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Crossing Bridges in Discourse Representation

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**Abstract**

Ambiguity in everyday speech comes from many sources, one of which is anaphoric indeterminacy, such as when a pronoun can refer to more than one thing. I consider in this paper a type of indeterminacy of noun phrases with bridging descriptions, as treated under van der Sandt's (1992) theory of discourse representation and Krahmer and van Deemter's (1998) hypothesis of partial matches. The indeterminacy is between binding, when the meaning of a word comes from something previously mentioned, and accommodation, when a reference to something new is encountered. For example, in *If John buys a car, the young man checks the motor first*, the *young man* is indeterminate between binding to *John* or accommodating as referring to a different person; in addition, *the motor* is a bridging reference because there is no explicit link between the motor and the car it is a part of. A questionnaire study confirms the partial match hypothesis but finds no differences between bridges and explicit descriptions in terms of this type of anaphoric ambiguity.

## Crossing Bridges in Discourse Representation

### Introduction

Everyday language is riddled with open questions for linguists. For instance, in the preceding sentence, how did you, the reader, know that *open* was meant as *unsolved* rather than *clear and unobstructed* (e.g. open land)? How did you know the questions are pertinent to linguists instead of having been created for the benefit of linguists (e.g. “linguistics textbooks are written for linguists” — here *for* means *for the benefit of*). These are cases of lexical and structural ambiguity. The word *these* in the last sentence is also ambiguous, in a sense: It refers to something previously mentioned, but which thing?

The first aspect of the problem this thesis is concerned with is anaphoric indeterminacy. Anaphors are words that refer to something previously established in the discourse, its antecedent. In the previous paragraph, *these* is an anaphor that referred to the linguistic examples that were mentioned before it. Anaphors constitute pronouns (he, she, etc.), reflexives (themselves, each other), and sometimes demonstratives (these, those) and noun phrases (NPs). Anaphoric indeterminacy is when an anaphor can refer to more than one thing. For example: *John and Bill went to the store. He bought a lot.* The type of indeterminacy I consider is between binding, when the meaning of one word comes from something previously mentioned, and accommodation, when a reference to something new is encountered. In the first example below, *the new teacher* has a bound reading (it binds to the first reference to a teacher), while in the second it has an

accommodated reading.

- (1) We just hired a new teacher. The new teacher hasn't arrived yet.
- (2) The students are waiting. The new teacher hasn't arrived yet.

The second aspect of the problem is bridging references, roughly defined as when a definite description does not anaphorically refer back to something in the discourse, yet still has some unsaid link to the discourse (see Clark, 1977). Consider:

- (3) We won by default. The game was canceled.

The game was never mentioned before the second sentence, but there is an unsaid link between *the game* and *won*, namely that *the game* refers to the same game that *won* refers to. The game isn't an anaphor in a conventional sense, but there is an anaphoric sense in which it is interpreted. It is thought, then, that bridging makes anaphoric resolution more difficult. Though we don't notice it in everyday speech, Vieira and Teufel (1997) found that 20 percent of definite descriptions (a class of noun phrases) in a small corpus they chose were bridging references.

For the purposes of this thesis, I will refer to NPs that have an unsaid link to something in the discourse as bridging references. The unsaid link will be the bridge. Because bridges are implicit, I will use "explicit" to denote some uses of NPs that introduce new references not using bridging descriptions. For instance, *We won by default. The game that we won was canceled.* is the explicit counterpart to (3). I will also use the term conditional, as a noun, which refers to *if ... then ...* constructions.

The question I set out to answer is whether anaphoric indeterminacy works any differently when bridging references are involved, as opposed to when relations between anaphors and antecedents are explicit. Because bridges are implied, I

hypothesized that they would be more likely to generate indeterminacy than equivalent explicit conditions. To test this, I asked 24 participants, via questionnaire, to give their intuitions about a set of short discourses. Their responses were expected to indicate differences in the degree of bind/accommodate indeterminacy in the questions. The primary variable in the discourses was whether the discourse contained a bridging (implicit) link or an explicit link. The cause of indeterminacy was also manipulated.

In the next section (Linguistic Theory), I will explain the linguistic background and motivation for the design of the study. The design is based on a particular theory of discourse representation and noun phrase interpretation (van der Sandt, 1992) and on particular hypotheses about indeterminacy in anaphor resolution (Krahmer & van Deemter, 1998). Then I will outline the design of the study (Experimental Design), including the experimental procedure and the specific hypotheses. In Results, I present the results of the questionnaire. Finally, in the Discussion section, I will tie up loose ends and bring together my new view of bridging references.

### **Linguistic Theory**

This section builds up to the theory behind the experiment. It is a lot of theory for a seemingly simple experiment yet it all went into how the experiment was designed. The experiment is based on bind/accommodate indeterminacy which is derived from presupposition theory. But, noun phrases, rather than presuppositions, are the overt components of bridging references considered here, so a theory connecting the two is presented.

*Presuppositions*

Presuppositions are the first stop on the trail of linguistic building blocks. Though there is no single definition of presupposition that linguists all agree upon, there are constructions that uncontroversially exemplify the notion. These classic examples are stated by Beaver (1997):

- (4) Have you stopped beating your wife?
- (5) The King of France is not bald.

These two sentences presuppose that the listener *was beating his wife* and that *there is a unique king of France*, respectively. If both parties in the conversation of (4) knew that the listener was not beating his wife, the sentence would be awkward. The listener might ask, “What do you mean?” Presuppositions must be generally known, or agreed upon, or somehow previously established in the conversation for their use to be appropriate.

Contrast (4) and (5) with:

- (6) I heard you are beating your wife like a rented mule.
- (7) France has a bald King.

If it had not been established in conversation or generally known that France has a king, (7) would be less problematic than (5). If the listener thought it generally known to be false, his reaction would be different. He wouldn’t be confused, but rather would think the speaker is mistaken — “You’re wrong,” he would say — or perhaps think he himself is mistaken. (4) and (5) make the indicated presuppositions, while (6) and (7) do not.

The hallmark of presuppositions is that even when negating or otherwise modifying a sentence, they can continue to be entailed when the non-presupposed

*assertions* of the sentence are not. For instance,

(8) I told you that Palmer Hall is now the campus center.

(9) I didn't tell you that Palmer Hall is now the campus center.

(10) I knew that Palmer Hall is now the campus center.

(11) I didn't know that Palmer Hall is now the campus center.

*Know that* causes the fact following it to be presupposed, so in both (10) and (11) *Palmer Hall is the new campus center* is entailed by uttering the sentence. It must be true, regardless of whether "I" know it. *Tell . . . that* is not a presupposition trigger, so although the proposition might be entailed by (8), once (8) is negated into (9) it is definitely not entailed. In (9) it need not be the case that Palmer Hall is the new campus center.

Beaver (1997) listed eleven categories of constructions that cause presuppositions, including the following: *the thing* presupposes the existence of *thing* (definite NPs), *his thing* presupposes he has a *thing* (possessives), *know that some fact* presupposes *somefact* is true (factive verbs), and *he stopped verb-ing* presupposes that he had been *verb-ing* (temporal modifiers). (The other categories were quantificational NPs, clefts, wh-questions, counterfactual conditionals, intonational stress, categorical restrictions, iterative adverbs, and others.) He summarized an initial formal definition of presupposition relevant to these examples: A presupposes P if and only if A entails P, and not-A entails P (in a trivalent logic where A and P are either true, false, or unknown for any given world). Going back to the above examples, both (10) and its negation (11) entail that Palmer Hall is now the campus center. Beaver provided several other more complex definitions, which are beyond the scope of this paper.

The discussion above about Palmer Hall leads naturally to the problem of projection: When are the presuppositions of the parts of a sentence inherited by the whole sentence? Consider these sentences adapted from Beaver:

(12) If whoever discovered the elliptic form of the planetary orbits died in misery, then his misery changed the world.

(13) Somebody died in misery.

(14) Somebody discovered the elliptic form of the planetary orbits.

Which of (13) and (14) are entailed by (12)? That is, from (12), can one conclude either of (13) or (14)? *His misery* presupposes someone's misery, and it could only have been satisfied if (13) is true. But, it is not entailed by (12). Only (14) is entailed by the sentence. (13) seems to be true only within the consequent of the conditional (the consequent is what follows the *then* in an if ... then ...).

Before we can understand projection, a framework for discourse representation is needed.

### *Discourse Representation Theory (DRT)*

DRT attempts to explain how sentences in a discourse form a context that shapes the interpretation of future sentences in the discourse (van Eijck & Kamp, 1997). A simple example from van Eijck and Kamp shows why this is necessary:

(15) A man entered. He smiled.

In (15), *he* binds to *a man*, its antecedent. Without the context of the first sentence, *he* would not bind to anything and could have any referent. The presence of the first sentence provides a context for the second that causes the binding to occur. The mind must retain some information about the context.

