partee (1984) has offered an analysis of temporal quantifiers, introducing discourse referents for events into DRSes. The scope of such operators seems to be limited to the sentential domain, as with other types of operators. Yet, *it* in (33b) seems to refer back to *a train*. Our intuition that (33b) is temporally subordinate to (33a) is confirmed by the most natural interpretation of the optional temporal adverb *always*. We do not take it to quantify over all times; rather, as in the modal cases we have considered above where the operator's domain is restricted by the accommodation of contextually salient material, the domain of *always* here is restricted to the salient set of times: those in which a train leaves for Boston.

We can easily imagine DRSes for the examples in (31)–(33) which parallel the representations I have proposed for examples involving modal subordination, but use non-modal operators. But how would we interpret such representations? When operators range over cases, over locations of a particular sort, or over temporal intervals, are they quantifying over entities which differ essentially from the possible worlds over which modal operators range?

Recent work on the use of partial models in semantic interpretation, such as Barwise and Perry (1983), Kratzer (1985), and Landman (1986), suggests that these operators do not differ essentially in their range. Rather, they all range over *situations*, however these are defined in a particular theory. For example, in this type of approach, we might paraphrase the truth conditions for (31) informally as, "In every situation which is a convention, Harvey courts a girl, and in every such situation, she comes to the banquet with him". In the context of the theory developed here, we might think of situations as partial worlds (though, of course, this is not their character in all of the theories mentioned). Possible

worlds themselves can be thought of as just the limit case of total situations. So, when we move to using partial models, I believe that we will find that we can provide a unified analysis of the **generalized discourse subordination** involved in the cases in (31)–(33), as well as in the modal examples considered earlier. In each case, the second sentence in a discourse is interpreted as involving an operator (explicit or implicit) whose force is relativized so that it ranges only over the type of situation given in part by the first sentence. The development of a formal theory of DRS interpretation which incorporates this idea goes beyond the scope of this paper; however, see Roberts (forthcoming) for such a theory, as well as for a detailed consideration of apparent restrictions on sequences of tense in discourses involving modal subordination.

There is one other type of case which seems closely related to discourse subordination and involves universal quantifiers. (34) is due to Barbara Partee (p.c.), (35) to Sells (1985):[19]

(34)a. Each degree candidate walked to the stage.
  b. He took his diploma from the Dean and returned to his seat.
(35)a. Every chess set comes with a spare pawn.
  b. It is taped to the top of the box.

I call this phenomenon **telescoping**: from a discussion of the general case, we zoom in to examine a particular instance. In (34), *he* and *his* seem to refer to an individual who instantiates *each degree candidate*, though this NP is in the prior sentence. In (35), on the preferred reading where *a spare pawn* is under the scope of the subject of (a), *a spare pawn* seems to serve as antecedent for it in (b).

A pair of examples from Fodor and Sag (1982) show that the possibility of anaphoric relations in such telescoping cases depends in part on the plausibility of some sort of narrative continuity between the utterances in the discourse:

---

[19] Sells offers (35) (= his 31) as an example of temporal subordination. The reference time of (b) is that provided by (a); however, this does not necessarily mean that temporal subordination is involved. In Sells' example (33), on the other hand, the quantifier in (a) under whose scope (b) seems to fall is a quantifier over times.

Sells also offers (i) (= his 33b) as an example of temporal subordination:

(i)a [Every rice-grower in Korea]$_i$ owns [a wooden cart]$_j$.
  b Usually [he]$_i$ gets [it]$_j$ from [his]$_i$ father.

Although the adverb of quantification *usually* is sometimes temporal, I don't believe it is in this case. Rather, here it seems to quantify over something like cases or instances of the rice-grower/wooden cart pairs introduced in (a). Hence, I take (i) to illustrate a case of subordination to the universal quantifier.

(36)   Each student in the syntax class was accused of cheating on the exam, and he was reprimanded by the dean.
(37) # Each student in the syntax class was accused of cheating on the exam, and he has a Ph.D. in astrophysics.

Even though the second conjunct of (37) is in the present tense, unlike the first conjunct, this does not seem to be the source of the unacceptability of the anaphoric relation indicated, as can be seen by replacing *has* with *had*. Neither does the second conjunct itself seem implausible as a general statement; consider the felicity of (38):

(38)   Each candidate for the space mission meets all our requirements. He has a Ph.D. in astrophysics and extensive prior flight experience.

In these cases, we begin a narrative with a statement about a class of individuals, then we zoom in on one instantiation of that class to continue the narrative. The problem with (37) seems to be that for some reason the second sentence does not comfortably continue the narrative in this fashion. At present, the precise character of the constraints on telescoping eludes me, so that here I cannot do more than note that these cases exist and that they are apparently related to the phenomenon under consideration here.

