

## Modality and Discourse Processing<sup>1</sup>

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### Abstract

Two self-paced reading time experiments investigated the application of the semantic theories of Discourse Representation Theory (Kamp 1981; see also, Heim 1982) and Modal Subordination (Roberts 1987, 1989) as the basis for a model of discourse processing. The results of Experiment 1 support the empirical contrast as described by Roberts (1987, 1989), that is, that intersentential anaphora is constrained by the scope of modal operators. The results of Experiment 2 suggest that there are processing effects associated with the increased semantic complexity of a semantic representation. By the *Minimal Structure Hypothesis*, I explain the different processing times associated with different modals. The advantage of this discourse processing model is that it uses grammatical information to rule out incoherent discourses. Thus, the Roberts-Heim-Kamp framework seems to be a promising enterprise for constraining a psycholinguistic theory of discourse processing.

### 0.0 Introduction

The goal of this paper is to demonstrate that a grammatically constrained theory of discourse representation may serve as a promising competence model for discourse processing. Previous psycholinguistic works on discourse processing recognized that discourses are structured in some way, and tried to identify some organizational principle, (see Grosz & Sidner 1985; Malt 1985; Trabasso & Sperry 1985). Thus "intentional structures," "causal structures" and differences between narrative text versus dialogue text within a discourse have been posited as different means of organising discourse information. In this paper, I use the recently developed semantic theories of Discourse Representation Theory, (Kamp 1981; see also, Heim's File Change Semantics 1982) and Modal Subordination (Roberts 1987, 1989) to constrain a possible psycholinguistic theory of discourse processing. The complex nature of discourse processing entails that two experiments cannot definitively decide on a particular model as such. However, empirical support for contrasts suggested by the above theories indicate that operator scope (here modals) may define different domains in discourse. Because the discourse processing model that emerges is based on linguistic theories of natural language, it captures constraints on "discourse grammar," namely constraints on intersentential anaphora. In accounting for anaphora, this model has an advantage over previous models since the constraints

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<sup>1</sup>This is a slightly revised version of a general paper I wrote while a student at UMass. I am indebted to Charles Clifton, Lyn Frazier, Angelika Kratzer and Barbara Partee for their invaluable assistance during the original writing of this paper. Paul Portner, Hotze Rullmann, Michael Hoover and Bob Bracewell also provided lively discussion and suggestions along the way. I'd also like to thank an anonymous reviewer for helpful comments. Any remaining errors are the author's.

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posited are not without grammatical significance. The empirical findings presented below support the promising framework that I adopt.

Specifically, I will explore how sentences containing modal auxiliaries may be processed on-line in discourse. Examples of such sentences are given in (2), this is in contrast to sentences that are not modal, as in (1), (for further elaboration, see Section 1.0).

- (1) a. Susan went to the store.  
b. Susan likes chocolate.
- (2) a. Susan could go to the store.  
b. Susan might like chocolate.

The main finding of this work is that modality must be represented at the discourse representation level. Roberts (1987) (cf. Karttunen 1976; Heim 1982) showed that introducing a modal in discourse creates structure in the discourse representation that constrains anaphoric relations. Compare the mini two sentence discourses below:

- (3) a. John might buy a book.  
b. It would be a murder mystery.
- (4) a. John might buy a book.  
b. #It's a murder mystery.<sup>2</sup>

Whereas discourse (3) is fine, (4) is odd, intuitively. Experiment 1 seeks to find experimental data that support the contrast found in the discourses above.

Besides showing that sentence modality organises a discourse representation, this work shows that the semantic representations of different types of modals affects processing times. Intuitively, modal sentences seem more complex than non-modal sentences. This intuition suggests that perhaps it is the intrinsic content of modals in general that makes processing modal sentences more difficult than non-modal sentences. The findings of Experiment 2 argue against such an "intrinsic content" hypothesis, and suggest instead that where there is a complexity effect associated with a modal, it is the structure required for its interpretation that makes it more difficult to parse. By the Minimal Structure Hypothesis (see below), the more structure the discourse representation of a sentence requires, the more time the processor takes to parse the sentence. Further, I show that not all modals are alike; *would* and *should* sentences are processed differently. This difference is accounted for by the Minimal Structure Hypothesis.

The outline of this paper is as follows: Section 1.0 outlines the semantic theory of DRT and modality; Section 2.0 lists the parsing assumptions made in this paper; Section 3.0 describes the processing predictions we expect based on the linguistic theories described in 1.0. Section 4.0 outlines Experiment 1; Section 5.0 is the Discussion section for Experiment 1; Section 6.0 describes Experiment 2 and 7.0 is its Discussion section. Section 8.0 explores alternative semantic and psychological theories to account for the data. Section 9.0 continues with some

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<sup>2</sup> Intended anaphoric relations are indicated by underlining antecedent and anaphor. The symbol '#' here and below indicates that the sentence is infelicitous in that context.

open questions not previously addressed; Section 10.0 concludes this paper.

## 1.0 Background

In the experiments that follow, I am concerned with understanding how the mood of an utterance affects pronoun resolution in discourse, and whether the semantic interpretation of modals in discourse has any on-line effects. As a starting point, I will outline the grammatical assumptions I make about modals and their semantic interpretation.

### 1.1 *Modal Subordination*

Roberts (1987, 1989) illustrates the phenomenon of modal subordination (MS) using sentences (5)-(8) below:

- (5) The birds will get hungry (this winter).
- (6) a. If Joan forgets to fill the birdfeeder, she will feel very bad.  
b. The birds will get hungry.
- (7) a. If John bought a book, he'll be home reading it by now.  
b. # It's a murder mystery.<sup>3</sup>
- (8) a. If John bought a book, he'll be home reading it by now.  
b. It'll be a murder mystery.

MS involves two issues. The first issue is how tense/mood is interpreted with regard to context. This is shown in (5) and (6b). While the interpretation of the tense in (5) means some time in the future, i.e., this winter, in (6b) the birds will get hungry (only) sometime after Joan forgets to fill the birdfeeder.<sup>4</sup>

The second issue, which we will look at in some depth, is the role mood plays in constraining intersentential anaphoric relations.<sup>5</sup> While the mini two sentence discourse in (7) is infelicitous, (8) is fine. Ostensibly, the presence of the modal *will* in (8b) allows for proper pronoun resolution.

### 1.2 *Modality*

When discussing the mood of an utterance, it is not the emotional state of the speaker with which we are concerned. Instead, the mood of an utterance refers to the speaker's commitment to the truth of the proposition expressed. I repeat examples (1) and (2) below. The difference between these examples is that in the former sentences, it is a fact that Susan went to

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<sup>3</sup>There is one possible reading where this sentence is grammatical. That is where *a book* is taken to refer to a specific book, one that John has already talked about. The specific reading of *a book* would entail that it be immune to the scope of modal quantifiers. For this paper, we are concerned with the indefinite reading of NPs only.

<sup>4</sup>See Partee (1984), "Nominal and Temporal Anaphora" which also addresses how tense is interpreted "anaphorically."

<sup>5</sup>See Karttunen (1976) for a classic discussion of this issue.

the store, or likes chocolate, according to the speaker. When a modal is introduced into the sentence, as in (2), the speaker is not committed to the truth of the proposition.

- (1) a. Susan went to the store.  
b. Susan likes chocolate.
- (2) a. Susan could go to the store.  
b. Susan might like chocolate.

The modals *could* and *might* indicate possibility, so that the sentences could be translated as "Possibly, Susan will go to the store," or "Possibly, Susan likes chocolate." Besides the notion of possibility, the grammatical information of modality also indicates necessity (cf. above sentences with the modals *must*, *would* and *should* below).

- (9) a. Susan must go to the store.  
b. Susan would go to the store (if she had the time).  
c. Susan should go to the store.

The sentences above have the force of necessity, unlike the ones in (2). Following the interpretation outlined above, sentences containing modals are called *non-factual*, sentences without modals (which are assertions) are *factual*.

### 1.3 The Semantic Interpretation of Modals

To properly interpret modals, their meaning must be evaluated with regard to what Kratzer (1979) calls the *conversational background*. This is because modals are ambiguous between epistemic and deontic readings. This is illustrated in the following examples:

- (10) a. Jockl must have been the murderer.  
b. (in view of the available evidence, Jockl must have been the murderer.)  
(Kratzer 1988: (5))
- (11) a. Jockl must go to jail.  
b. (in view of what the law provides, Jockl must go to jail).  
(Kratzer 1988: (6))

Once the extra piece of information is provided, in the b. examples above, the modal is no longer ambiguous between an epistemic or deontic reading. Usually, we know from the context whether the modal is interpreted deontically or epistemically. It is the conversational background<sup>6</sup> (Kratzer 1979) which makes clear how the modal is to be interpreted. The type of conversational background (e.g., deontic or epistemic) is determined by context. It is a function which assigns to each possible world the set of propositions that are true in that world in terms of (the b. like phrases) "given what we know" or "what the law provides." The interpretation of the modal

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<sup>6</sup> I am simplifying Kratzer's terminology here. I use the term "conversational background" as a cover term for "modal base" and "ordering source." The reader is referred to Kratzer (1979, 1981, 1988) for further elaboration.

proposition will depend on the parameter of the type of conversational background.