The goal of DRT is to specify how the mind represents the context of a

discourse. A simplistic DRT might say that the mind keeps a list of all nouns mentioned, so that when anaphora appear later the mind can search the list for the most appropriate antecedent. But a discourse involves more than just maintaining a list. One must also remember all of the facts asserted about the nouns. Instead of a list, picture a series of buckets, one for each noun mentioned. Each time a fact is asserted about a noun, the fact is tossed into the appropriate bucket.

The buckets below represent a combination of some of the above sentences.

Bucket Discourse Representation

king of France	man	wife
is bald	entered smiled	is the wife of man

A problem has already arisen: How can buckets refer to each other? In the buckets above, the *wife* bucket says that it is the wife of the man. If there were two buckets for men, the bucket representation would not be able to specify which man the wife is the wife of — even if it were perfectly clear in the discourse. Instead of labeling each bucket with what it refers to, I will label the buckets with “reference markers” (as in van Eijck & Kamp, 1997) which will be letters that refer to the thing the bucket represents. The bucket structure would now be written as:

Revised Bucket Discourse Representation

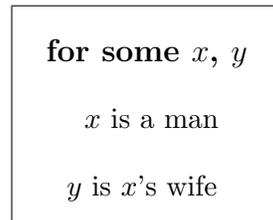
$x$	$y$	$z$
$x$ is king of France	$y$ is a man	$z$ is the wife of $y$
$x$ is bald	$y$ smiled, entered	

For reasons I will return to later, the revised bucket discourse representation is not sufficient for representing real discourses. I will follow the model of van Eijck

and Kamp (1997), which can be summarized as follows. 1) Propositions about a reference marker must be within the box (bucket) that defines the reference marker. Thus,  $z$  is the wife of  $y$  would be an illegal construction because it is not within the  $y$  box. 2) Boxes can contain other boxes.

To express the existence of a man and his wife, we would create a discourse representation structure (DRS) as follows:

#### Discourse Representation Structure



For simplicity, I have collapsed the  $x$  and  $y$  boxes into one, rather than nesting one in the other.

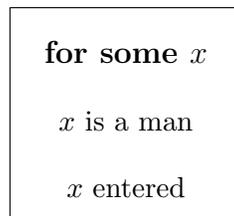
DRT needs to not only specify how the structure of a discourse is represented at any given point in the discourse, but also how the DRS came to be that way.

Let's take the discourse (15) sentence by sentence:

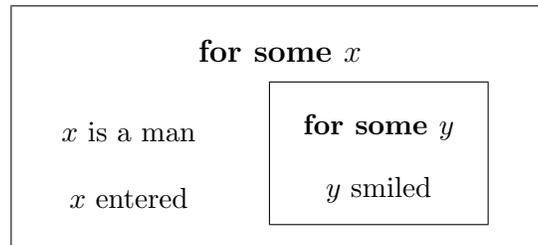
(16) A man entered.

(17) He smiled.

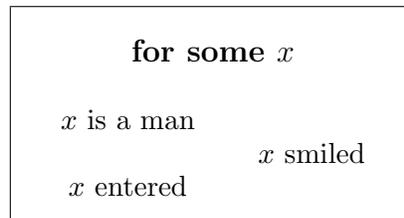
The DRS starts off empty, without any boxes or reference markers. When (16) is read, a new box is created for the NP (*a man*), and the relevant facts about the man are entered into the box:



When the next sentence is read, again a new box will be created for the NP (*He*) and the relevant facts will be entered into the box. But, this time, the box will be created within the most recently created box. This yields:



*He*, being an anaphor, must refer to something previously established, i.e. a reference marker already in the DRS. In this case, it is “bound” to its antecedent *a man* by equating  $y$  with  $x$ . Equating the reference markers means replacing all occurrences of  $y$  with  $x$  and removing the definition of  $y$ :

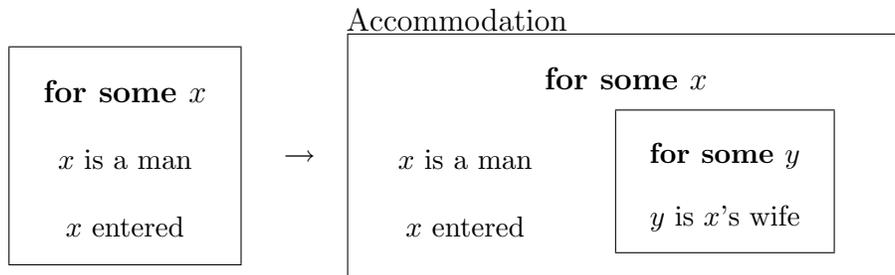


Note that anaphors can only bind to antecedents that have scope over them. An anaphor not contained in the box of an antecedent cannot bind to that antecedent.

DRT helps us to understand how anaphors are bound to their antecedents. In addition to binding, there is a second DRS operation: accommodation. When something not in the DRS is encountered, it is accommodated — that is, it is added into the DRS as a new reference marker. In (16), the reference marker for *a man* was accommodated, yielding  $x$ , because it had not been seen before. Now consider this:

(18) A man entered. The man’s wife smiled.

*The man's wife* is accommodated with the procedure diagrammed below. It is accommodated and not bound because no reference marker in the DRS (only *a man* at this point) is suitable for being a wife. Just as with binding, a new box is drawn for the new NP within the last box created and the relevant facts are entered into the box. The reference marker is not equated with any other reference marker, so the box is left as it is.



Because *y*'s box is contained within *x*'s box, statements in *y*'s box can pertain to both *y* and *x* without violating the first rule that statements about a reference marker must be within the reference marker's box.

DRT also helps us to understand why certain pronoun uses are valid and others are not. This can be seen by how DRT may explain the difference in grammaticality of these two examples (from van Eijck & Kamp, 1997):

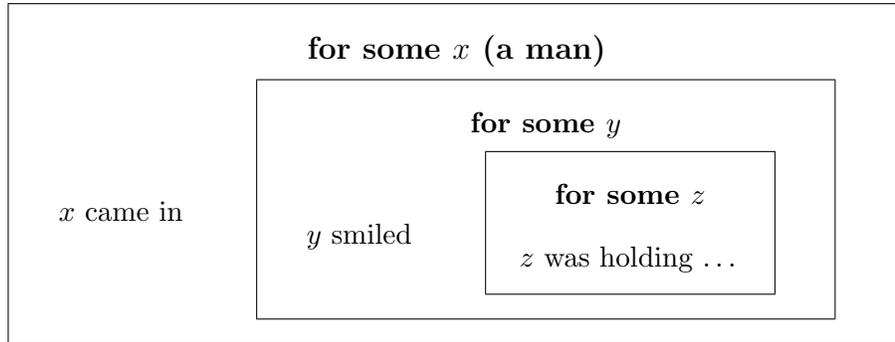
(19) A man came in. He smiled. He was holding a flower in his right hand.

(20) If a man came in, he smiled. He was holding a flower in his right hand.

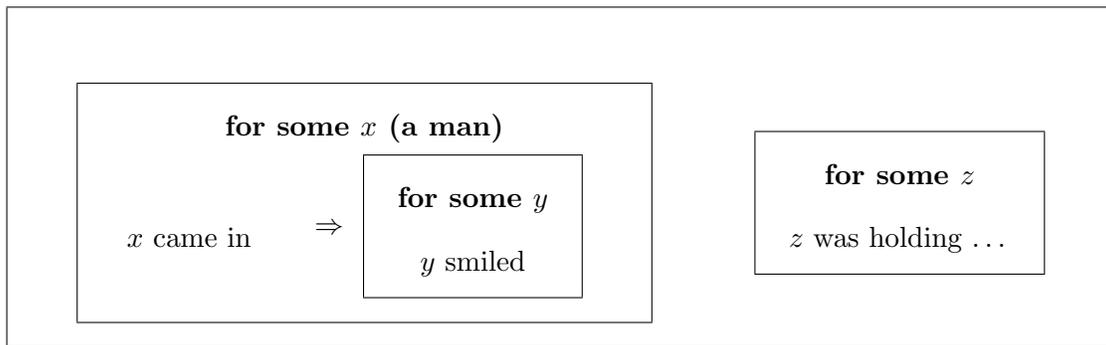
For these examples, only the readings where the two *he*'s both refer to *the man* is important. Example (19) is grammatical while (20) is not because *he* in the second sentence is unable to bind to *a man*. DRT can give a reason based on the rule that an antecedent can only be bound by anaphors within its scope. If the DRS's for

(19) and (20) are as follows, then the ungrammaticality of (20) is explained (van Eijck & Kamp, 1997).

Example (19) Proposed DRS



Example (20) Proposed DRS



In the first DRS,  $z$  can bind to  $y$  because the box that contains  $y$  contains  $z$ , and  $y$  can similarly bind to  $x$ . (So, the three nouns can refer to the same individual.) But in the second,  $z$  is outside of the box containing either  $x$  or  $y$ , and so it cannot bind to either and share their meaning. Putting aside the question of why the two DRSs are different, the evidence here indicates anaphor resolution may be just an aspect of DRT.