CONCLUSION

Summarizing, modal subordination is a phenomenon wherein the interpretation of a clause α is taken to involve a modal operator whose force is relativized to some set β of contextually given propositions. We say that in that context, α is interpreted as modally subordinate to the propositions in β, or, rather loosely, that α is modally subordinate to the clauses (if any) used to express β. Intrasententially, the consequent of a conditional is modally subordinate to the antecedent clause, as in conditional donkey sentences. Intersententially, modal subordination involves the accommodation of material from prior utterances to serve the role of an antecedent for the subordinated clause. In both cases, the antecedent clause, whether or not accommodated, plays a crucial part in determining the derived context set which is used to restrict the range of the (explicit or implicit) operator over the modally subordinate clause. In cases which involve pronominal anaphora, accommodation is constrained by the requirement of explicit prior representation of potential anaphoric antecedents.

Note that under the conception just sketched, not all cases of intersen-

tential anaphoric relations where the anaphoric antecedent occurs in a nonfactual utterance should be analyzed as involving modal subordination. Consider, for example, (39) (due to Fred Landman, p.c.) and (40) (due to Jerry Morgan, p.c.):[20]

(38)a.   The author claims that <u>Vulcan</u> exists after all.

     b.   <u>It</u> has circled around Mercury for ages without us ever noticing <u>it</u>.

(39)a.   Last night I dreamed I got <u>a red Porsche</u> for my birthday.

     b.   I drove <u>it</u> all over the countryside and loved every minute of it.

     c.   This morning I woke up and much to my surprise found <u>it</u> parked in my driveway.

The speaker may intend (38b) to be modally subordinate to (38a), simply continuing her exposition of the author's claim. But she may instead just implicitly accept that claim, intend for the hearer to accommodate its truth, and then utter (38b) in the factual mood. (39b) seems to be a continued description of the speaker's dream, and hence nonfactual and subordinate to the nonfactual complement clause describing the dream state in (39a). (39c), however, requires us to accommodate the information that the dream was, after all, about a real car; the pronoun *it* gets its antecedent from this accommodated factual material, as in the factual reading of (38b), and not by virtue of being itself in a nonfactual clause. These are not, then, examples of modal subordination as I have defined it above, though they are related to the cases involving modal subordination by virtue of the accommodation involved and its crucial role in providing an anaphoric antecedent.

    Of course, one might accept this general characterization of modal subordination while questioning the use of Discourse Representation Theory as the vehicle for its formal expression. Alternative approaches are conceivable within File Change Semantics, Situation Semantics, and the Dynamic Montague Grammar of Groenendijk and Stokhof (1988). Comparison of these theories and consideration of their adequacy in this respect goes beyond the scope of this discussion. However, we can now state one criterion which a theory must meet so that we may use it to formalize modal subordination. That theory must give us a means of keeping track of the information available in a discourse context, what I have called the common ground, so that we can talk in a precise way

---

[20] Landman and Morgan don't necessarily share my analysis of these examples.

about its effect on interpretation. And this notion of common ground must be sufficiently rich to permit us to keep track of (possibly non-existent) entities mentioned in discourse, as we have done here with discourse referents, and to distinguish between information which is explicitly introduced into the common ground in the course of a conversation and information which is only implicitly assumed.

References

Barwise, Jon and John Perry: 1983, *Situations and Attitudes*, MIT Press, Cambridge, Massachusetts.

Carlson, Marcia: 1982, 'The Representation of Disjunction', manuscript, University of Massachusetts, Amherst.

Chierchia, Gennaro and Mats Rooth: 1984, 'Configurational Notions in Discourse Representation Theory', in C. Jones and P. Sells (eds.), *Proceedings of NELS 14*, University of Massachusetts, Amherst.

Chomsky, Noam: 1981, *Lectures on Government and Binding*, Foris, Dordrecht.

Evans, Gareth: 1977, 'Pronouns, Quantifiers and Relative Clauses (I)', *Canadian Journal of Philosophy* 7, 467–536.

Farkas, Donka, F. and Yoko Sugioka: 1983, 'Restrictive If/When Clauses', *Linguistics and Philosophy* 6, 225–58.

Fitch, Frederick: 1952, *Symbolic Logic*, Ronald, New York.

Fodor, Janet and Ivan Sag: 1982, 'Referential and Quantificational Indefinites', *Linguistics and Philosophy* 5, 355–98.

Geach, Peter T.:1962, *Reference and Generality*, Cornell University Press, Ithaca.

Grice, H. P.: 1967, 'Logic and Conversation', William James Lectures, Harvard, published in D. Davidson and G. Harman (eds.), *The Logic of Grammar*, 1976.

Groenendijk, Jeroen and Martin Stokhof: 1988, 'Dynamic Montague Grammar: Going Back to MG and Beyond DRT', unpublished manuscript, University of Amsterdam and Philips Research Laboratories.

Heim, Irene: 1982, *The Semantics of Definite and Indefinite Noun Phrases*, Ph.D. dissertation, University of Massachusetts, Amherst.