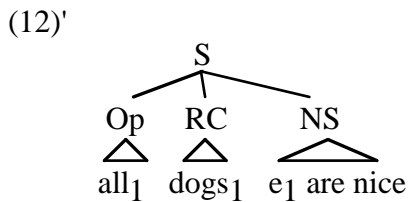
### 1.3.2 Modals are Operators

Syntactically, modals are operators. Heim (1982) regards modals as quantifiers over possible worlds.<sup>7</sup> As such they require a tripartite structure at the level of Logical Form, as adverbs of quantification. To exemplify the analogy between adverbs of quantification and modals, let us compare (12) and (13):

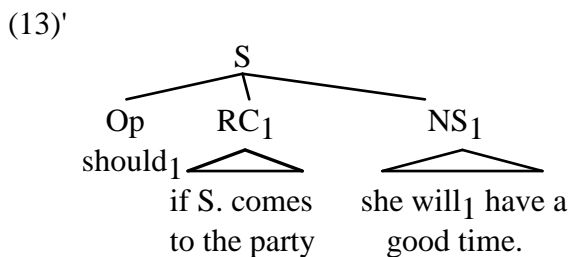
(12) All dogs are nice.

(13) If Susan comes to the party, she should have a good time.

The LF representaton for (12) is shown below:



The determiner *all* is restricted to quantify only over those individuals which are dogs. The structure (12)' is interpreted as "*For all individuals* which are dogs, they are nice." Similarly, the LF representation for (13) is the following:



The interpretation of (13)' is the following: In view of what we know about "fun", *in all those worlds* where Susan comes to the party, she will have a good time."

The restrictive clause restricts the domain of possible worlds in an extremely specific way. This contrasts with how the conversational background restricts the domain. In 1.3.1 we saw that the the domain was restricted to include all those possible worlds where "in view of what the law provides" is true or "in view of what we know" is true. These are broad restrictions, compared to the (relatively) infinitesimally small set of worlds where Susan attends the party. This contrast will become important later.

<sup>7</sup> See Heim, Ch. 2, Section 4.1, pp. 171-195.

### 1.3.3 Summary

In this section the semantic interpretation of modals was outlined. Modals are sentence operators which can take tripartite structures at the level of LF, like adverbs of quantification. Their interpretation is context dependent. The conversational background determines the type of modality (e.g., epistemic or deontic or circumstantial, etc.) and also orders the set of possible worlds that we are to consider, where only those worlds that are stereotypically like ours are considered when evaluating a proposition.

A modal clause indicates nonfactual mood, which means that its kernel clause<sup>8</sup> may not necessarily be true. Thus, modals mark hypothetical suppositions in a discourse. The kernel sentences are temporarily added to the common ground,<sup>9</sup> presumably to explore the consequences of the supposition if it were true. In the next section I go on to outline the linguistic theory which the experiments of this paper test.

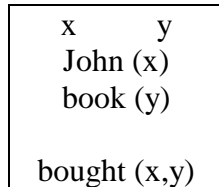
## 1.4 Discourse Representation Theory and Modality

### 1.4.1 DRT

Discourse information in Kamp's Discourse Representation Theory (DRT) is represented syntactically by a Discourse Representation Structure (DRS), which is depicted as a box. Statements which are asserted as facts are entered one after another into the box. This box represents the 'whole' discourse. A discourse may also contain subparts which are temporary assumptions; these are represented as separate DRSEs embedded in the matrix DRS and possibly embedded within each other. Kamp's level of DRS corresponds to the level of the File in Heim (1982).

The DRS for the simple sentence (14) is shown in (14)'.  
 (14) John bought a book.

(14)'



In the Kamp/Heim framework, definite and indefinite NPs are uniformly translated as variables. The sentence is reduced to "bought (x,y)." The variables are predicated of the descriptive content of the NP, which is called the "condition" on the NP.

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<sup>8</sup>Following a suggestion made by Barbara Partee (personal communication), one needs to distinguish the sentence *containing* a modal from the "clause," which is the sentence minus the modal verb. This distinction is necessary since it can be a *fact* that (i) "John should leave," but not a fact that (ii) "John leaves," ((ii)= (i) - Modal). I call clauses of type (ii) the *kernel* clause, and sentences of type (i) the modal clause. These terms will be used since currently there is no alternative terminology available.

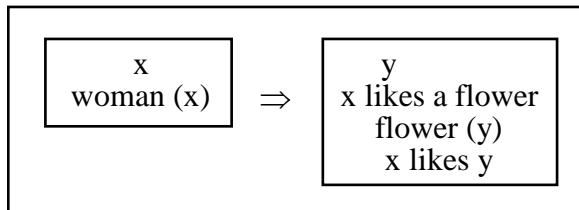
<sup>9</sup>The *common ground* is the set of presuppositions participants in a discourse share at any given point.

The above DRS is constructed in the following way: variables are entered on the top line of the box. The top line of the box represents the ‘universe’ of the DRS. The definition of truth induces existential quantification over the whole discourse representation, —(14) is true if *there is* something in the model which the two conditions on x and y in this DRS provide a true description of.

DRSes are uninterpreted formal structures. To be interpreted they are "embedded" 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," (Roberts 1987: 15). For quantified sentences, the Restrictive Clause (RC) and Nuclear Scope (NS) are represented as separate boxes: an antecedent DRS which functions as the RC and the consequent DRS functions as the NS. These boxes are depicted at a subordinate level of the matrix box.

(15) Every woman likes a flower.

(15)'



(15)' is true if for every way of matching x with a woman there is a way of finding a flower that the woman likes.

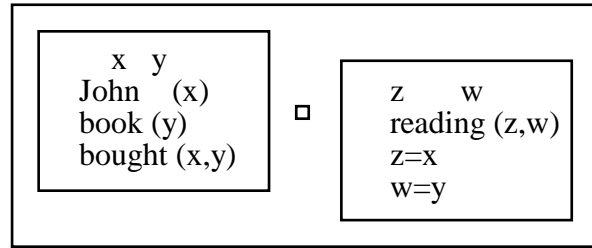
1.4.2 Representing Modality

Roberts (1987, 1989) extends DRT to represent factual versus nonfactual propositions. Factual sentences are always entered onto the matrix box; the "kernel" sentence is always in subordinate boxes. (See Footnote 8). One effect of placing a nonfactual clause in a subordinate box is to get existential quantification over any indefinite contained in the clause. Let's look at (16) to illustrate how DRS and modality interact.

(16) If John bought a book, he'll be home reading it by now. (Roberts 1987: 16, (3))

Although the entire conditional is asserted in (16), neither the antecedent nor the consequent is factual in mood. As such the antecedent is entered onto a subordinate level of the DR, as in (16)':

(16)'



### 1.4.3 Accessibility

The variables  $z$  and  $w$  must be equated with their antecedents. An antecedent is *accessible* if it is located at the same or superordinate level of box structure. When a clause containing a pronoun is represented, as in the consequent of (16), the antecedent for the pronoun must be indicated, or the resulting DR will be ill-formed. A discourse referent for the pronoun is entered on the appropriate level of the discourse structure, here  $z$  for *he* and  $w$  for *it* in the consequent box. To find an antecedent, we locate any discourse referent on the same or higher level of structure. The potential antecedent in (16) is said to be accessible to the pronoun's discourse referent. This is because the antecedent box is superordinate to the consequent box, thus the discourse referents  $z$  and  $w$  may take the discourse referents for *John* and *a book*,  $x$  and  $y$ , as their antecedents. This is shown by equating the anaphors with their accessible antecedents.

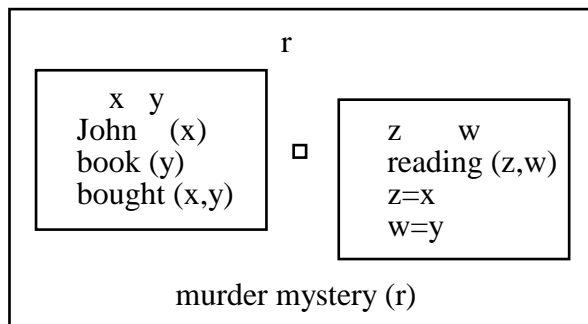
Let us now move on and examine how Roberts (1987, 1989) treats examples (7) and (8), repeated here as (17) and (18):

- (17) a. If John bought a book, he'll be home reading it by now.  
 b. # It's a murder mystery.