Linguists that support this “dynamic” perspective on discourse representation (dynamic because the DRS is constantly being updated) have put forward rule sets

that attempt to explain how a sentence  $S$  affects the discourse representation structure  $C$  such that  $C$  is transformed into a new discourse representation having all of  $C$ 's old information as well as the information contained in  $S$  as interpreted with respect to  $C$ . This leads to two paths away from conventional semantics. On the first path, two DRSs may have the same truth condition yet differ in how they change with regard to new context-changing sentences. (Consider the differences between *someone did not smile* and *not everyone smiled*, which are logically equivalent. Only the first can be followed with *he was angry*.) On the second path, sentences are not represented in terms of their truth conditions but instead in terms of how they change the discourse context (van Eijck & Kamp, 1997).

Despite its usefulness, DRT is lacking from a psychological perspective. DRT does not specify how errors in a DRS are corrected with new information. For instance, if a DRS box is learned to be false (e.g. if someone outright says “what I just said was false”), there must be a way to remove the box from the DRS or else enclose it within a conditional. No such way exists through binding and accommodation. DRS also cannot contain logically incompatible propositions, but people can (e.g. I believe myself to be less than six feet tall but more than 3 meters; P. N. Johnson-Laird, personal communication, April 12, 2004). van der Sandt (1992) requires that accommodation not violate the logical consistency of the DRS. Despite these shortcomings, I assume DRT to be a close approximation to how discourse context is mentally represented.

### *Merging Presuppositions and DRT*

Previously I stated that possessives are presupposition triggers. *The man's wife* in (18) should presuppose the existence of the wife of that man. Her existence

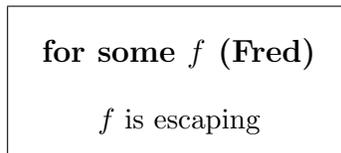
is not established in the conversation (the presupposition fails), yet the sentence is perfectly understandable. In fact, it is precisely because her existence was not established that DRT and anaphor resolution make use of accommodation.

Beaver (1997) explains the acceptability of failed presuppositions as a process called initially “tacit extension” and later named accommodation. Like anaphors in DRT, when a presupposition has not been established, the listener “accommodates” the presupposition by treating it as if it had been established. Given the similarity, perhaps DRT can also shed light on presupposition projection.

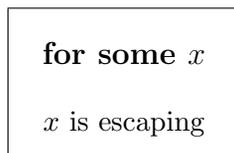
(21) Fred is escaping, but Mary doesn’t realize that somebody is escaping.

(Beaver, 1997)

The DRS of (21) up to the comma looks like the diagram below. (I have a reference marker for Fred because he might be a character in a hypothetical situation. In this case, the box that defines Fred represents the scope in which his character was introduced. If Fred is a real person mutually known by both parties in the discourse, the box would instead be representing global scope, the box that contains all of the reference markers in the listener’s general knowledge.)



The rest of the sentence is integrated into the DRS within the scope of  $f$ , but the presupposition triggered by *realize that* (that *somebody is escaping*) must be satisfied. For it to be satisfied, we say the presupposition must be either bound — matched up with something in the DRS and then discarded — or accommodated — inserted as a new proposition within the DRS (van der Sandt, 1992). The presupposition is represented by

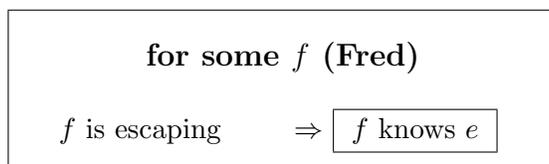


which can be matched up with what is in the DRS by replacing  $x$  with  $f$ . Since it matches, it is bound to its counterpart in the DRS, and the box is thrown out. The presupposition is satisfied.

Accommodation is a more interesting story.

(22) If Fred is escaping, then he will know that the escape route is closed.

The DRS of (22) just before accommodating the presupposition will look like



where  $e$  represents *the escape route is closed* and  $\Rightarrow$  indicates the conditional. The DRS is incomplete, however:  $e$  is not defined anywhere, and because  $e$  is presupposed by *know*, it must be bound or accommodated. There is nothing similar for it to bind to, so it must be accommodated.

There is actually more than one place in the DRS where the proposition could accommodate. It can be entered into any box that has scope over the box where the proposition is made, and since a box can be nested within many boxes, there can be many such boxes. The proposition in the above example is made in the inside box (simplistically, it was the last box created before the proposition was made). There are three boxes in the diagram that contain the proposition, and thus three locations for accommodation: It can accommodate within the scope of the consequent (after the *then* in an *if ... then ...*; the inner box), within the scope of the antecedent of

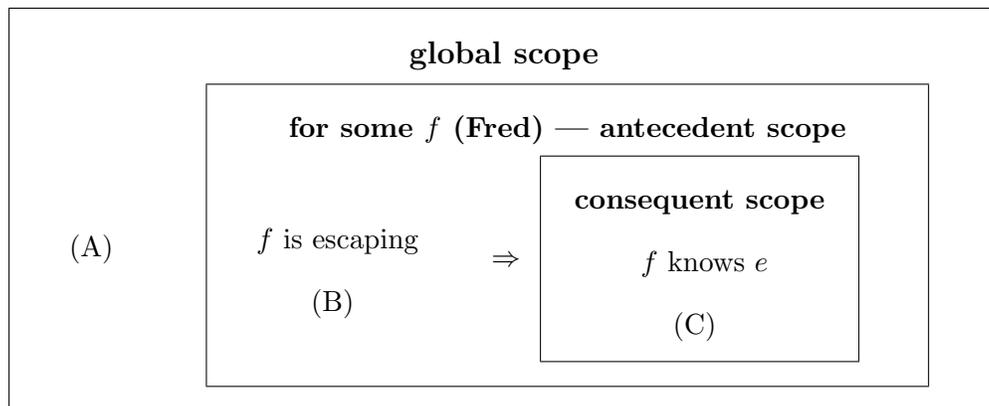
the conditional (what falls between the *if* and *then*; the outer box), or outside of the conditional in global scope (outside of the outer box). Each has a different meaning:

- (23) If Fred is escaping, then the escape route is closed and he will know it.
- (24) If Fred is escaping and the escape route is closed, then he will know it.
- (25) The escape route is closed. If Fred is escaping, then he will know it.

In the first, which represents accommodation in consequent scope, whether the escape route is closed depends on whether Fred is escaping. In the second, which is antecedent scope, Fred’s escaping and whether the route is closed are independent but variable. In the third, the escape route is accommodated in global scope, and it is without question closed.

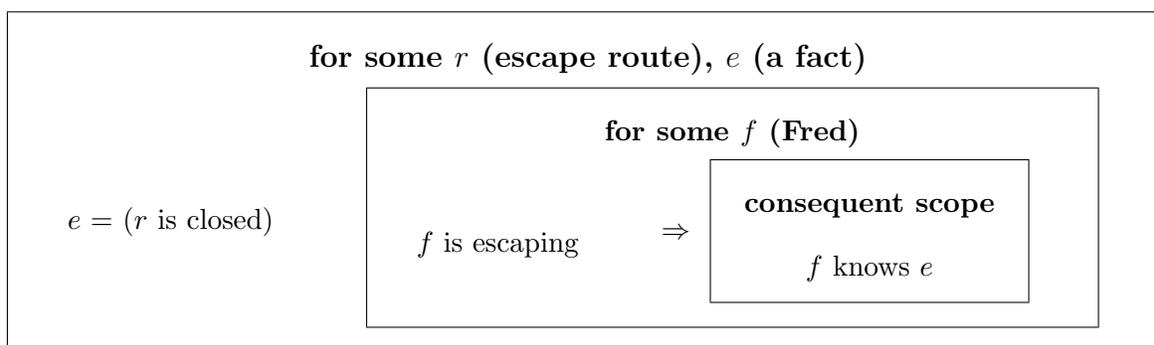
Note that I replaced the presupposition with the anaphor *it* and reinserted the presupposition where it is to be accommodated. It is an interesting parallel that the anaphor *it* can bind to the presupposed statement here in the same way that the original presupposition could be accommodated in that position.

The three possible accommodation sites for the reference marker *e* are indicated in the following diagram as (A), (B), and (C). (A box for global scope has been drawn around the original diagram.)



Van der Sandt (1992) claims the widest scope possible is chosen for

accommodation (here it is global scope, or example (25)). This should match the reader's intuitions that (22)'s meaning is closest to (25). With  $e$  defined, the DRS is:



Are the DRT rules that explain anaphor resolution the same rules that explain presupposition projection? Van der Sandt (1992) was the first to point out that problems of anaphor resolution are parallel to problems of presupposition projection.

(26) If John owns a donkey, he beats it.