Heim, Irene: 1985, 'Presupposition Projection and Anaphoric Relations in Modal and Propositional Attitude Contexts', unpublished manuscript, University of Texas at Austin.

Isard, Stephen: 1975, 'Changing the Context', in L. Keenan (ed.), *Formal Semantics of Natural Language*, Cambridge University Press.

Jespersen, Otto: 1965, *The Philosophy of Grammar*, Norton, New York.

Kadmon, Nirit: 1987, *On Unique and Non-Unique Reference and Asymmetric Quantification*, Ph.D. dissertation, University of Massachusetts, Amherst.

Kamp, Hans: 1981, 'A Theory of Truth and Semantic Representation', in Jeroen Groenendijk, Theo M. V. Janssen and Martin Stokhof (eds.), *Formal Methods in the Study of Language*, Vol. I, Mathematische Centrum, Amsterdam, reprinted in J. Groenendijk, T. Janssen and M. Stokhof (eds.), (1984), *Truth, Interpretation and Information*, Foris, Dordrecht, pp. 1–41.

Karttunen, Lauri: 1976, 'Discourse Referents', in J. McCawley (ed.), *Syntax and Semantics* 7, Academic Press, New York.

Kratzer, Angelika: 1977, 'What "must" and "can" Must and Can Mean', *Linguistics and Philosophy* 1, 337–55.

Kratzer, Angelika: 1979, 'Conditional Necessity and Possibility', in R. Bauerle, U. Egli and A von Stechow (eds.), *Semantics from a Different Point of View*, Springer-Verlag, New York.

Kratzer, Angelika: 1980, 'The Notional Category of Modality', in Eikmeyer and Rieser (eds.), *Words, Worlds and Contexts*, deGruyter, Berlin.

Kratzer, Angelika: 1981, 'Partition and Revision, The Semantics of Counterfactuals', *Journal of Philosophical Logic* **10**, 201–16.

Kratzer, Angelika: 1985, 'An Investigation into the Lumps of Thought', manuscript, Technische Universitat, Berlin.

Ladd, D. Robert, Jr.: 1980, *The Structure of Intonational Meaning*, Indiana University Press, Bloomington, Indiana,

Landman, Fred: 1986, *Towards a Theory of Information: The Status of Partial Objects in Semantics*, Foris, Dordrecht.

Landman, Fred: 1987, 'A Handful of Theories of Discourse Representation Theory', unpublished manuscript, University of Massachusetts, Amherst.

Lewis, David: 1973, *Counterfactuals*, Harvard University Press, Cambridge, Massachusetts.

Lewis, David: 1975, 'Adverbs of Quantification', in E. L. Keenan (ed.), *Formal Semantics of Natural Language*, Cambridge University Press.

Lewis, David: 1979, 'Score-Keeping in a Language Game', in Bauerle et al. (eds.), *Semantics from a Different Point of View*, Springer-Verlag, Berlin.

Partee, Barbara H.: 1973, 'Some Structural Analogies between Tenses and Pronouns in English', *Journal of Philosophy* **70**, 601–609.

Partee, Barbara H.: 1984, 'Nominal and Temporal Anaphora', *Linguistics and Philosophy* **7**, 243–86.

Pierrehumbert, Janet: 1980, *The Phonology and Phonetics of English Intonation*, Ph.D, dissertation, MIT, Cambridge, Massachusetts.

Reichenbach, Hans: 1947, *Elements of Symbolic Logic*, University of California Press, Berkeley.

Roberts, Craige: 1985, 'Anaphora, Coreference and the Binding Theory', manuscript, University of Massachusetts at Amherst.

Roberts, Craige: 1986, *Modal Subordination, Anaphora, and Distributivity*, Ph.D, dissertation, University of Massachusetts at Amherst.

Roberts, Craige: forthcoming, 'Modal Subordination, Situations, and Reference Time'.

Selkirk, Elisabeth O.: 1984, *Phonology and Syntax: The Relation Between Sound and Structure*, MIT Press, Cambridge, Massachusetts.

Sells, Peter: 1985, 'Restrictive and Non–Restrictive Modification', Center for the Study of Language and Information, Report No. CSLI-85-28.

Stalnaker, Robert: 1979, 'Assertion', in P. Cole (ed.), *Syntax and Semantics* **9**, Academic Press, New York.

Stalnaker, Robert: 1985, 'Belief Attribution and Context', manuscript of a talk given in the Colloquium in Philosophy of Oberlin College, April, 1985.

Stenning, K.: 1978, 'Anaphora as an Approach to Pragmatics', in M. Halle, J. Bresnan and G. Miller (eds.), *Linguistic Theory and Psychological Reality*, MIT Press, Cambridge, Massachusetts.

Webber, Bonnie Lynn: 1978, *A Formal Approach to Discourse Anaphora*, Bolt Beranek and Newman, Report No. 3761.

Department of Linguistics
Ohio State University
204 *Cunz Hall*
1841 *Millikin Road*
Columbus, OH 43210
U.S.A.