- (18) a. If John bought a book, he'll be home reading it by now.  
 b. It'll be a murder mystery.

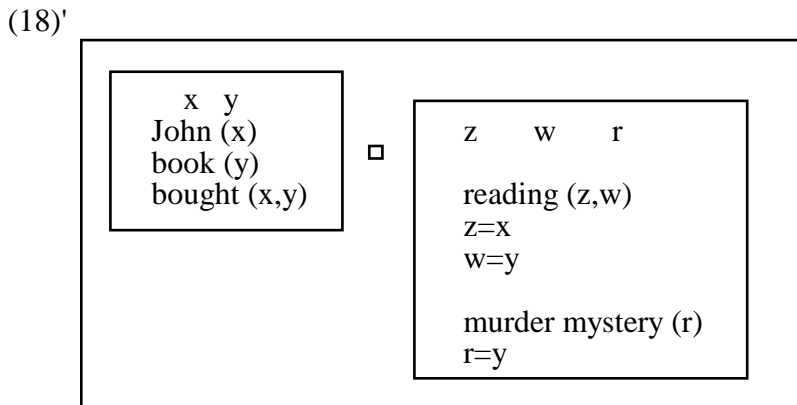
There is no modal in (17b), hence it is in the factual mood. A conditional such as (17a) is only felicitous "where we do not know the truth of the antecedent, and in this case, this entails not knowing whether John bought a book...Hence, we are not tempted to interpret the two clauses [(17a), (17b)] as in the same, nonfactual mood, and there is no evidence of modal subordination." (Roberts 1987: 19). The DRS for (17) is shown below:

(17)'





The DRS for (17a) is as in (17)'. The factual clause (17b) is entered at the top level of the DR. The discourse referent *r* is assigned to the pronoun *it*, and the condition "murder-mystery(*r*)" is added. Because the discourse referent for *a book*, *y*, is contained in a subordinate box, it is not an accessible antecedent for *r*. As such, the discourse is not felicitous, unless there is a prior plausible antecedent available, or where the pronoun is deictic. At this point we can infer the DRS for (18):



The discourse referent for *it*, *r*, is inserted in the nonfactual box already created for the clause (18a) Since the discourse referent for *a book* is now at the same level as that for *it*, (i.e. it is accessible), *r* is felicitously equated with *y*, and the discourse is fine.<sup>10</sup>

A brief summary is due here. Discourses may be represented using Kamp's box theory (1981), which successfully handles anaphora in quantified sentences, ("donkey sentences"). DRT can also represent anaphoric constraints across sentences if we assume that factual clauses are represented on the matrix box, while nonfactual clauses are represented on a subordinate box. An anaphoric relation is licit if the antecedent for the pronoun's discourse referent is at the same or superordinate level; this defines the "accessibility" requirement for antecedents.

Roberts actually modifies the DRS for (18). This is because for discourses such as (19):

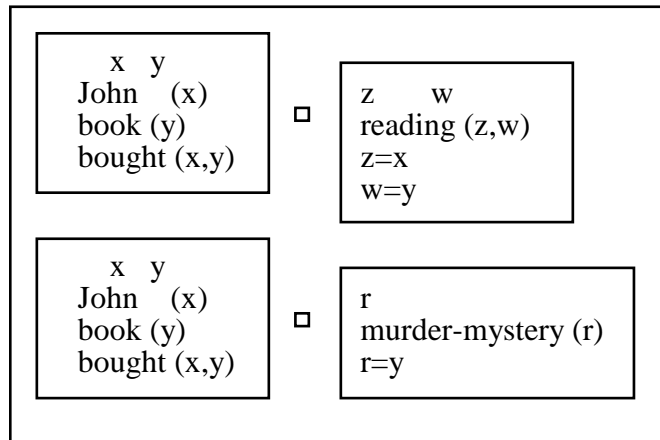
- (19) a. A wolf might walk into your house.
- b. It would eat you first. (Roberts 1987: 21, (11))

a DRS like (18)' does not represent the right truth conditions, "A wolf might enter your house and it would eat you first." The correct truth conditions are instead, "A wolf might enter your house, and *if it does (enter your house)*, it would eat you first." Roberts suggests that the second clause (19b) be preceded by the restrictor "if (the kernel clause of) (19a)" Let us look at the resulting DRS for (18):

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<sup>10</sup> Notice that proper names and specific indefinites will always be entered on the matrix box, escaping the scope of modal operators. See (i):  
 (i) Susan might go to the party. She's a party animal.  
 Though *Susan* is contained in a nonfactual sentence, it is available for anaphora later in a factual sentence because the discourse referent for *Susan* is entered on the matrix box, which is also where factual clauses are represented.

(18)"



The interpretation for (18)" would be "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," (Roberts 1987: 27).

The process of copying the first clause to form an antecedent for the second clause is called the "accommodation of the missing antecedent" approach. Roberts uses the term "accommodation" in the sense of Lewis (1979). "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, but in sentences which are not conditional in form, modal subordination involves pragmatic accommodation of a contextually salient proposition (or propositions) to serve as an antecedent for the nonfactual clause," (Roberts 1987: 26).

### 1.5 Summary

In this section I briefly described the semantic theories of modality and DRT. DRT defines discourse domains via boxes; these domains are defined in general by operators. In the space of this paper we will be addressing the issue of domains as defined by modal operators.

Roberts' (1987, 1989) theory of Modal Subordination gives a formal account for the intuitive observation that antecedents contained in modal sentences can only be referred to from other (like) modal sentences. This relation is captured via accessibility relations between antecedents and anaphors.<sup>11</sup> An antecedent is accessible if it is located at the same or superordinate level of the DRS. Because nonfactual propositions are entered at a subordinate level, antecedents in nonfactual clauses will only be accessible to pronouns which are also in nonfactual clauses. Antecedents in factual clauses will be accessible to pronouns in either factual or nonfactual clauses.

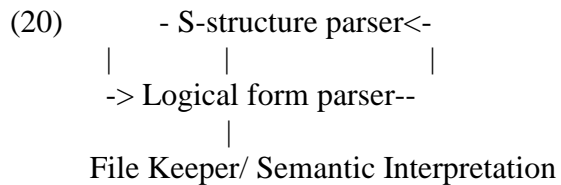
This semantic theory will be used to test whether it can constrain a psycholinguistic theory of discourse processing. DRT is a good candidate theory because it captures grammatical restrictions within and across sentences. Before we discuss possible predictions one could make

<sup>11</sup> Roberts' system does not deal with the types of observations in Lakoff (1972) and Heim (1990), which contrast the sentences: "John believes it is raining and hopes it will stop" versus \*"John hopes it is raining and believes it will stop." Clearly we have two nonfactual clauses here, but the inaccessibility of the antecedent has to do with the specific properties of the nonfactuals. Accounting for these examples is beyond the scope of this paper.

based on the above theory, I will describe the assumptions I make about the Human Sentence Processor.

## 2.0 Parsing Assumptions

I assume an S-structure parser that makes use of syntactic information only, and which resolves local ambiguities via the strategies of Minimal Attachment and Late Closure (Frazier and Fodor 1978). The crucial assumption I make is that the parser interprets as soon as it can, such that the configuration it computes is an enriched "LF-like" representation; certain operations such as quantifier construal, etc. take place as soon as possible. I also assume the existence of the Co-reference Device of Nicol 1988, which resolves anaphoric relations intrasententially. In addition to this, I assume the existence of the "File Keeper" (to use terminology of Heim 1982) which represents discourse level information and computes intersentential co-reference relations.



The File Keeper may be distinct from or possibly a subset of the Semantic Interpretation Module. The S-structure parser and LF parser function as a unit (this is indicated in (20) by feedback arrows going between the S-structure and Logical form parsers); their output is a tree-like representation. This representation is input to the File Keeper, which builds some discourse representation and possibly interprets the representation.

## 3.0 Processing Hypotheses and Predictions

I assume a DRS representation of modality as a competence theory used to constrain psycholinguistic theory. This is in contrast to the way that Kamp and Heim have written the theories; the language they use leads one to believe that the grammatical rules used to describe DRT can directly be interpreted as psycholinguistic rules used by the parser. In the experiments below, I show that DRT interpreted directly as a processing model is not tenable.