(27) If John owns a donkey, he beats his donkey.

(26) is a classic problem for pronoun resolution. The semantic conundrum came down to a problem of scope. A conditional statement is classically expressed as [antecedent]  $\rightarrow$  [consequent], with brackets indicating scope. Brackets here are similar to boxes: Variables defined in one pair of brackets cannot be seen from outside of the brackets. (26) would be represented as  $[x=\text{John}; [x \text{ owns a donkey}] \rightarrow [x \text{ beats } y] ]$ , with John moved to global scope because it is assumed he is an already established referent in the conversation. Still,  $y$  needs to be defined somewhere. It can be defined in one of two places: 1)  $[x=\text{John}; [x \text{ owns } y (y = \text{a donkey})] \rightarrow [x \text{ beats } y] ]$ , or 2)  $[x=\text{John}; y = \text{a donkey}; [x \text{ owns } y] \rightarrow [x \text{ beats } y] ]$ . The first case violates the condition that anaphors can only be bound within their scope.  $y$  is defined in one set of brackets and bound in another. In the second case,

the semantic meaning of the sentence has changed. Bringing  $y$  into global scope means the sentence is about one particular donkey that hypothetical farmers might own, or the sentence is about all donkeys in the world. Neither captures the exact meaning for (26). This case of anaphor resolution had baffled linguists because there was no way to represent the sentence logically and preserve its meaning (Chierchia & McConnell-Ginet, 2001).

If the pronoun is replaced with a presupposition, as in (27), then the problem changes from anaphor resolution to presupposition resolution. *His donkey* presupposes a donkey and similarly must bind to *a donkey*. And like an anaphor, a presupposition can only bind to antecedents that it is in the scope of. The scope problem for anaphors above would cause the same problem for presuppositions.

DRT solves this problem because we can put one scope within another. By putting the consequent within the scope of the antecedent rather than beside it (as in the diagrams above), the problem of scope goes away. Using DRT here would solve the classic donkey anaphora problems because the anaphor would be in the scope of *a donkey*. This is why the bucket discourse representation structure could not hold water: buckets (or boxes) need to nest. If DRT can explain NP presuppositions as well as pronoun resolution, maybe the two are one and the same (van der Sandt, 1992).

Van der Sandt (1992) proposed that all presuppositions are anaphoric at the level of discourse representation. Presupposition triggers must be bound to an accessible antecedent in the DRS, just like pronouns, or accommodated. NP presuppositions differ from pronominal anaphora only in that they contain descriptive content that allows them to accommodate.

There is another parallel between anaphora and presuppositions, which will be the foundation of the experiment in this thesis. Like anaphora, presuppositions may be indeterminate.

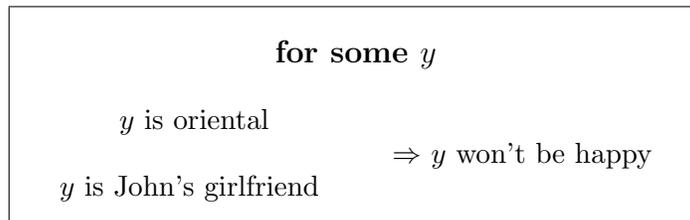
(28) John met James for lunch. He was late.

The anaphor is indeterminate in what its antecedent is. Presuppositions can be indeterminate in a different way: between a binding or accommodation reading. Is its antecedent already in context, or does it accommodate as a new representation?

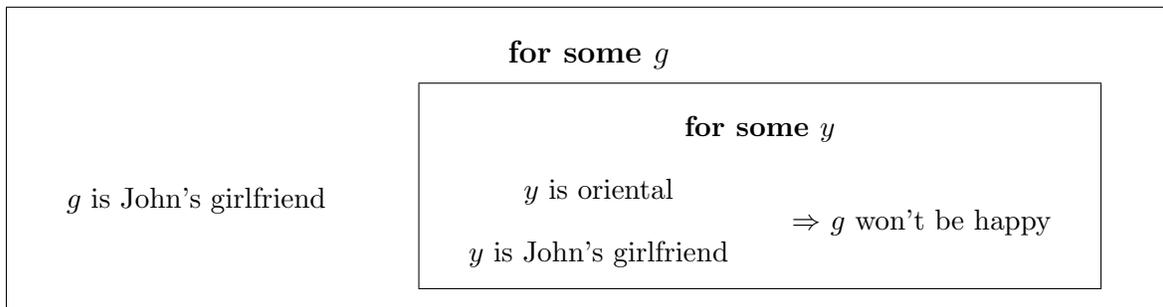
(29) If John has an oriental girlfriend, his girlfriend won't be happy. (van der Sandt, 1992)

There is a true indeterminacy in (29) between *his girlfriend* referring to *an oriental girlfriend* or a different girlfriend. Here are the two DRSs:

Example (29) - Bound Reading



Example (29) - Accommodated Reading



Van der Sandt does not predict an indeterminacy using his model of binding and accommodation (so says Krahmer & van Deemter, 1998) because he rank orders

possible interpretations. Binding is always preferred over accommodation, and anaphors are always bound to the nearest antecedent (in terms of scope) if possible. Otherwise, accommodation takes place at the highest scope that is consistent (van der Sandt, 1992). Example (29) would always be read with the bound interpretation because binding is possible, and this is contrary to our intuition.

We can now use the terms anaphor and NP presupposition almost interchangeably. Both operate through the same two DRS operations binding and accommodation.

#### *Widening the Scope of Presupposition Theory*

I have shown how definite descriptions (e.g. *the man*) and possessives (e.g. *his wife*) are presupposing and anaphoric. Such simple descriptions behave according to van der Sandt's (1992) theory. Krahmer and van Deemter (1998) say all kinds of NPs can be anaphoric, including for instance indefinite descriptions (*a man*) that are accented. But they found a problem when they investigated imperfect anaphor/antecedent relations: partial matches cause indeterminacy.

Returning to (29) (repeated below), why is it truly indeterminate? Here are four sentences from Krahmer and van Deemter (1998) that show that the binding/accommodation preference is not fixed.

**(30)** If John has an oriental girlfriend, his girlfriend won't be happy. (29)

**(31)** If John has sons, his young children will be spoiled.

**(32)** If Fido catches a cat, the cat must be old.

**(33)** If John has a girlfriend, his oriental girlfriend won't be happy.

Binding is possible in all four cases, according to DRT, so one should expect them all to have bound readings (i.e. the girlfriend *is* the oriental girlfriend and the sons

are the young children). But, in fact (30) and (31) are indeterminate and in (33) accommodation is strongly preferred. What makes these sentences behave this way is how well the antecedent and anaphor match. There are four conditions:

- Exact match: Only when the anaphor and antecedent exactly match is binding preferred (*a cat/the cat* in (32)).
- Antecedent more informative: When the antecedent is strictly more informative than the anaphor, there is a true indeterminacy. Neither binding nor accommodation is preferred over the other (*oriental girlfriend/girlfriend* in (30)).
- Incompatible: When the antecedent and anaphor are incompatible in so far as neither's description semantically implies the other, there is indeterminacy (*sons, young children* in (31)).
- Anaphor more informative: When the anaphor is strictly more informative than the antecedent, accommodation is strongly preferred (*girlfriend/oriental girlfriend* in (33)).

There are two exceptions to these conditions. The conditions do not hold for pronouns because, as the theory goes, pronouns lack sufficient descriptive content to accommodate so there could only be a binding reading. In addition, when the anaphor refers to a subgroup of its antecedent, binding is not ruled out. For example: *The farmer owns cows. The mad cows are kept over there.* Although *mad cows* is more informative than *cows*, the extra information is used to pick out a subset of the cows and so may not introduce an indeterminacy.

### *Bridging*

Noun phrases that refer back to something in the DRS but are not themselves already in the DRS involve bridging. Here are two examples:

(34) Yesterday an M.P. was killed. The murderer got away. (van Eijck & Kamp, 1997)

(35) If John buys a car, he checks the motor first. (Piwek & Krahmer, 2000)

In (34), *the murderer* has not been mentioned before, but it refers back to the murdered M.P. The “bridge” is that *the murderer* is the perpetrator of the killing of that particular M.P. Similarly in (35), the motor isn’t just an arbitrary motor with no connection to anything else. One knows it is the motor of *John’s car*, although the connection was never stated.

Bridging is the process in the listener’s mind of solving the puzzle of what the speaker intended as the connection between an anaphor and its context (Clark, 1977). In the car/motor example, the speaker intended a connection between the anaphor, the motor, and an anchor in context, the car, and the connection (the bridge) was that it is the motor of that car. For Clark the anaphors were “given” information, what we now call presuppositions. Based on the theory presented so far, Clark’s definitions apply equally to all anaphoric NPs as to presuppositions.