To test for predictions, I make the minimal assumption that structure building is costly. Thus, the more structure a representation requires, the more cost is associated with the representation, and the cost is reflected in longer processing times. Since the goal is to understand how DRT can constrain a processing theory of discourse comprehension, the minimal assumption we can make is that the unit of the "box" is a minimal unit of structure. For our purposes, the more boxes a representation entails, the more complex it is.

### 3.1 Predictions

(i) The Discourse Representation Structure will affect the process of pronoun-antecedent resolution. Specifically, if the parser is presented with two discourse situations, one where the non-factual antecedent and pronoun are contained in sentences of the same mood type, and

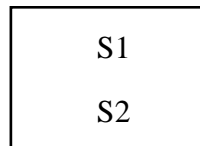
another where the pronoun is contained in a factual clause (and thus "inaccessible" by DRS), the sentence containing the pronoun will be processed faster when it is contained in a non-factual clause than when it is in a factual clause. Using theoretical terms, pronouns with *accessible* antecedents should be processed faster than those with *inaccessible* antecedents. This prediction will be tested in Experiment 1. Note that it is not true that every time there is a difference of mood, anaphora is ruled out. This is because a referent contained in a factual clause is *always* accessible. So a discourse that switched from Factual to Nonfactual should be fine, as in (21):

(21) Susan bought a car. It might be blue.

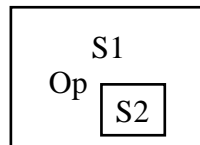
Switching mood in discourse should not present a problem for the parser. Switching mood is only a problem if (i) anaphora is involved and (ii) the antecedent is in a non-factual clause whereas the pronoun is not.

(ii) Wherever DRS theory proposes differences in structural complexity between two representations, the more complex structure should take more time to build than the simpler one. The materials of Experiment 2 are designed to test this prediction. Three types of two sentence discourses are examined; they are a factual sentence followed by another factual (F-F), factual followed by a nonfactual sentence (F-NF) and nonfactual followed by nonfactual (NF-NF). The corresponding DRSeS are shown below:

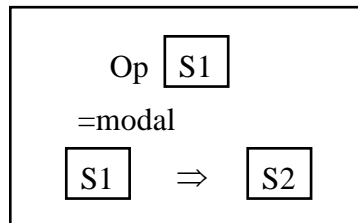
(22)a. F-F



b. F-NF



c. NF-NF



A strict interpretation of the structural complexity effects predicts that the time to process three types of discourses should differ, such that the pattern of results look like the following: NF-NF > F-NF > F-F. Because the representation for NF-NF is the most structurally complex, it



### 4.3 Results

The resulting mean reading times of the third sentence, S3, are shown in Table 1; all reaction times five standard deviations greater than the subject's mean were discarded.

Table 1

Mean Reading Times in Milliseconds per Character for S3	
Nonfactual	57
Factual	62

An anova test that compared the two conditions, Nonfactual versus Factual indicated a significant difference between the conditions,  $F(1,47) = 15.6$ ,  $p < .00048$ .

### 5.0 Discussion for Experiment 1

Experiment 1 investigated the difference in reading times for the sentences S3a versus S3b, repeated below:

- (25) S1: Cathy will probably buy a house.  
 S2: She's been looking at the market lately.  
 S3a: It would be a Colonial.  
 S3b: It's a Colonial.  
 S4: Luckily, she has a good agent.

The results of Experiment 1 confirmed the predictions made regarding the accessibility effect; where an antecedent is *accessible* if it is in the right type of domain in the discourse representation. The difference between the reading times for sentences that contained a pronoun with an accessible antecedent (S3a) versus those which had an inaccessible antecedent (S3b) was highly significant,  $p < 0.00048$ . These results support the idea that modal subordination relations have to be represented at the discourse level,<sup>13</sup> such that the representation of modality segments the discourse into different anaphoric domains.

In this experiment a search effect was found such that when the antecedent was contained in an accessible domain (i.e., was felicitous), the clause containing the pronoun was processed much faster than when the antecedent was in an inaccessible domain. Notice that this result was found despite the fact that the factual S3a. (*it's...*) sentences are syntactically and semantically simpler to represent than the corresponding nonfactual S3b. (*it would ...*) sentences.<sup>14</sup>

It is evident that the difference in time is due to search effects associated with processing

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<sup>13</sup> Angelika Kratzer pointed out to me that it could be that the cost associated with the sentence that has an inaccessible antecedent could instead be accounted for by assuming that the antecedent in S1 is re-interpreted as taking wide scope over the modal. The cost is thus in raising the variable representing the discourse referent outside of the subordinate box onto the matrix box. However, the materials do not bias for such a specific reading, and for our purposes, we will assume that the nonspecific reading is the salient reading.

<sup>14</sup> Note that these results are preliminary; in future experiments, the length of S3 will be controlled for.

the pronouns and is not a property of NF-F discourses because intuitively such discourses are fine when no anaphoric dependency (constrained by modality) exists between the sentences:

(26) Susan might play a sport this summer. She loves soccer.

We change sentence modality all the time. It is only when there is a potential antecedent under the scope of a modal (such that a potential *accessible* antecedent is defined) that the complexity effect emerges. This suggests that the effect is due to some aspect of the search process or other aspects of processing the pronouns.

In summary, the results of Experiment 1 support the type of representation instantiated in Roberts (1987, 1989) where nonfactual clauses define separate domains represented in discourse structure. These representations define accessible domains for pronouns and their antecedents. When the antecedent is located in an inaccessible domain there is a large difference in real time processing compared to when the antecedent is contained in an accessible domain.<sup>15</sup>

## 6.0 Experiment 2

### 6.1 Description of Experiment 2

Mini two sentence discourses were tested to check for the computation of non-factuality. There were 24 items; 12 used the non-factual *should*, biased for its deontic reading, and 12 used the modal *would*. Each item had three conditions: Factual-Factual (F-F), Factual-Nonfactual (F-NF) and Nonfactual-Nonfactual (NF-NF). These conditions are exemplified below:

- (27) a. Susan will major in math. She will take Calculus III first. (F-F)  
 b. Susan will major in math. She should take Calculus III first. (F-NF)  
 c. Maybe Susan will major in math. She should take Calculus III first. (NF-NF)
- (28) a. Mario will run for President again. He will win this time. (F-F)  
 b. Mario will run for President again. He would win this time. (F-NF)  
 c. Maybe Mario will run for President again. He would win this time. (NF-NF)

### 6.2 Method

42 psychology undergraduates at the University of Massachusetts at Amherst participated in this self-paced reading study for extra class credit. The study consisted of 114 items, 24 of which belonged to this particular study; there were 48 other experimental items and 42 fillers in all. The fillers for this experiment included the following: five 2 sentence discourses that contained *would*, five others with *should*, where no modal subordination occurred; and 10 other

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<sup>15</sup> A anonymous reviewer notes that the findings for Experiment 1 do not necessarily support the theory presented above. According to him/her, all that is necessary is that a semantic theory differentiate between factual and non-factual clauses. While I agree that the above mentioned distinction is crucial, on its own, it is not enough to account for the facts. Importantly, one needs a theory that is able to make such a distinction in a *discourse*. Roberts' theory is unique in that it can make such distinctions within a theory of discourse representation. For further discussion, please see Section 8.0.

2 sentence discourses. Each condition type (F-F, F-NF, NF-NF) was seen an equal number of times by each subject and over the course of the experiment each discourse type was tested equally often in each sentence. Three counterbalancing conditions were used.

Before the start of the actual experiment, subjects participated in a practice trial of twelve 2 sentence discourses. The presentation of the items was one sentence at a time on a CRT screen. The subject pushed a lever when she was ready to read the next sentence. Reading times for the second sentence in the discourse were recorded. After the subject had read the second sentence and had pushed the lever, a question was presented. The purpose of the question was to check whether the subject was paying attention. Questions were basic Yes-No, True-False or simple wh-extractions; an example is shown below:

(29) Frank will go to the party, afterall. He should get a haircut before he goes.

Question: Is Frank's hair too short?

YES

NO

### 6.3 Results

The resulting mean reading times of the second sentence are shown in Table 2; all reaction times two standard deviations greater than the subject's mean were discarded.

Table 2

<b>Mean Reading Times in milliseconds per character</b>			
	F-F	F-NF	NF-NF
should	52	51	50
would	55	60	57

For purposes of analyses the 2 conditions F-NF and NF-NF were combined. A 2x2 analysis ([should versus would]x[F-NF+NF-NF]) indicated a significant interaction of,  $F(1,41)= 5.79$ ,  $p < 0.021$ . The nonfactual conditions were longer for the *would* condition, no significant difference was found for the *should* condition.

In addition, the main effect of *should* versus *would* was significant,  $F(1,41)= 15.20$ ,  $p < 0.001$ . Sentences with *would* are slower than *should*.

A T-test indicated that the difference between 55 and  $((60+57)/2)$  was nearly significant,  $T(41)= 1.93$ ,  $p < 0.054$ . There was no difference among the nonfactuals in the *should* and *would* conditions,  $F(1,41) < 1$ .

## 7.0 Discussion for Experiment 2

### 7.1 Summary of results

Overall, whenever the modal *would* is used, some extra processing time is required. The interaction between the *would* and *should* sentences indicates that there is a significant difference as to how these are processed,  $p < 0.021$ . Furthermore, there is strongly suggestive evidence that *would* takes more time to process than *will*,  $p < 0.0549$ . For the *should* discourses,



no difference in processing time among the three conditions, F-F, F-NF and NF-NF were found. As just indicated, there was a significant difference between the F-F condition for *would* and the F-NF and NF-NF conditions. There was no significant difference between the F-NF<sub>would</sub> versus NF-NF<sub>would</sub> conditions.

These results do not confirm the predictions made earlier. We did not predict a difference between the behaviour of *should* and *would*. While it's clear that *would* is complex, *should* is not. The results suggest *would* and *should* may be interpreted differently and that this difference affects processing times.<sup>16</sup>

## 7.2 About "would" and "should"

Stump (1985: 49-50), in his chapter on "Modality and Free Adjuncts" indicates that the modal *would* on its hypothetical reading can require an "if-clause" in the previous discourse in order to be interpreted. "If-clauses" are nonfactual restrictors. In order for *would* to be used felicitously on its hypothetical reading, there should be an explicit (nonfactual) conditional in the common ground. No such constraint is placed upon the usage of *should*. It does not need a restrictor.<sup>17</sup>

The implication of the above difference between *should* and *would* is that, where there is no sentence internal restrictor, *would* requires a context to supply a restrictor in order to be interpreted. This contrasts with *should* where no restrictor is required for interpretation.

In an off-line judgement task, I asked six native English speakers to judge whether the second sentence (S2) of Experiment 2's NF discourses were acceptable when uttered in isolation, in an "out of the blue" situation.

- (30) a. S1: (Maybe Susan will major in math.)  
S2: She should take Calculus III first.
- b. S1: (Maybe Mario will run for President again.)  
S2: He would win this time.

The sentences were duly modified so that all pronominal elements were replaced with proper names. All references to specific times mentioned in the preceding context were deleted, etc. such that each S2 like (30)a. and b. was modified to the version like (31):

- (31) a. Susan should take Calculus III.  
b. Mario would win the election.

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<sup>16</sup> Note that throughout this section, when I refer to "structural considerations" I will have occasion to refer to the LF level of tripartite trees and/or to the DRS/File level of box structure. While both vocabularies are useful for expository reasons, ultimately DRT terms will be adopted (see Section 7.4.1) since the experiments are concerned with discourse level phenomena. If DRT is indeed the right theory to account for the findings of the experiments, then I also will show that some types of box building are more costly than other types.

<sup>17</sup> Given this information it is surprising to note that for the *would* sentences, no significant difference was found between the F-NF and NF-NF conditions; even though Stump's observation suggests that the NF-NF condition should be easier to process than the infelicitous discourse F-NF. This point will be addressed below.

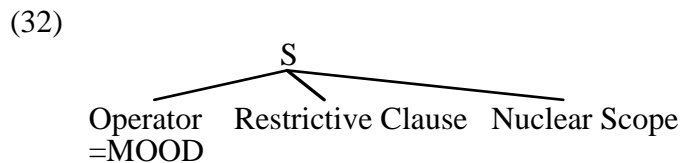
Subjects were to assume that they and the speaker of the utterance shared some vague common ground. The results were consistent across subjects. I found that the 12 *should* sentences were all acceptable in isolation. This makes sense given that in everyday life we generally accept the existence of things we just "ought" to (or "should") do. The judgements for the *would* sentences were not so straightforward. Some speakers allowed certain *would* sentences to stand on their own, only one subject disallowed all the *would* sentences in isolation. Except for the item "Mario would win the election" (which was consistently judged as bad) most sentences varied in their acceptability when in isolation. Overall, the *would* sentences were generally unacceptable without a supporting context.

I then re-tested each subject; each *would* sentence they judged as unacceptable was paired with its corresponding S1. All judgements changed such that the *would* sentences were judged acceptable in context. Beyond this, I found that the acceptability of the *would* sentences in isolation improved if I changed the sentence (beyond the changes already mentioned above) so that it included an unstressed PP, as in "Mario would win in the election this year," or "Sam would do a good job on this project." This follows since unstressed PPs may serve as restrictive clauses.

There are two possible accounts for the above findings. I will discuss each in turn.

### 7.3 The Internal Priority Hypothesis

As a first hypothesis, assume that the structure built for the semantic interpretation of modals is always tripartite, as in (32):



Assume further that the parser uses the following general strategy:

- (33) *Internal Priority Strategy*  
 Choose sentence internal information over sentence external information wherever possible.

The motivation behind (33) is that it is more costly to have to extract sentence external information compared to internal information, at least where external information is optional for interpretation. (33) might follow from the hypothesis that filling in sentence external information would strain short term memory limitations, since the current sentence and any possible previous sentence would have to be processed simultaneously.

With the above assumptions, Experiment 2's findings may be accounted for as follows: It has been established that *should* can be evaluated without any explicit background information (see Section 7.2), since hearers/readers are all too ready to accept some (unspecified) deontic conversational background. Diesing (1990, 1992) and Berman (1990) point out that the Restrictive Clause is where presupposed material goes; as such we expect something like the vague conversational background material to fill the RC. This default information would have to

consist of some function like, "Given what we know about good and evil...", or "Given the laws...", etc., applied to possible worlds. *Should* would then be calculated with respect to this (default) information. The interpretation of hypothetical *would*, on the other hand, cannot occur with default information. An overt restrictor must be supplied. For the most part, materials of Experiment 2 required that the restrictor be supplied by S1. Thus, the RC for *would* is filled not with some default conversational background parameter, but with explicitly stated material in the discourse.

Because the materials in Experiment 2 supported interpreting *should* with sentence internal information in contrast with *would* which required sentence external information for interpretation, the *should* sentences are predicted to be processed faster than *would* sentences, by (33). This is because searching outside the current sentence is a costly endeavour for the parser.<sup>18</sup>

Summarising, the Internal Priority Hypothesis accounts for the difference between *would* and *should* based not on structural considerations, but on search space considerations. In order to make this hypothesis convincing we need to assume that all modals are interpreted with similar configurations, so as to not confound the issue; if structural requirements are different, we expect there to be a cost in building the more complex structure.

### 7.3.1 Problems

The Internal Priority Hypothesis account will be discarded for both theoretical and empirical reasons: First, the simple equation made between the conversational background parameter and the restrictive clause is ill formed, theoretically. As was pointed out in Section 1.3.2, the conversational background and the restrictive clause, though they perform similar functions in restricting domains, are not to be equated. The RC defines the domain in a very specific way, in contrast to the conversational background which restricts the domain by a very general restrictor type, as in "deontic" worlds versus "epistemic" worlds. The RC is too simple a space to contain the entire corpus of the conversational background.<sup>19</sup>

Second, if the size of the search space (as indicated by Internal Priority Hypothesis) was the factor that accounted for the difference between *should* and *would* then search effects are expected. Specifically, felicitous antecedents should facilitate the search process, while infelicitous antecedents should complicate the search process, resulting in longer RTs. The felicitous versus infelicitous antecedent case is exhibited in Experiment 2, this is the F-NF<sub>would</sub> condition versus the NF-NF<sub>would</sub> condition, (see Section 7.2 and Footnote 17). However, recall that there was no significant RT difference between these two conditions. No search effect was found.

Since the search space is not the issue, what is? Below I modify the assumption depicted in (32), that all modals are interpreted using the same LF structure. This difference in structural interpretation requirements between *would* and *should* forms the basis for the account I adopt in Section 7.4.

### 7.4 Minimal Structure Hypothesis

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<sup>18</sup> I am assuming that in a *would* sentence where enough PP information is given the parse will be sentence internal.

<sup>19</sup> Thanks to Angelika Kratzer (personal communication) for making this point clear to me.

Suppose that the parser is operating under a "Minimal Structure" strategy, (completely analogous to Frazier and Fodor's Minimal Attachment strategy):

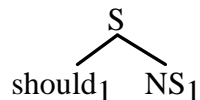
(34) *Minimal Structure Hypothesis*

When constructing parse, postulate only as much structure as is required by the well-formedness rules of the grammar.