Clark found four broad categories of bridges. Direct reference is when an anaphor refers directly to something mentioned. Though this can involve implications, it is not a type of bridging considered here. Indirect reference by association involves standard relationships between the anchor and anaphor, such as a part-whole relation (*I looked into the room. The ceiling was very high. The bridge is that a ceiling is a part of a room.*). Indirect reference by characterization involves roles played in a situation being described (*John was murdered. The murderer got away. The bridge is that murder involves a murderer.*). Causes/consequences involves a rhetorical relation between two propositions (*John had a suit on. It was*

*Jane he hoped to impress.* The bridge is that John’s dressing up was a consequence of his desire to impress.). The variability in types of bridges shows how ubiquitous they are in language.

There are two factors, Clark says, the listener considers when solving the problem: “What bridge can [the listener] construct (1) that the speaker could plausibly have expected him to be able to construct and (2) that the speaker could plausibly have intended?” (p 413) Effort and plausibility constraints (Piwek & Krahmer, 2000) help decide which possible bridge to use.

Bridging poses a problem for DRT: Is *the murderer* bound or accommodated? It cannot be bound, as an antecedent does not exist in the DRS, and it cannot merely be accommodated because that would not establish a connection between the new reference marker and something in context.

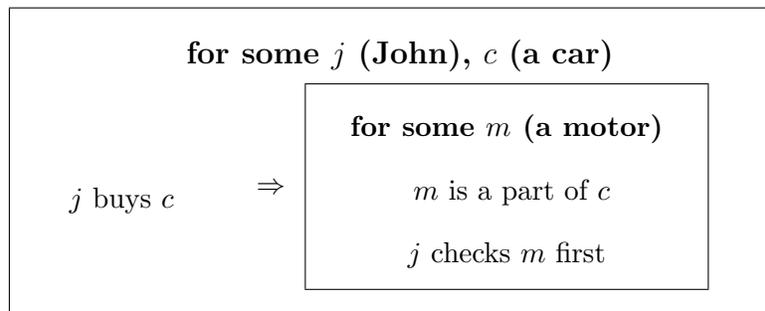
Piwek and Krahmer (2000) present three classical approaches to bridging. In the abduction account, mutually known logical steps can become bridges. That is, if  $P$  is known, and  $(P \text{ and } R) \rightarrow Q$  is mutually known, then if  $Q$  is presupposed (and not already established), accommodate  $R$  and  $Q$ . Applying this to (35):  $Q = \textit{the car has a motor}$ ;  $P = \textit{it's a car}$ ; and  $(P \text{ and } \textit{cars have motors}) \rightarrow Q$  are both mutually known; so, *cars have motors* may be accommodated. This is a dubious account, as it does not explain how *cars have motors* was chosen over other possible explanations, and furthermore it is not clear how this would integrate with the specific instances of a car and a motor in a DRS.

The two other positions summarized by Piwek and Krahmer (2000) are that bridging is a lexical phenomenon, where anaphors match up with antecedents based on the properties of their head nouns (similar to Clark’s direct references), and that

bridges result from rhetorical structure (similar to Clark's causes/consequences). Though Piwek and Krahmer push these positions aside, they are important components of bridging references that I've presented.

*The locus of bridging in DRS*

For (35), the car/motor sentence, we want a theory that generates a DRS that looks something like this:



What's new about this model is the presence of *m is a part of c*, which I hypothesize the listener assumes as he accommodates the new reference marker *m*. As in the earlier examples of accommodation, *m* could have accommodated at three places: within the consequent of the conditional (as it is in the diagram above), in the antecedent of the conditional (below *j buys c*), or in global scope. Without any further theory we would expect the motor to accommodate at the highest possible level (in global scope) resulting in a meaning equivalent to:

(36) There is some motor. If John buys a car, he checks that motor first.

This sentence does not mean the same as (35). If we build on it by then adding the bridge, we would expect to see the first example below, where the bridge, too, is accommodated at the highest possible level it can (in the scope of the antecedent of the conditional because it refers to *c* and must be in its scope). The sentence continues to have the wrong meaning. There are five possible DRS's for

each possible accommodation site of *the motor* and *m is a part of c*, which have meanings equivalent to

- There is a motor. If J buys a car and that motor is in the car, he checks it.
- There is a motor. If J buys a car, that motor is in the car and he checks it.
- If J buys a car and there is a motor in the car, he checks it.
- If J buys a car and there is a motor, the motor is in the car and he checks it.
- If J buys a car, there is a motor in the car and he checks it.

The third is close but not quite the right meaning because if John buys a car, it may not be the case that he checks anything — namely if the car lacks a motor.

The last one seems most reasonable to be what was meant. Instead of accommodating the anaphor and bridge at the highest scopes, both are accommodated at the lowest possible levels. We need a revised theory that explains why bridging does not take place at the highest possible level.

If we replace the bridge with an explicit account of the motor, we should arrive at the same meaning.

(37) If John buys a car, he checks *its motor* first.

The motor must still be accommodated within the scope of the consequent to prevent the possibility that John buys a car (without a motor) and doesn't check anything. This is very similar to an example from van der Sandt (1992):

(38) If John has children, he will regret that all of his children are bald.

in which *all of his children are bald* is to be accommodated. It cannot accommodate in global scope, because that would be beyond the scope of the antecedent of *his children*. So, van der Sandt says, its landing site is in the antecedent of the conditional, which I believe to be wrong.

My explanation for the site of accommodation is two-fold. First, a hypothesis: The NP and the bridge must be accommodated at the same level of scope because it is a defining quality of the NP that it has the property contained in the bridge. In the first, second, and fourth interpretations above, the motor may or may not be the car's motor. This does not agree with intuition. Wherever in the DRS the motor exists, so does the bridge.

Secondly, I fall back on van der Sandt's rule that accommodation be consistent *and also* not violate certain pragmatic rules. (One such rule, for example, was that every update to the DRS should provide some new piece of information.) We can extend this to say that if an accommodation lands in a conditional, the new conditional must entail the old conditional. This is pragmatically reasonable: The overt message should not be changed by the covert workings of the DRS. Such a rule would properly exclude all but the second and last interpretations above. This leaves us with just the last interpretation, which should match the reader's intuitions.

This last rule is equivalent to the following: Propositions accommodated into the antecedent of a conditional must have already been entailed by it.

There is one other possible interpretation of (35):

(39) John only buys cars with motors. If John buys a car and it has a motor, he checks it first.

In this case, the motor may accommodate into the scope van der Sandt (1992) predicts because a second implicature is accommodated in global scope that causes the bridge to be entailed by the antecedent. Whether the anaphor accommodates into antecedent scope with a global-scope implicature or alone into consequent scope is a topic for future research.

*Predictions*

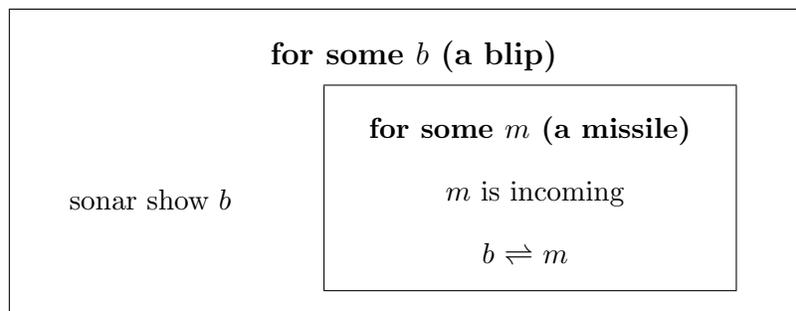
The goal of the research presented here was to give an experimental perspective on the accommodated propositions, like *the car has a motor*, that allow bridging to occur. I hypothesized that discourses involving bridging would be more ambiguous than comparable discourses without bridging, and I tested this under several conditions of how well the anaphor matched its antecedent.

**Experimental Design**

The focus of this research is on the effects of partial matches (how well an anaphor matches its antecedent) on bridges, the implied link between something in the DRS and an anaphor. In the car/motor example, the implicit proposition is that the car has a motor. How is the implicit proposition different from an equivalent explicit proposition? This experiment made use of the partial match predictions of Krahmer and van Deemter (1998) (i.e. exact match, antecedent/anaphor more informative, incompatible match) to peer into the workings of implied propositions.

An example will help. Let us build the DRS for the following short discourse.

(40) The sonar shows a blip. The missile is incoming.