If (34) is assumed then the difference in processing times for *should* and *would* can be accounted for, providing we assume that each modal requires different structural configurations for interpretation.

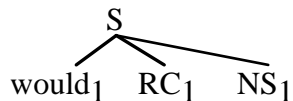
Earlier discussion indicated that *should* does not require explicit background information (in the form of a restrictor) for interpretation. Further, it was concluded that the RC was not the space that the default conversational background information could assume. As such, *should* may be interpreted with a bipartite structure as in (35):

(35)



The modal operator *should* takes as its LF argument a nuclear scope, the assertion, or "kernel" sentence.<sup>20</sup> Hypothetical *would* on the other hand, needs a restrictor in order to be properly interpreted:

(36)



Hence it is the added structural requirement that *would* take a restrictive clause that accounts for the processing differences between *should* and *would* by the Minimal Structure Hypothesis.

The Minimal Structure Hypothesis predicts that the parser will preferably interpret *would* using a bi-partite structure. The bi-partite structure is not incompatible with other readings of *would*, since there are readings of *would* that act like *should*. As Coates (1983) points out, *would* can have the following types of meanings, (adapted from Coates 1983: 207-208)

(37) a. *Willingness*

- (i) He would gladly help. (i.e., he is willing to help).
- (ii) She would never return.
- (iii) His blue eyes gazing seriously through a wisp of fair hair which would keep falling across his eyes.

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<sup>20</sup> Barbara Partee (personal communication) pointed out that this could be a problem, since it's not clear how *should* gets interpreted. What I am implying is that the conversational background material is not represented at LF or DRS; this information is in a different component of the Semantic Interpretation Module.

b. *Predictability*

- (i) That would be the milkman. (i.e., I confidently predict that that is the milkman at the door).

These meanings are unlike the hypothetical versions of *would* used in the experiment (which as Stump observed, require a conditional in the common ground). Given this ambiguity, the Minimal Structure Hypothesis (34) predicts that the parser will preferably choose the bi-partite structure, as a first hypothesis. If further information requires an alteration, such as postulation of more structure, then a revision of analysis will be necessary. The cost is therefore due to revising an earlier, simpler structure into one more complex.<sup>21</sup>

#### 7.4.1 *An Issue of Levels*

As I indicated earlier, in this section I would be referring to both LF structure and DRS. Below, I discuss how both the tree structure account and the box account work using Minimal Structure.<sup>22</sup> Suppose that the RC building (which is costly) occurs at LF for *would* sentences. The material required to fill in the RC is provided by context, which is information not yet available. At the pre-discourse level, assume that the RC gets built, and then filled with some variable, "x" to be filled in at a later level. This would still contrast with the interpretation of *should*, which at LF only requires a bi-partite structure.<sup>23</sup>

We could instead assume that there is no LF level, and that the RC gets built once, at DRS. Then the cost is due to building a RC box, (not RC node at LF). Presumably the cost of node building or RC box building (referred to as box splitting) dwarfs any possible cost associated with filling it in. Remember that I have to assume this in order to account for the insignificant difference in processing time found in Experiment 2 for the felicitous and infelicitous *would* discourses, NF-NF and F-NF, respectively. For the purposes of this paper, we may assume that the cost associated with *would* is due box-splitting.<sup>24</sup>

#### 7.5 *Summary of discussion for Experiment 2*

The results of Experiment 2 are accounted for by a Minimal Structure strategy. Where there is ambiguity between a bi-partite and tri-partite structure, the bi-partite structure is always expected to be built. These structural complexity effects were interpreted as box effects. Hypothetical *would* 's requirement for a restrictive clause resulted in longer processing times for sentences that contained this modal. It was suggested that because *should* does not have this requirement, that it may not be as costly to parse. Indeed, it was found that there was no

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<sup>21</sup>Note that these results are preliminary, since the items analysis did not show a significant difference in reading times for *should* versus *would*. This is because the original hypothesis I assumed was that there would be no difference between *would* and *should*. As such, I did not control for the different types of sentences. The resulting "noise" in the data are responsible for the items analysis result.

<sup>22</sup>While there is a theoretical debate about the validity of the levels LF and DRS, i.e. whether we need both, and if one, which one? this debate will not be addressed in my paper. Instead I discuss how assuming the cost is incurred at each of the different levels would have to be explained.

<sup>23</sup>This option was pointed out to me by B. Partee (personal communication).

<sup>24</sup>A point about Experiment 1 is due here: note that the search effects there did dwarf the cost of building the RC for the nonfactual S3b. (*it would*) sentences.

significant difference in processing times for *should* between the F-F, F-NF and NF-NF conditions. Thus, building different domains in discourse structure is only costly when a restrictive domain is introduced; otherwise box building is cheap, as it was for *should*. This observation will be further explored in Section 9.0.

## 8.0 The Value of a Roberts-Heim-Kamp Approach

In this section I show the value of adopting a Roberts-Heim-Kamp type theory (henceforth RHK theory) to capture the findings of this paper.<sup>25</sup> Given the complicated nature of discourse processing, it is not the case that the two experiments reported here can only be described using

RHK theory. However, I would maintain that for reasons given below, the RHK approach is the most promising type of theory to use in exploring on-line theories of discourse processing.

### 8.1 *RHK as a Semantic Theory*

First of all, the particular semantic theory of Modal Subordination à la Roberts (1987, 1989) is valuable because to my knowledge, it is the *only* theory of modality that takes discourse information into account. Other well-known theories of modality (see inter alia, Kratzer 1979, 1981, 1988; Coates 1983) interpret modals at the *sentence* level only. While these other approaches may take the role of context into account, Roberts' theory requires that modals are interpreted as part of a discourse structure, (see Section 1.4.1). As such, a formal semantic theory of modality in discourse, such as the RHK theory, is precisely the type of theory needed to capture the findings of Experiments 1 and 2 where non-factual sentences were used in discourse.

Another merit of the RHK theory as a semantic theory is that context is formally represented as a linguistic object. As such, this approach easily lends itself as the basis for a performance theory of discourse processing. Note that the closely related theories of Heim (1982, 1990) are roughly theoretically equivalent to the specific theory adopted in this paper. However, Heim's File Card semantics builds context into part of the truth conditions, so that context is never explicitly represented. The value of the RHK approach is that it serves as an adequate representation of discourse structure. For example, regarding Experiment 1: perhaps other semantic theories or psychological theories would indicate that the antecedent is in the wrong location or is 'too far' from the pronoun. The RHK approach gives us a specific and principled way of representing how it is that the antecedent is in the wrong location. Using Roberts' terminology, an antecedent is not accessible if it is located in a box that is superordinate to the box which contains the pronoun (see Section 1.4.1). As for Experiment 2, the representation of the restrictor is key in terms of explaining the long reading times associated with box splitting. Thus, the unique incorporation of discourse structure in the interpretation of modals, and the requisite representation of context make the RHK a viable semantic theory to use as the basis for a performance model of discourse processing.

### 8.2 *The Value of RHK over other Psychological Approaches*

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<sup>25</sup>Thanks to an anonymous reviewer for pointing out that the theoretical value of a DRT approach as adopted in this paper is not obvious.

The fact that the relations between utterances in a discourse influence how information in them is processed or stored has long been recognized. As such, several theories have been proposed to account for the segmentation of discourse structure. I propose that the RHK theory is superior to other psychological approaches because the organisation of discourse information is based on purely grammatical considerations, i.e. modality.

Psychological accounts tend to use non-linguistic information as the building blocks of discourse structure. It is not obvious that constructs such as story grammar, causal relatedness, or intentional structures (Rumelhart 1975; Trabasso & Sperry 1985; Malt 1985) are the same across languages and cultures. Given these constructs, we would expect to see variation cross-linguistically. However, we expect that all languages have a means of representing non-factuality, and that all languages must do so at the discourse level. In this sense, the RHK approach has strong cross-linguistic implications, whereas this is not as crystal clear for the other theories mentioned.

Another advantage of this approach over psychological ones is that it can potentially be extended to cover cases of generalized subordination in discourse.<sup>26</sup> Roberts (1987: 35) notes that "examples involving temporal factors, adverbs of quantification (Lewis 1975), and universal quantifiers display close parallels to modal subordination." Adverbs of quantification quantify over cases or situations in the actual world, whereas modals quantify over possible worlds. The generic example below displays discourse subordination phenomena:

- (38) a. If a farmer owns a donkey, he beats it.  
 b. It always develops festering wounds.  
 b.' #It developed festering wounds. (Roberts 1987: 35, (24))

Using the tenets of modal subordination theory, the discourse above can be captured naturally (see Roberts 1987 for discussion). This is in contrast to the psychological explanations above which would have difficulty predicting that modal auxiliaries and quantificational determiners induce similar effects. Thus, the linguistic RHK explanation clearly recognizes the status of operators and how their scope may be extended in discourse; as such discourses as above are treated similarly to modal subordination cases.

Next, a further possible psychological (i.e. purely non-linguistic) account for the findings of Experiment 2 could maintain that sentences containing the modal *would* are simply more difficult to integrate into discourse than sentences containing other modals, such as *should*, presumably because of the meaning of *would* being more complex. I note here that the linguistic theory proposed provides a formal, explicit way of explaining the differences in difficulty. The meaning of the modal *would* is more complex to represent, and given an assumption like the Minimal Structure Hypothesis, it is therefore more difficult to process. One way to test the linguistic account over the psychological one would be to test whether similar effects held for the modal *might* in discourse. Paul Portner (personal communication) indicates that this is another modal that requires an overt restrictor for interpretation. A future experiment could show that *might* differs from, say *must*, in exactly the same way that *would* differs from *should*. If this were indeed the case, it would indicate that the linguistic approach is superior to one which relies on vague notions of difficulty. The value of the theory adopted in this paper is that it pinpoints where we expect to see such difficulty as manifested in long reading times for

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<sup>26</sup>See Roberts 1987, p. 35ff. for discussion.

sentences, and it gives us a way to *represent* this difference.

### 8.3 Summary

Thus, the value of adopting RHK theory is that it sensibly accounts for the empirical findings of this paper. Without it, the findings would be interesting quirky (isolated) facts. That is, we would have to say that pronouns cannot be related to antecedents that have not been firmly established, and that *would* is a difficult modal to integrate in discourse — that would be the end of it. RHK theory allows us to put together these findings in a meaningful way. Antecedents are only accessible if they maintain a certain structural relationship with their pronouns; this structural relationship is dictated by non-factuality, or operator scope in general. Certain structures are cheaper to represent than others, namely, grammatical information like modality is cheap, whereas restrictive clause accommodation is expensive. As a result, modals that require restrictors take longer to process than modals that do not. Finally, the RHK approach also allows for interesting questions be raised, and this is taken up in Section 9.0.

## 9.0 General Discussion: Implications and Further Studies

### 9.1 Lexically driven processes versus post-lexical processes

#### 9.1.1 Types of boxes

In Section 7.0 it was established that RC box building (=box splitting) is expensive and thus different from other types of box building. This explained why longer processing times are associated with sentences that contain hypothetical *would*, whereas no differences were seen for the different conditions for *should*. Notice that it cannot be inferred that *should* clauses are simply entered on the main box, since *should* shows anaphoric constraints like *would* :

- (40) a. Susan should buy a house, what with the rent she's paying.  
 b. It could be in the neighbourhood.
- (41) a. Susan should buy a house, what with the rent she's paying.  
 b. #It's in the neighbourhood.

If *should* clauses were entered on the main box, which corresponds to the factual level, then we expect that the discourse in (41) to be felicitous. The fact that it is not indicates that *should* clauses do get entered onto a subordinate box.<sup>27</sup>

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<sup>27</sup> It's not clear to me whether the NF-NF<sub>should</sub> DRS is like the *would* case. *Should* is not a box splitter, but presumably the reason why Roberts incorporated the accommodation approach over the insertion approach was for truth-conditional reasons. Clearly, *should* will take an antecedent clause in the discourse below:

(i) A wolf might enter your house. It should eat you first.

compare (i) to (ii):

(ii) Maybe Susan will major in math. She should take Calculus III first.



Box building which represents modality is not costly. This is in contrast to the process of box-splitting; the RC box is expensive to build. These findings could support the hypothesis that there is a difference between grammatically driven box building versus box building by Roberts' accommodation approach.

The hypothesis is that representing modality using boxes is cheap because the instruction to build a box comes directly from the lexical information of the modal. Since all modals are nonfactual, the parser knows that once it identifies a modal, a subordinate box must be built. This is simpler than building a box after acquiring disambiguating material that indicates a certain lexical interpretation of a term that requires a RC, which was the case for *would*. Perhaps then, we should expect RC building to be less costly for *if*-clauses than for *would* clauses. *If* always forms a restrictor; in this way it is just like these modals that require subordinate boxes. Comparing the different possible types of RC building, (*if*-clause, *every*, and other constant box splitters versus *would* an ambiguous box splitter) would form a good experiment to follow up on this study. We expect that sentences containing the unambiguous box-splitter operators be easier to parse than sentences containing *would*.

### 9.1.2 Antecedent Types

Recall that despite the intuitive difference in felicity between the F-NF<sub>would</sub> and the NF-NF<sub>would</sub> discourses, no significant difference was found between these conditions. The nonsignificant difference between the F-NF<sub>would</sub> and the NF-NF<sub>would</sub> conditions could follow from the hypothesis that the parser did not find the grammatically defined form of the antecedent and that this was enough to confuse it so that no difference was seen between conditions. A possible follow-up study would check to see if the two conditions would differ when in the NF-NF case, the S1 of this "felicitous" discourse contains an explicit *if*-clause, (as Stump 1985 suggests *would* grammatically requires) instead of simply a nonfactual sentence, (which was indicated in Experiment 2's sentence materials by either "maybe" or "perhaps"). The overt conditional could facilitate the search to such an extent that the infelicitous discourse would be comparatively slower.

In summary, it has been suggested that because in Experiment 2 the specific grammatical form of the antecedent DRS required for *would* was not found, accommodation of the restrictive clause was equally costly for the F-NF and NF-NF conditions.

## 9.2 Sentence Internal Restrictive Clauses

If building the RC is the right explanation of the difference between *should* and *would*, then we predict that the differences between these modals should disappear where both types of clauses have explicit restrictors as in (42):

- (42) a. If John bought that car, he would lose money.

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(ii) is the type of discourse used in the experiment; there was no anaphoric connection between the first and second sentences. I'm not sure whether it is necessary that *should* take an antecedent DRS here. If it isn't necessary to have a RC, then the account for why *should* did not show any complexity effects would be because there was no box splitting. If it is however, then this is a problem for my account.

- b. If John bought that car, he should lose money.<sup>28, 29</sup>

The overt *if*-clause signals restrictive clause building (see Heim 1982: 134). Since both modals take tripartite structures here, we expect that there be no difference in processing time between the modals; presumably the processing time associated with *should* should increase compared to the instances seen in Experiment 2. Notice that the Internal Priority Hypothesis makes different predictions here. Since in (42), *should* can be interpreted via sentence internal information, we do not expect that it take more time to process here than in Experiment 2. This should be tested at a further date.

### 9.3 Implications for ambiguous operators

Next, the above account makes interesting predictions regarding weak determiners. Weak determiners can appear in "there-insertion" contexts, while strong determiners cannot, (see Milsark 1974). This is shown below:

- (43) a. There is/are a/some/a few/many/57 fly (flies) in my soup.  
 b. \*There is/are the/every/all/most fly (flies) in my soup. (Diesing 1990: 93,  
 (4))

With the exception of *the*, strong determiners are quantificational, and take tripartite structures for interpretation. As Diesing (1990) points out, "weak determiners are ambiguous between a presuppositional reading and a non-presuppositional reading in which they merely assert the existence of whatever entities they are applied to." (Diesing 1990: 94) The ambiguity is exemplified below:

- (44) a. There are some ghosts in my house.  
 (unstressed *some*, asserts existence of ghosts)  
 b. Some ghosts are in the pantry, the others are in the attic.  
 (presupposes existence of ghosts) (Diesing 1990: 94, (5))

The presuppositional reading is interpreted via a tripartite structure (since presupposed material goes in the RC) and the cardinal reading requires a bipartite structure for interpretation.

Given the above, we expect that when a sentence containing a weak determiner occurs in isolation, it should be processed faster than when it occurs in context. This is because the contextual reading should bias the presupposed reading which requires a tripartite structure; (provided that it establishes a specific NP to refer to). The isolated version of the sentence should require the bipartite reading. A test example is shown below:

<sup>28</sup> This was pointed out to me by P. Portner (personal communication).

<sup>29</sup> Barbara Partee notes that (42b) sounds strange. She suggests that the restrictors associated with *should* clauses should be oriented towards some goal; compare (42b) to "If John wants to major in math, he should take calculus", i.e. if it is John's goal or desire that x, then he should do y. Further research is required to describe a typology of types of restrictors that different modals require, or that "agree" with different modals.