What is the relation between the blip and the missile? This bridge is represented in the DRS above as  $b \rightleftharpoons m$ . Based on Clark's (1977) categories, it

might be a direct reference — the missile and the blip are the same thing — or a part/whole relation — the blip is a physical part of the missile — or something else entirely. In this case, it is something along the lines of the blip representing the missile. I leave it as a symbol because we don't have any direct knowledge of what it actually is. Now the speaker continues:

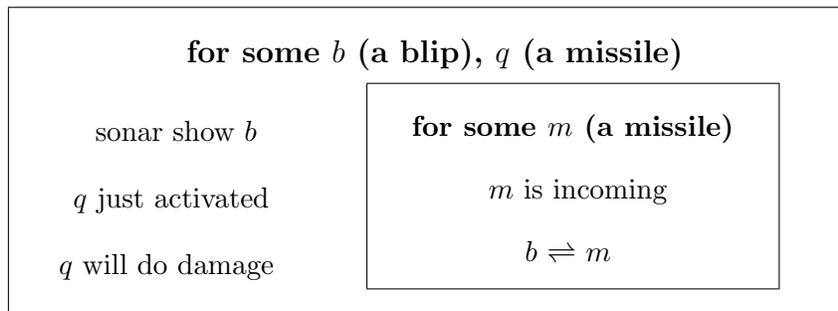
(41) The missile that was just activated will do a lot of damage if it hits.

The definite noun phrase presupposes the existence of a *missile that was just activated*:

Presupposition	Potential Antecedent
<p><b>for some <math>q</math> (a missile)</b></p> <p><math>q</math> just activated</p>	<p><b>for some <math>m</math> (a missile)</b></p> <p><math>b \rightleftharpoons m</math></p>

The presupposition is satisfied if either 1) a suitable missile antecedent is found in context for  $q$  to bind to, or else 2)  $q$  is accommodated. One possible antecedent for  $q$  is  $m$ . They match in so far as they both are missiles. However, the information associated with each reference marker is not necessarily the same, depending on what the bridge is. (That  $m$  is incoming is left out because partial match relations supposedly only involve a comparison with the noun phrase that introduced the antecedent.) Krahmer and van Deemter (1998) come into the picture. If  $b \rightleftharpoons m$  is standing in for  $q$  *just activated*, then binding will be preferred because the anaphor exactly matches its antecedent. If  $b \rightleftharpoons m$  is standing in for something more informative than  $q$  *just activated*, then there will be a true indeterminacy. If  $b \rightleftharpoons m$  and  $q$  *just activated* are logically unrelated to each other, there will also be an indeterminacy. Finally, if  $q$  *just activated* is more informative than  $b \rightleftharpoons m$ , then the presupposition will accommodate.

Practically speaking, the difference between the binding and accommodation readings is whether the discourse mentions one or two missiles. One missile means it had the bound reading; two missiles accommodation. Asking naive readers whether the discourse is talking about one or two missiles tells us about the implied relation between  $b$  and  $m$ . If someone reads the short story and concludes there were two missiles, then accommodation must have occurred, resulting in a DRS that looks like:



The questions examined next are whether the partial match effect will show up reliably in an experiment, and whether the partial match effect interacts with the nature of the description of the antecedent. For instance, if the bridge  $b \rightleftharpoons m$  were stated explicitly (what I liberally call an “explicit bridge”), would this change the effect of a partial match? Here is how I found the answers to these questions . . .

### *Procedure*

Subjects were administered questionnaires comprising 24 short texts, each followed by a question. Each subject was explained the nature of the questionnaire before participating. After returning the questionnaire, subjects were debriefed verbally and were given a debriefing handout.

Participants took the questionnaires in small groups, generally three at a time. They were verbally instructed to go with their intuitions on the questions and not



bridge (the explicit condition). There were three types of anaphor/antecedent matches: exact match, partial match, and change of bridge. The study is effectively a 2x3 design.

The exact match condition is when the last reference to the *thing* matches exactly with the information known about the previous reference to it. Krahmer and van Deemter (1998) would predict a bound reading. The partial match condition is when the last reference to the *thing* is not an exact match with what is known about it, for which Krahmer and van Deemter would predict a bind/accommodate ambiguity. The change of bridge condition is a mix between the two. The last reference to the *thing* is the same as in the partial match condition, but a sentence is inserted into the narration that changes the bridge into something else. An example is given in the next section. Change of bridge questions were expected to lessen the inconsistency introduced by partial matches.

Responses to the questions would indicate the degree of bind/accommodate ambiguity in the narrations. Circling 1 would indicate a bound reading, circling 2 would indicate an accommodated reading, and circling a point in the middle would indicate a degree of ambiguity.

The narrations were drawn from four topic areas to show the generalization of the hypotheses over different concepts and lexical choices. Each topic area contained 12 questions; the questions were constructed in parallel, such that the  $n$ th question across the four topic areas would be equivalent in terms of its values for the two independent variables. The  $12 \times 4 = 48$  questions were rotated over the first half of the 24 participants' questionnaires so that each question appeared more than once but not for the same participant, and so that the same topic area was not presented

for two consecutive questions on any participant's questionnaire. Each participant's questionnaire rotated through the four topic areas, and the order of rotation was permuted among the participants. Finally, the order of presentation of the 12 question types was divided into three blocks, and the order of presentation of the blocks was permuted among the participants. The second 12 questions on each questionnaire came from the same set of 48 questions but were all from two of the four topic areas. They were less randomized.

Here are four sample questions, each from a different topic area. The first two examples are parallel questions from two topic areas. All twelve question types are presented in the next section with examples from one topic area so the reader may easily make comparisons.

(42) Our inframagneto sensor shows a blip. The missile is incoming. The missile that was just activated will do a lot of damage if it hits. — How many missiles are in the short story?

(43) The dog dug into the ground. He found the rock. The red rock was heavy. — How many rocks are in the short story?

(44) The history teacher called on the student. The student in the class was unprepared. — How many students are in the short story?

(45) We went to the movies and saw a movie with an evil man. I don't usually go to the movies, but I made an exception. The villain was unstoppable. The villain in the movie was so evil. — How many villains are in the short story?

Missiles, rocks, students, and villains were the four topic areas. The twelve question types, along with the hypotheses made for each question, were as follows.

*Hypotheses*

Questions three through eight occupy the positions in the 2x3 design shown in the table below. Questions 1 and 2 were included to test the validity of the survey. Questions nine through twelve are not presented in detail in this thesis. They tested whether an intervening sentence would affect bind/accommodate ambiguity. No interesting results were found, so they are not discussed further.

	Exact Match	Partial Match	Change of Bridge
Implicit	Q3	Q5	Q6
Explicit	Q4	Q7	Q8

## The Questions

1. *Mismatch*. This question was present to find an upper bound on responses. The narration contains two mentions of the thing, the second of which (the anaphor) provides contradictory information to the first (the antecedent). Contradictory information should cause an accommodated reading, which should cause participants to choose high responses. (ex: *He found the rock. The unfound rock was heavy.* “Unfound” contradicts “found.”)

2. *More Informative*. This question was present to determine what score a genuine indeterminacy would cause. There are two mentions of the thing, the second of which provides more information than the first. A more informative anaphor should yield accommodation and a score close to 2. (ex: *He found the rock. The rock in the ground was heavy.* “In the ground” is extra information.)

3. *Implicit, Exact Match.* This question is minimally different from question 2 in that it has an introductory sentence, introducing a bridge between something in the intro text and the first reference of the thing. The hypothesis is that the bridge entails the second description of the thing (the description was chosen according to the hypothesized bridge). That description is no longer more informative than its antecedent but instead is an exact match. Exact matches should result in binding: a score of close to 1. (ex: [*The dog dug into the ground.*] *He found the rock. The rock in the ground was heavy.* Brackets here and below indicate the minimal difference. The bridge is hypothesized to be “the rock is in the ground.”)

4. *Explicit, Exact Match.* This question is minimally different from question 3 in that its intro text includes enough information to render the bridge of question 3 explicit. The hypothesis that “explicit bridges” should be less indeterminate than “implicit bridges” suggests a score closer to 1 than for question 3. (ex: *The dog dug into the ground [where a rock would be found]. He found the rock. The rock in the ground was heavy.* “Where a rock would be found” makes a bridge unnecessary because the antecedent of the first reference is actually stated in the intro text.)

5. *Implicit, Partial Match.* This question is minimally different from question 3 in that the second reference to the thing is inconsistent with the hypothesized bridge, instead of being an exact match. Inconsistent references should result in true indeterminacy: a score larger than that of question 3 (which should be an unambiguous exact match). (ex: *The dog dug into the ground. He found the rock. The [red] rock was heavy.* “Red” is inconsistent with the bridge “the rock is in the ground” but more informative than its antecedent “the rock.”)

6. *Implicit, Change of Bridge.* This question is minimally different from question 5 in that an intervening sentence between the two references changes the nature of the bridge such that the description inconsistent in 5 is now consistent with the bridge (how this should operate in the DRS is explained in the discussion section). If the second reference is an exact match, the indeterminacy in 5 should disappear. The second reference is now slightly less informative than the bridge, however, so the hypothesis is that the score is less than that of question 5 but more than a somewhat-comparable exact match situation (question 3). (ex: *The dog dug into the ground. He found the rock. [This ground only has red rocks.] The red rock was heavy.* The bridge is roughly “the rock is in the ground and is red,” which entails and is more informative than “red rock.”)