- (45) a. Many cocker spaniels wagged their tails.  
 b. There was a big commotion at the dog pound. The bus unloaded a whole bunch of cocker spaniels. Everyone instantly liked these dogs. Many cocker spaniels wagged their tails.

The sentence "Many cocker spaniels wagged their tails" will be interpreted on its presuppositional reading in (45b) The a. case does not presuppose a set of cocker spaniels. So a bipartite (non-presuppositional) reading should occur here. This is in contrast to the b case where a RC containing "cocker spaniels" will be built. Building this structure should make a difference between the a and b case above; the sentence in (45a) should take less time to process compared to when it occurs in (45b).

#### 9.4 Summary

In this section topics for further research were considered. The first topic was whether grammatically driven discourse level phenomena differed from pragmatically driven processes. It was suggested that the grammatical (or lexical) processes would be initiated faster than the pragmatic processes. Second, sentence internal restrictors for *should* were explored; we expect that where sentences containing *should* require a tri-partite structure for interpretation (like *would*), processing times would be longer than those found for *should* sentences in Experiment 2. Finally, operators that can take either bi-partite or tri-partite structures should be processed faster where the semantic theory predicts that the bi-partite structure be preferred, since by Minimal Structure, bi-partite structures are *always* preferred. This was shown for *would* and was extended to predict differences for the behaviour of sentences containing weak determiners in isolation versus in context.

## 10.0 Conclusion

Roberts' Modal Subordination theory (which incorporates the insights of Kamp's Discourse Representation Theory and Heim's File Change Semantics) is an adequate competence theory to constrain a model of discourse processing. This theory provides a promising starting point from which one can begin to look at issues surrounding intersentential processing strategies. As such, I conclude that the structures the theory imposes on discourse representations are respected at the processing level.

Although we did not see the cost of building modal representations (in Experiment 2) we certainly saw the effects of such a representation in Experiment 1. We saw that experimental data supported the intuitive notion that anaphora is ruled out when an antecedent is in a nonfactual clause and its anaphor is in a factual clause. I interpreted these data to support the idea that a discourse is segmented into different domains of quantification, represented as "boxes". A domain of quantification includes basic sentence information: the NPs are listed as variables and the verb information is listed with its (argument) variables.

A constraint is placed on what the variables may refer to cross-sententially or across domains. A factual domain is always accessible, whereas a nonfactual domain is sometimes accessible. This translates into the observation that an antecedent in a factual clause can be referred back to but an antecedent in a nonfactual domain can only be referred back to provided its anaphor is in a suitable (nonfactual) domain in the discourse structure.

In Experiment 2, no difference was found for processing discourses that by DRT differed in their level of structural complexity. It was concluded that representing modality is relatively cheap, since no difference was found between the F-F, F-NF and NF-NF *should* conditions. There was a nearly significant difference between the F-F versus F-NF and NF-NF *would* conditions, and a highly significant difference between the nonfactual *should* discourses and the nonfactual *would* discourses. In the final analysis, I relied on a structural complexity difference to explain the data: hypothetical *would* necessitates box-splitting (restrictive clause building), which is extra structure that *should* (and probably *will*) do not need in order to be interpreted.

It has been shown that there is some cost in constructing certain domains, or boxes. Box-splitting (restrictive clause building) is an expensive endeavour. The Minimal Structure Hypothesis was postulated to account for why a structural representation that included a restrictive clause is more costly to build than a representation without one. It is not clear at present why restrictive clause building is so much more expensive than modal box building. Some speculations were presented in the previous section to tease apart possible factors.

The Roberts-Heim-Kamp framework seems to be a promising enterprise for *constraining* a psycholinguistic theory of discourse representation. I maintain that DRT is a competence theory and not a performance theory. That is, although the above researchers often use processing terms when describing their respective theories, the DRT framework is not to be confused with a real processing theory of discourse representation. DRT does not have any account for why some boxes should be more costly to build than others. It also has little to say about the principles guiding the timing of discourse processing operations and their interaction with other processes. There are also no constraints on preference principles for how discourse information is processed. As such, it does not account for the differences between different modals.

Thus, discourses may be segmented according to the scope of modal operators. Where modal subordination occurs, the domain is extended to allow for across sentence anaphora. This approach to analyzing discourse processing contrasts with previous (psychological) approaches which did not appeal to linguistic constructs when defining how domains in a discourse are defined. Roberts' DR theory (1987, 1989) is able to account for certain discourse grammar effects, namely that of discourse anaphora. Crucially, it also has the advantage of ruling out incoherent discourses, by relying on linguistically defined notions of the accessibility of an antecedent.

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## GO TO A SYMPHONY

## WATCHA MOVIE

16. Maybe Dr. Smith will donate his inheritance to UMass./The college is his alma mater./It would be a large sum./It's a large sum./He'll decide at Alumni Weekend./{1 16

IS IT A LOT OF MONEY?

NO

YES

### Appendix B

#### Materials for Experiment 2

Key: a. sentences: F1 or NF1  
b. sentences: F2 or NF2

The three types of discourses examined: F1-F2, F1-NF2, NF1-NF2.

1a. Susan will major in math.|Maybe Susan will major in math.

1b. She will take Calculus III first.|She should take Calculus III first.

WHAT COURSE WILL|SHOULD SUSAN TAKE?

GEOMETRY

CALCULUS

2a. Jake will buy a novel.|Maybe Jake will buy a novel.

2b. He will get a relaxing story.|He should get a relaxing story.

WHAT KIND OF A BOOK WILL|SHOULD JAKE BUY?

RELAXING

ACTION-PACKED

3a. Mary will buy a car.|Maybe Mary will buy a car.

3b. She will take a mechanics course, first.|She should take a mechanics course first.

WHAT KIND OF A COURSE WILL|SHOULD MARY TAKE?

COOKING

MECHANICS

4a. Frank will go to the party, afterall.|Perhaps Frank will go to the party, afterall.

4b. He will get a haircut before he goes.|He should get a haircut before he goes.

IS FRANK'S HAIR TOO SHORT?

NO

YES

5a. Shirley will go camping.|Perhaps Shirley will go camping.

5b. She will not go alone.|She should not go alone.

6a. George will apply to college.|Perhaps George will apply to college.

6b. He will apply early next semester.|He should apply early next semester.

WHEN WILL|SHOULD GEORGE APPLY?

## EARLY NEXT SEMESTER

## LATE THIS SEMESTER

- 7a. Sarah will try to make a new dish.|Maybe Sarah will try to make a new dish.  
 7b. She will consult The Joy of Cooking.|She should consult The Joy of Cooking.

WHICH BOOK WILL/SHOULD SARAH CONSULT?

THE SIXTY MINUTE GOURMET

THE JOY OF COOKING

- 8a. Fred will go hunting this fall.|Maybe Fred will go hunting this fall.  
 8b. He will get a permit soon.|He should get a permit soon.

WHEN WILL FRED GO HUNTING?

THIS FALL

THIS WINTER

- 9a. Minnie will take the Sketching 101 course, afterall.|Maybe Minnie will take the Sketching 101 course, afterall.

- 9b. She will buy H2 pencils.|She should buy H2 pencils.

WHAT KIND OF PENCILS DOES MINNIE NEED?

HB

H2

- 10a. Mike will go to Sara's wedding.|Perhaps Mike will go to Sara's wedding.  
 10b. He will ask her about accommodations.|He should ask her about accommodations.

IS SARA GETTING DIVORCED?

NO

YES

- 11a. Barry will see a doctor about his knee.|Perhaps Barry will see a doctor about his knee.

- 11b. He will get a second opinion, too.|He should get a second opinion, too.

BARRY'S NOSE IS HURT

FALSE

TRUE

- 12a. Kevin will try to find a date for the party.|Perhaps Kevin will try to find a date for  
 the party.

- 12b. He will try a dating service.|He should try a dating service.

IS KEVIN GOING TO A PARTY?

NO

YES

- 13a. Mario will run for President again.|Maybe Mario will run for President again.

- 13b. He will win this time.|He would win this time.

WILL/WOULD MARIO WIN THIS TIME?

NO

YES

- 14a. My friend's business will hire a new salesperson.|Maybe my friend's business will  
 hire a new salesperson.

- 14b. The position will be open in May.|The position would be open in May.



NO

YES

23a. Charlene will tell Mark her secret.|Perhaps Charlene will tell Mark her secret.

23b. He will not tell anyone.|He would not tell anyone.

DOES CHARLENE HAVE A SECRET?

NO

YES

24a. Georgina will wash her husband's car.|Perhaps Georgina will wash her husband's car.

24b. He will appreciate that.|He would appreciate that.

IS GEORGINA MARRIED?

NO

YES

□