7. *Explicit, Partial Match.* This question has both a partial match and an explicit bridge. The addition of an inconsistent match from question 4 should cause a more accommodated reading (closer to 2) than question 4. The hypothesis that explicit bridges should be less indeterminate than implicit bridges suggests a score closer to 1 than for question 5. (ex: *The dog dug into the ground [where a rock would be found]. He found the rock. The [red] rock was heavy.*)

8. *Explicit, Change of Bridge.* This question has both an explicit bridge and a change of bridge. The hypothesis that explicit bridges should be less indeterminate than implicit bridges suggests a score closer to 1 than for question 6. Because of the change from partial match to change of bridge from question 7, the score for this question should be less than that of question 7 but more than a comparable exact match situation (question 3). (ex: *The dog dug into the ground [where a rock would be found]. He found the rock. [This ground only has red rocks.] The red rock was*

*heavy.*)

## Results

Participants' responses were recorded on a scale from 1, representing one instance of the thing, to 8, representing two instances of the thing. Table 1 shows the frequency distribution of responses on this scale, over the 24 participants and 12 question types ( $N = 24 \times 12 = 288$ ); only the first half of the questionnaires are considered. The mean response was 3.07 (SD 2.66), and the median was 2. The distribution was heavily skewed to the left, with half of all responses being 1. Choices 2 and 8 were the next most likely to be chosen, each with 1/4th the frequency of 1.

Table 1 - Distribution of Responses (N=288)

Participants' Responses on the 8-Point Scale								
Response	1	2	3	4	5	6	7	8
Frequency	143	34	15	14	13	14	16	39

The mean response and standard deviation for each question type is reported in Table 2, again for the first half of the questionnaires. With standard deviations between 1.5 and 3, the means are all fairly close together. Though most of the predictions trivially came true, it remains to be seen whether any results are statistically significant.

Table 2 - Mean (S.D.) Responses by Question Type (N=24)

Question 1	6.50 (2.41)		
Question 2	2.58 (2.08)		
	Exact Match	Partial Match	Change of Bridge
Implicit	2.25 (2.05)	4.46 (2.81)	2.75 (2.69)
Explicit	2.17 (2.24)	4.08 (2.90)	2.83 (2.46)

The second 12 questions of the questionnaires were added to allow for more within-subjects comparisons between questions of the same topic area than could be done with just the first half. Surprisingly, the within-subjects means were not any more informative than the results presented below in which the topic area varies. They are not considered further.

#### *Effect of Partial Match*

I predicted that exact match cases would have lower scores than their change of bridge counterparts, which should in turn have lower scores than their partial match counterparts. One 2-way comparison and ( $Q4 < Q7$ ) two 3-way comparisons ( $Q3 < Q6 < Q5$ ,  $Q3 < Q8 < Q7$ ) were predicted in the hypotheses section (almost following the block design). The 2-way comparison was tested with the Wilcoxon signed ranks test. For this test, the subjects are matched but the topic areas are not. For  $Q4 < Q7$  (means: 2.17, 4.08, respectively),  $T^+ = 143$ ,  $p(N=18) < .0062$  (one-tailed; large sample variance not corrected for ties). The 3-way comparisons were tested using the Page test for ordered alternatives. For  $Q3 < Q6 < Q5$  (means: 2.25, 2.75, 4.46),  $L = 304$ ,  $p(N=24; k=3) < .0104$ . For  $Q3 < Q8 < Q7$  (means: 2.25, 2.83, 4.08),  $L = 307.5$ ,  $p(N=24; k=3) < .0025$ . In all cases, the null hypothesis is

rejected at  $\alpha = .05$ . There is a main effect for partial matches.

As a result of the  $Q4 < Q7$  comparison, I can conclude that partial matches lead to higher scores in an “explicit bridge” case. The  $Q3 < Q6 < Q5$  comparison indicates that, as suspected, with implicit bridges, partial matches also lead to higher scores, and also that the change of bridge could lessen the inconsistency caused by an implicit bridge. The  $Q3 < Q8 < Q7$  comparison shows the same effect with explicit bridges.

#### *Effect of Implicit vs. Explicit Bridge*

I predicted that there should be a main effect that discourses with explicit bridges should have lower scores than their counterparts with implicit bridges ( $Q4 < Q3$ ,  $Q7 < Q5$ ,  $Q8 < Q6$ ). These comparisons exactly follow the block design. First, the  $24 \times 3 = 72$  responses for implicit bridge questions (mean 3.15) were compared to the 72 responses for the explicit bridge questions (mean 3.03). The Wilcoxon-Mann-Whitney test was used to compare these independent groups:  $W = 5062$ ,  $p < 0.53$ . The null hypothesis cannot be rejected, so no conclusion is yet made about this hypothesis.

Better statistical power might be found in comparing questions to their minimally different counterparts: testing the three pair-wise comparisons above. The Wilcoxon-Mann-Whitney test did not fair any better in this regard. The Wilcoxon test was then used: The question pairs were taken to be matched in that they were each taken by the same participant, and (except for the first comparison) the pairs were drawn from the same topic area. For  $Q4 < Q3$  (means: 2.17, 2.25, respectively),  $T^+ = 42.5$ ,  $p(N=13) < 1$ . For  $Q7 < Q5$  (means: 4.08, 4.46, respectively),  $T^+ = 44.5$ ,  $p(N=13) < 1$ . For  $Q8 < Q6$  (means: 2.83, 2.75,

respectively), the means in neither the between-subjects nor the within-subjects comparisons supported the hypothesis, so further analysis is not required. In no case was the null hypothesis, that  $Q3 = Q4$ ,  $Q5 = Q7$ , and  $Q6 = Q8$ , rejected. There is no reason to believe explicit bridges have lower scores than their implicit counterparts.

### *Topic Areas*

Subjects did not have characteristically different responses to each of the four topic areas. The Friedman two-way analysis of variance by ranks was employed over the set of questions, with questions matched by question type (number) across the topic areas. The null hypothesis is that the population medians for the four topic areas are all the same.  $F = 4.43$ , which is not greater than the critical value ( $N=12$ ;  $k=4$ ;  $\alpha = .05$ ) 7.82. The null hypothesis is not rejected, so the contents of the questions did not have a significant effect on the responses.

The mean responses for each actual question (32 questions: the 8 question types over the 4 topic areas), limited to the questions asked in the first half of each questionnaire, are listed in a table in the appendix. Each question appeared six times. Though the Friedman test above did not show a significant difference, so any oddities could have occurred by chance, the third topic area (students) had a mean score (4.08) peculiarly larger than the others (2.65, 2.92, 2.64). For questions 4, 7, and 12, that topic's mean (4.00, 7.17, 5.17) was much higher than the others (averages: 1.56, 3.06, 1.34). These questions will be given a closer look in the discussion section.

There may have been individual defective questions, but statistically the topic areas do not appear to be characteristically different.

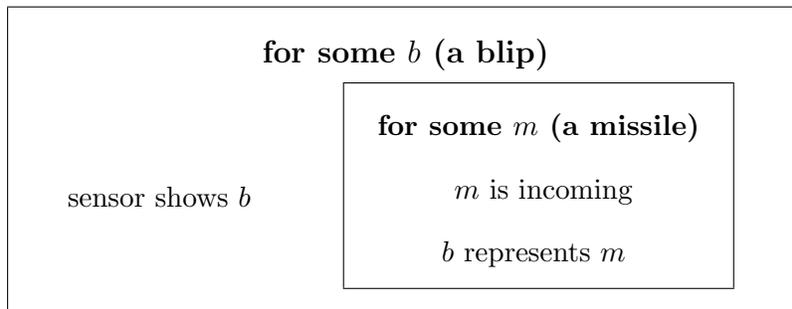
**Discussion**

*Representing the hypotheses in DRS*

At the beginning of the section on experimental design, I showed how a bridge fits into discourse representation and how the bridge might cause a partial match indeterminacy. Some of the hypotheses came straightforwardly from the example, but when I presented question 6, the change of bridge, I promised a full explanation. Question 6 built upon question 5, which I will now present in detail, using the missiles topic area. Below is question 5, followed by the hypothesized DRS.

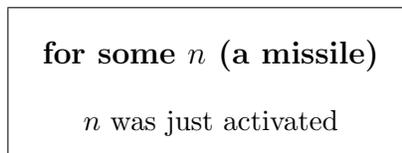
(46) Our inframagneto sensor shows a blip. The missile is incoming. The missile that was just activated will do a lot of damage if it hits. (Q5)

Question 5 DRS



The following is the presupposition:

Question 5 Presupposition

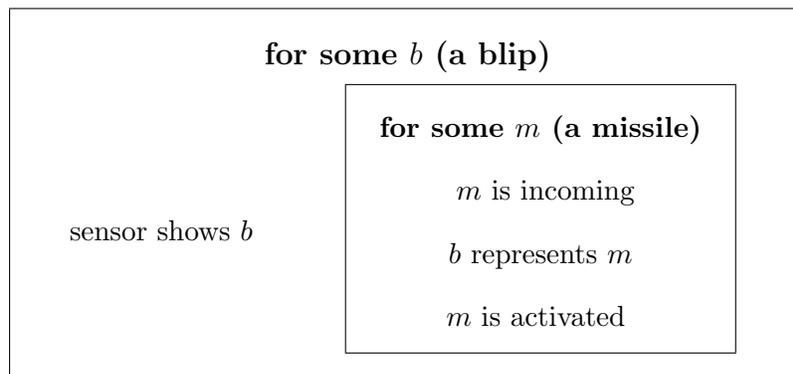


The presupposition box must be bound or accommodated. If it is bound to  $m$  by equating  $n$  with  $m$ , there is a partial match situation:  $b$  represents  $m$  does not

match  $n/m$  *just activated*. The partial match results in a bind/accommodate indeterminacy, which we found in the experiment. Question 6 is hypothesized to work as follows:

(47) Our inframagneto sensor shows a blip. The missile is incoming. Blips appear when missiles are activated. The missile that was just activated will do a lot of damage if it hits.

Question 6 DRS



Now the presupposition  $n/m$  *just activated* is more similar to the first reference of the missile ( $b$  represents  $m$  and  $m$  is activated). The indeterminacy is supposed to lessen, which it did. Partial match relations should only be affected by the noun phrases that introduce the antecedent and anaphor, yet here a sentence that does not refer to either affected the relation. Either partial match relations involve all available the knowledge about the antecedent and anaphor, or else the information in the change of bridge affected the actual bridge that was integrated earlier and bridges are able to affect partial match relations. This remains an open question.

*Variation in topic areas*

One topic area had three questions that elicited markedly (but not statistically) higher responses from its parallel questions in the other topic areas. In

retrospect, it is clear these questions were not truly parallel. Question 7, the partial match + explicit bridge question, should have elicited a relatively high score.

Question 7 from the students topic area had twice the score of the corresponding rocks topic question. For the students question, participants were forced to make a comparison between a student who was called on by a teacher (the antecedent) and a student who had just walked in (the anaphor). For the rocks question, participants compared a rock found in the ground to a red rock. Without a doubt, the two cases are different. In the first, our mental schema that describes the activity in classrooms says that students that are called on are sitting in their chairs, not walking into the room. The descriptions are not compatible, resulting in a bias away from binding, toward accommodating. In the second, a rock's being red is perfectly compatible with it being found in the ground. Thus, there is no reason to avoid binding the references. The difference between the two cases seems to have more to do with our preconceptions of things than the structural relations between the antecedent and anaphor, which Krahmer and van Deemter (1998) do not precisely account for.

### *Answered Questions*

I set out to answer two questions. The first was whether Krahmer and van Deemter's (1998) partial match predictions would hold up in an experiment. I have shown that they do. The question types that involved an exact match between antecedent and anaphor resulted in scores at the binding-side of the spectrum and the question types involving a partial match resulted in scores significantly higher, indicating accommodation was more preferred.

This was the case for both explicit descriptions and bridging references, which

is not an obvious result of Krahmer and van Deemter's (1998) proposal. Krahmer and van Deemter believed a partial match is determined by comparing an anaphor to the phrase in which the potential antecedent was introduced. Partial matches result only if the actual description of the antecedent when it was introduced is not exactly how the anaphor is phrased, as opposed to comparing the anaphor with all knowledge about the antecedent. Bridges, being unsaid, are not obviously a part of the introduction of an antecedent. I have shown that anaphors can be in partial match relations with antecedents who are described, in part, by implicit bridges.

Krahmer and van Deemter (1998) also raised the question of whether there is an interaction between partial matches and bridging. This was the second question I hoped to answer. I found no interactions under a variety of partial match conditions: Simple partial matches, partial matches with changes of bridge, and inserted sentences (from the set of questions I did not present here) had no significant difference in effect between implicit bridges and explicit descriptions.

### *What's Missing*

Cataphors and verb phrase presuppositions were not given much attention in this thesis, though they are important cases of anaphora. Cataphors are anaphors whose antecedents occur after the anaphor. They come up in constructions like *After he read, the poet left the stage.*, where the anaphor, *he*, precedes its antecedent, *the poet*. Cataphors are a problem for DRT if sentences are integrated into the DRS part-by-part, as I have been doing. At the time when the phrase containing the cataphor (*after he left*) is integrated into the DRS, the cataphor has no suitable antecedent in the DRS, so it cannot be bound. As a pronoun, it also cannot be accommodated. The sentence is expected to have no valid interpretation,

but it does. Because it is a large open problem, cataphors were not considered here.

I also did not spend much time on verb phrase presuppositions. These are presuppositions of propositions, such as *you were beating your wife*, rather than of the existence of something, as in *his wife*. I showed how presupposed propositions are handled by DRT in the cases of *someone escaped* and *the escape route is closed*. But, I did not investigate the partial match effect on these types of presuppositions, which would have made an interesting experiment.

### *Hindsight, Future Direction*

In hindsight, it is less surprising that implicit bridges and explicit descriptions are not different. If bridges were any less informative or any more indeterminate than their explicit counterparts, then we, language users, would be less likely to use bridges so promiscuously in speech. We use bridges in exactly the cases when we think our listener will understand what we meant, and, as a listener, we know that if we figure out the bridge, then that is what the speaker meant. If we know what the speaker meant, there's no reason to penalize the message just because it wasn't said overtly.

More interesting interactions might be found where partial matches and bridges come in contact with the difficult cases of presupposition projection: in conditionals, around plural nouns, and within quantifications. These cases might help answer the question of the locus of bridging I raised earlier: Can propositions accommodate into the antecedents of conditionals, or do bridges in conditionals come along with globally accommodated general knowledge? A questionnaire study using the same bind/accommodate indeterminacy technique could be used to tackle these questions.

Early in this thesis I showed how two seemingly unrelated aspects of linguistics — anaphor resolution and presuppositions — can be unified under one model of discourse representation theory. Then I conducted an experiment with the hypothesis that explicit descriptions are different from implicit descriptions. Bridges could not be distinguished from explicit descriptions in this study, and that says something about how linguists should approach the problem. Rather than assuming bridging is different from accommodation and binding, we should be investigating how they are the same. We should seek the solution to the bridging problem in a unified account of anaphor resolution in DRT.

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## Appendix A

### Topic Areas

The following information is enough to reconstruct the eight questions in each topic area, based on the descriptions of the question types in the Experimental Design section.

#### *Topic A - Missiles*

Question 1: “The missile is incoming. The outgoing missile will do a lot of damage if it hits.” Question 2’s extra info is “missile on sonar.” Intro text is “Our inframagneto sensor shows a blip.” The second reference changes starting at question 3 to “The missile represented by the blip will do a lot of damage if it hits.” Explicit bridge: “a blip that represents a missile.” Partial match: “the missile that was just activated.” Change of bridge: “Blips appear when missiles are activated.” The hypothesized bridge was “The blip represents the missile.”

#### *Topic B - Rocks*

Question 1: “He found the rock. The unfound rock was heavy.” Question 2’s extra info is “rock in the ground.” Intro text is “The dog dug into the ground.” Explicit bridge: “the ground where a rock would be found.” Partial match: “red rock.” Change of bridge: “This ground only has red rocks. ” The hypothesized bridge was “The rock was found in the ground.”

*Topic C - Students*

Question 1: “The history teacher called on the student. The science student was unprepared.” Question 2’s extra info is “the student in the class.” Intro text is “The principal was observing the class.” Explicit bridge: “which had many students.” Partial match: “the student who had just walked in.” Change of bridge: “The student had just been in the hall.” The hypothesized bridge was “The student is in the class.”

*Topic D - Villains*

Question 1: “The villain was unstoppable. The easy villain was so evil.” Question 2’s extra info is “the villain in the movie.” Intro text is “We went to the movies.” Explicit bridge: “and saw a movie with an evil man.” Partial match: “the villain we saw last night.” Change of bridge: “We watched a scary movie last night, but the movie we saw today was a romance.” The hypothesized bridge was “The villain was in the movie.”

## Appendix B

### Mean Responses for Questions in Each Topic Area

The mean responses for the first eight question in the four topic areas are presented below. The average is the mean response for all twelve questions in the topic area.

Mean Response by Question and Topic (N=6)				
Question	Missiles	Rocks	Students	Villains
1	6.50	7.33	6.33	5.83
2	1.83	2.33	2.67	3.50
3	1.67	1.83	3.33	2.17
4	1.00	1.50	4.00	2.17
5	3.83	4.67	6.50	2.83
6	1.83	4.33	1.67	3.17
7	4.17	2.83	7.17	2.17
8	2.00	2.00	4.67	2.67
Average	2.65	2.92	4.08	2.64

## **Appendix C**

### **Honor Pledge**

I pledge my honor that this paper represents my own work in accordance with University regulations: