

Description Formation and Discourse Model Synthesis

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1. Introduction

Many researchers in linguistics, psychology, philosophy and artificial intelligence have recently begun to abandon a purely linguistic approach to **definite anaphora** <*2> in favor of a notion of reference into some kind of **model** of the discourse, cf. Karttunen [1976], Levin & Goldman [1978], Lyons [1978]. Stenning [1975]. My own research on definite anaphora (cf. Webber [1978a&b]) follows this approach, in particular making the following five assumptions:

1. One objective of discourse is to enable a speaker to communicate to a listener a **model** s/he has of some situation. Thus the ensuing discourse is, on one level, an attempt by the speaker to direct the listener in synthesizing a similar model.
2. Such a **discourse model** can be viewed as a structured collection of entities, organized by the roles they fill with respect to one another, the relations they participate in, etc.
3. The function of a **definite anaphoric expression** is to refer to an entity in the speaker's discourse model (DM_S). <*3> In using a definite anaphor, the speaker assumes (a) that on the basis of the discourse thus far, a **similar** entity

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<*2>. Although I will soon explain what I mean precisely by "definite anaphora", the term basically denotes a **function** that some types of syntactic expressions can serve. Expressions which can function as definite anaphors include definite pronouns and definite descriptions. Other roles that definite pronouns and descriptions can fill are discussed in Geach [1962], Partee [1972], Norman & Rumelhart [1975] and Webber [1978a].

<*3>. A similar assumption is made by Karttunen [1976], Levin & Goldman [1978], Lyons [1978] and Stenning [1975].

will be in the listener's model (DM_L) as well and (b) that the listener will be able to access that entity via the given definite description or definite pronoun.

4. The referent of a definite anaphor is thus an entity in DM_S , which the speaker presumes to have a counterpart in DM_L . Discourse entities may have the properties of individuals, sets, events, actions, states, facts, beliefs, hypotheses, properties, generic classes, typical set members, stuff, specific quantities of stuff, etc.
5. In deciding which discourse entity a definite anaphor refers to, a listener's judgments stem in part from how the entities in DM_L are **described**. (When a discourse entity E is the referent of a definite anaphor A , one might distinguish that description of E conveyed to the listener by the immediately preceding text and consider it A 's **antecedent**.)

The point of making these assumptions explicit is to stress that insofar as reasoning about discourse entities is mediated by their descriptions, discourse entity descriptions are critical to anaphor resolution.

Now one consequence of these assumptions about discourse models and reference is that the task of understanding definite anaphora can be decomposed into several complementary parts:

1. deciding whether a definite pronoun or definite description is truly anaphoric (i.e., is intended to refer to some entity presumed to already be in DM_L) or whether the term fills some other role in the discourse;
2. synthesizing a discourse model which is similar to that of the speaker and inhabited by similar discourse entities;

- 3. constraining the possible referents of a given anaphoric expression down to one possible choice - the "anaphor resolution" problem;
- 4. determining what other functions a definite description is intended to fill besides enabling the listener to construct or get to its referent.

While I cannot hope in this short paper to cover even one of these four sub-tasks, what I shall try to do is illustrate how the explicit data - i.e., the actual sentences of the discourse, produced by a particular person (or a particular computer program) in a particular situation - provide material for the model synthesis process. In particular, I shall show (1) how indefinite noun phrases are associated with the evocation of new discourse entities, independently of any higher-level expectations, and (2) how those new discourse entities will initially be described. I will claim that such an initial description (ID) is critical to both model synthesis and anaphor resolution since it allows the listener to reason appropriately about the discourse entity in order to assign it to an appropriate role vis-a-vis his or her higher-level expectations. <*4> Moreover, since it is possible for a discourse entity's current role assignment to be found incorrect, it is the entity's ID that allows it to be re-assigned to another role with respect to the listener's revised expectations.

In Section 2 I will consider indefinite noun phrases vis-a-vis the discourse entities they evoke and how those entities are described. I will contrast them briefly with non-anaphoric definite noun phrases and then show that all determined noun phrases, including odd ones like "few orc eggs", "many lemon gum balls", etc. pattern after either definites or indefinites vis-a-vis the discourse entities they evoke and how those entities can be described. In Section 3 I will show how this approach to definite anaphora in terms of discourse entities and their descriptions can accommodate certain problematic cases of anaphoric reference that have been discussed in the linguistics and philosophic literatures - the famous "donkey" sentence (cf. Bartsch [1976], Edmundson [1976], Hintikka & Carlson [1977]) and the problem of reference in disjunctive contexts (cf. Karttunen [1977]). Finally, to show that it is not

<*4>. From different points of view, discussions of the relationship between the explicit text and higher-level organizing structures can be found in Collins, Brown & Larkin [1977] and Webber [1978b].

just definite and indefinite noun phrases that can evoke entities in the listener's discourse model, I will illustrate in Section 4 an example of deictically-evoked entities and comment on the problem of describing them appropriately.

2. Indefinite Noun Phrases and Discourse Entities

Except after a copula, indefinite noun phrases <*5> may evoke a new discourse entity into a listener's discourse model. <*6> What I want to focus on here is appropriate IDs for them. Consider the following sentences.

- 1a. Wendy bought a yellow T-shirt that Bruce had liked.
- b. It cost twenty dollars.
- 2a. Each third-grade girl brought a pelican to Wendy's house.
- b. She is roosting them on her front lawn.
- 3a. If Bruce manages to catch a fish, he will eat it for dinner.
- 4a. John didn't marry a Swedish woman.
- b. She was Norwegian.
- 5a. Whether Bruce buys a mini-computer or an Advent TV,
- b. he will have to do the repairs on it himself.
- 6. Every man who owns a donkey beats it.

I claimed earlier that the initial description (ID) of a newly-evoked discourse entity is critical for both model synthesis and anaphor resolution, since the ID mediates all reasoning about the entity until its assignment to some role within the model. An entity's ID should imply neither more nor less about it than is appropriate. Now consider what an appropriate description would be for the discourse entity that "it" refers to in sentence 1b. It is not "the yellow T-shirt that Bruce had liked", since sentence 1a. can be uttered truthfully even if Bruce had liked several yellow T-shirts (and both speaker and listener were aware of that fact). Nor is it "the yellow T-shirt that Bruce had liked and that Wendy bought", since sentence 1a. can

<*5>. I will often refer to these as "existentials" because of their logical interpretation as existential quantifiers. <*6>. An indefinite noun phrase following a copula functions together with the copula as a predicate, e.g.

Beverly is a bargain hunter.

Bruce became a librarian.

As such, it is purely descriptive and does not refer to any particular librarian or bargain hunter, cf. Kuño [1970].

be truthfully uttered even if Wendy had bought several such T-shirts. What is an appropriate description for the referent of "it" is something like "the yellow T-shirt that Bruce had liked and that Wendy bought and that was mentioned in sentence 1a."

What I am claiming is that in the case of a singular existential that is not within the scope of either negation, a universal quantifier, a hypothetical (e.g. "if", "suppose") or one of several other special contexts (cf. Webber [1978a]), the entity it evokes will be appropriately described via a conjunction of (1) the description inherent in the noun phrase (e.g. "yellow T-shirt that Bruce had admired"); (2) a predicate that embodies the remainder of the sentence (e.g. "which Wendy bought"); and (3) a predicate that relates that entity to the utterance evoking it (e.g. "which was mentioned in (or evoked by) sentence 6a."). This is the description that I am calling the entity's "initial description" or ID. Given how I specified its components then, it should not be surprising that I will claim that the ID of an existentially-evoked discourse entity can be derived from an appropriately structured sentence-level logical representation. Such a representation is independently motivated by its use in regular inference procedures.

Using a somewhat simplified version of the formalism described in Webber [1978a], a simple rule can be stated for forming the ID of an existentially evoked discourse entity - i.e.,

(Ex:C) . $F_x \implies$
(Ez) . $z = ix: Cx \ \& \ F_x \ \& \ \text{evoke } S, x$

Here (Ex:C) is an example of restricted quantification, in which C represents an arbitrary predicate which x satisfies. F_x represents an arbitrary open sentence in which x is free; i stands for Russell's definite operator, iota; and S is the label assigned to the proposition on the left-hand side of the arrow. Informally, this rule, which I shall call [RW-1], says that if a proposition S states that there is a member x of class C which makes F_x true, then there exists an individual describable as "the C which F's which was evoked by proposition S". This individual is taken to be the discourse entity evoked by the existential noun phrase. For example, let Y stand for the predicate corresponding to "yellow T-shirt that Bruce had liked". <*7> Then sentence 1a. can be represented simply as

<*7>. I will soon be more precise about the representation of relative clause containing noun phrases. Here, where the descriptive part of the noun phrase can be treated as an unanalyzed unit, the predicate name Y is an adequate representation.

(Ex:Y) . Bought Wendy, x

Since this matches the left-hand side of the above rule, it follows that

(Ez) . $z = ix: Y x \ \& \ \text{Bought Wendy, } x$
& evoke S_{1a}, x

That is, there is an individual describable as "the yellow T-shirt that Bruce had liked, that Wendy bought and that was evoked by sentence 1a." The discourse entity so described is the referent of "it" in sentence 1b.

Examples 2-6 illustrate singular indefinite noun phrases in some of the special contexts noted above. While I will only be discussing examples 5 and 6 in this paper, notice that in all five cases, the entity evoked by the indefinite noun phrase is appropriately described by taking into account at least the three factors mentioned above. That is, in example 2 the referent of "them" can be described uniquely as "the set of pelicans, each of which, mentioned in sentence 2a., some third grade girl brought to Wendy's house." <*8> In example 3, the referent of "it" can be described as "the fish mentioned in clause 3a. that Bruce has managed to catch, if Bruce has managed to catch a fish". In example 4, the negation appears intended to scope only "Swedish". Thus the discourse entity referent of "she" can be described as "the woman mentioned in sentence 4a. that John married". (We later learn in sentence 4b. that she is Norwegian rather than Swedish.) IDs for the two other existentially-evoked discourse entities in examples 5 and 6 will be discussed in Section 3.

Notice that a definite noun phrase in the same context as an indefinite noun phrase will also evoke a discourse entity, but one whose ID is somewhat different. To see this, consider the following sentences

<*8>. A rule similar to [RW-1] is given in Webber [1978a] for existentials scoped by universals. In all, six such rules are given covering

1. independent existentials (sg/pl)
"I saw {a cat, three cats} on the stoop."
2. definite descriptions (sg/pl)
"I saw the {cat, cats} which hate Sam."
3. distributives
"Each cat on the stoop hates Sam."
"The three cats each scratched Sam."
4. universally quantified existentials
"Each boy gave each girl {a peach, three peaches}."
5. class dependent definites
"Each boy gave a woman he knew the {peach, two peaches} she wanted."
6. class dependent distributives
"Each boy I know loves every woman he meets."

- 7a. Wendy bought the yellow T-shirt that Bruce had liked.
- b. It cost twenty dollars.
- 8a. Each third grade girl has seen the pelican on Wendy's lawn.
- b. They prefer it to the plastic flamingo she had there before.
- 9a. John didn't marry the Swedish woman.
- b. He threw her over for a Welsh ecdysiast.

In each case, an appropriate description for the discourse entity evoked by the singular definite noun phrase is just that singular definite noun phrase itself "the yellow T-shirt that Bruce had liked", "the pelican on Wendy's lawn", "the Swedish woman". While it is certainly true that the definiteness of these noun phrases may be contingent on context (i.e., identifiability within the speaker's model of the underlying situation) nevertheless unlike entities evoked by indefinite noun phrases, those evoked by definites do not depend for their appropriate IDs on the particular sentences the definite noun phrases appeared in.

The same characteristic behavior of definites and indefinites discussed for singular noun phrases holds for plural noun phrases as well. That is, while both indefinite and definite plural noun phrases evoke discourse entities, the unique initial descriptions that can be assigned to those entities will differ in the two cases. To see this, consider the following example.

- 10a. I saw the guys from "Kiss" on TV today.
- b. I saw the three guys from "Kiss" on TV today.
- c. I saw all three guys from "Kiss" on TV today.
- d. I saw some guys from "Kiss" on TV today.
- e. I saw three guys from "Kiss" on TV today.
- 11. They were being interviewed by Dick Cavett.

Sentences 10a-c each contains a definite plural noun phrase. That noun phrase should evoke a discourse entity into the listener's model, one appropriately described as "the (set of) guys from 'Kiss'". This can be verified by following either of these sentences by sentence 11 and considering what is the referent of the definite pronoun "they". <*9>

<*9>. While sentences 10b&c. provide the additional information that the number of guys in "Kiss" is three [not actually true - BLW], that information is not needed in order to describe the set uniquely.

Sentences 10d&e, on the other hand, each contains an indefinite plural noun phrase. That noun phrase will evoke a discourse entity appropriately described as "the (set of) guys from 'Kiss' that I saw on TV today and that was mentioned in Sentence 10d(e)". This is because either sentence is consistent with there being other members of "Kiss" whom I didn't see on TV today, as well as other members whom I did see but whom I don't mean to include in my statement. <*10> Notice again, that the set size information provided in sentence 10e. is not necessary for describing that set uniquely. However, it too may be useful later in resolving definite anaphora.

An interesting point is that there seem to be no other patterns that English determiners follow vis-a-vis discourse entity IDs. To see this consider the following sentences.

- 12a. Few linguists smoke since they know it causes cancer.
- b. Few linguists were at the party, but they drank more than the whole Army Corps of Engineers.
- 13a. Many linguists smoke although they know it causes cancer.
- b. Not many linguists smoke since they know it causes cancer.
- c. Many linguists don't smoke since they know it causes cancer.

In sentence 12a, the referent of "they" is the discourse entity appropriately described as "(the entire set of) linguists". That is, "few <x>s" can evoke the same discourse entity as the definite noun phrase "the <x>s". However as

However, it should not be ignored, as it may be needed later in resolving a definite anaphor like "the three guys". <*10>. This latter point is a subtle one, and usage may vary from person to person. That is, some people intend an indefinite plural noun phrase contained in a sentence S "Some <x>s P" - to refer to the maximal set - i.e., "the set of <x>s which P". Other people intend it to refer to some subset of that set - "the set of <x>s which P which I (the speaker) intended to mention in sentence S". For a system to cope with this variation in usage, it would be better for procedures to derive the latter, non-maximal set description, which is always appropriate. If a system is sophisticated enough to associate a "belief space" with the speaker (cf. Cohen [1978]), other procedures can later access that belief space (if necessary or desirable) to judge whether the maximal set interpretation might have been intended. (This will again become an issue when I discuss other determiners like "many" and "several".)

sentence 12b. shows, "few <x>s" can also pattern after the indefinite plural: the referent of "they" is the entity appropriately described as "the just-mentioned set of linguists who were at the party". (We learn from "few" that this set is small or smaller than the speaker expects.)

"Many", on the other hand, seems to pattern only after the indefinite plural. In sentence 13a., the referent of "they" is appropriately described as "the just-mentioned set of linguists who smoke" (We learn from "many" that this set of linguists is large or larger than the speaker expects.) Sentence 13b. shows that the reverse polarity "not many" acts like "few" vis-a-vis evoking discourse entities: the referent of "they" is the entire set of linguists. However as sentence 13c. shows, a NEG which occurs in the sentence auxiliary does not effect this same change in behavior: "they" refers to the just-mentioned set of linguists who don't smoke.

3. Two Interesting Reference Problems

Recall that the purpose of this paper is to point out the importance of description formation to both discourse model synthesis and reference resolution and to show that this process can, to an important degree, be formalized. I have taken as given the notion that a listener is using both the discourse and his or her knowledge of the world to synthesize a model of what s/he believes to underlie the discourse. Definite anaphora are viewed as means by which the speaker refers to entities in DM_S that are presumed to have counterparts in the listener's model. What I want to show in this section is that this approach to definite anaphora can accommodate not only straight-forward cases as discussed above, but certain problematic cases as well.

3.1 Parameterized Individuals

The problem of formally characterizing the referent of "it" in examples like 6 below has often been discussed in the linguistics and philosophy literatures cf. Bartsch [1976], Edmundson [1976], Hintikka & Carlson [1977].

6. Every man who owns a donkey beats it.

The problem has been taken to be that while "it" intuitively seems related to the embedded noun phrase "a donkey", there is no way to represent this logically in terms of simple quantifier scoping. What I shall show is that an approach in terms of discourse entities and their IDs makes this intuitive relationship simple both to explain and to represent.

First notice that this problem arises independently of how the matrix noun phrase is determined.

- 14. A man I know who owns a donkey beats it.
- 15. The man who owns a donkey beats it.
- 16. Which man who owns a donkey beats it?
- 17. No man who owns a donkey beats it.

In all these examples, "it" seems intuitively related to "a donkey". Informally, one might describe its referent as "the just-mentioned donkey he owns", where "he" is bound to whatever value that "(each, a, the, which, no) man who owns a donkey" may take. But this is just a discourse entity of a rather special type - one with a parameterized ID, rather than a rigid one. I call such entities "parameterized individuals", borrowing the term from Woods & Brachman [1978]. <*11>

Notice that parameterized individuals behave somewhat differently from the "actual" discourse entities the sentences evoke. <*12> That is, parameterized individuals all have the same ID, independent of how the noun phrase containing the relative clause is determined. On the other hand, the actual discourse entities evoked by these sentences do not. For example,

- 18a. Each man who owns a donkey beats it.
it = the donkey he owns
- b. However, the donkeys are planning to get back at them.
the donkeys = the set of donkeys,
each of which some man
who owns a donkey owns
- them = the set of men, each of whom
owns a donkey
- 19a. The man I know who owns a donkey
beats it.
it = the donkey he owns
- b. But the donkey is planning to get
back at him.
the donkey = the just-mentioned
donkey that the man I
know who owns a donkey
owns
- him = the man I know who owns a
donkey
- 20a. Which man who owns a donkey beats
it?

<*11>. The phrase "parameterized individual" is being used somewhat loosely to include "parameterized" sets, stuff, etc. For example,

- (i) No man who owns two donkeys beats them.
them = the two donkeys he owns

<*12>. By "actual" discourse entities, I mean ones that can be referred to anaphorically in subsequent sentences.

- it = the donkey he owns
- "None"
- b.*Are the donkeys planning to get back at {him, them, ???}?
the donkeys = ???
- c.*Is the donkey planning to get back at {him, them, ???}?
the donkey = ???

To show that this approach to definite anaphora in terms of discourse entities and their descriptions can explicate "donkey" sentences as well, I will have to introduce a bit more of the formalism described in Webber [1978]. That bit involves an extension of restricted quantification, cf. [RW-1] above. In restricted quantification, a quantification operator (e.g. \forall, \exists), the variable of quantification and the class it ranges over (noted implicitly as a predicate) constitute a structural unit of the representation. For example, "Every boy is happy" can be represented as

$(\forall x: \text{Boy}) . \text{Happy } x$

This is truth functionally equivalent to

$(\forall x) . \text{Boy } x \Rightarrow \text{Happy } x$

Similarly "Some boy is happy" can be represented as

$(\exists x: \text{Boy}) . \text{Happy } x$

which is truth functionally equivalent to

$(\exists x) . \text{Boy } x \ \& \ \text{Happy } x$

The extension I will introduce will permit the representation of noun phrases with relative clauses as well as simple noun phrases. Semantically, a relative clause can be viewed as a predicate. One way to provide for arbitrary predicates is through the use of the abstraction operator, represented as " λ " by Hughes & Cresswell [1968], following Church [1941]. For example, the noun phrase "a peanut" can be represented as

$(\exists x: \text{Peanut})$

while the noun phrase "a peanut that Wendy gave to a gorilla" can be represented as

$(\exists x: \lambda(u: \text{Peanut})[(\exists y: \text{Gorilla}) \text{Gave Wendy}, u, y])$

In this case

$\lambda(u: \text{Peanut})[(\exists y: \text{Gorilla}) \text{Gave Wendy}, u, y]$

names a unary predicate which is true if its argument is a peanut that Wendy gave to some gorilla.

Using this notation, sentence 6 can be represented as

$(\forall x: \lambda(u: \text{Man})[(\exists y: \text{Donkey}) . \text{Own } u, y])$
Beat x, IT

By applying rule [RW-1] to the embedded clause $[(\exists y: \text{Donkey}) . \text{Own } u]$, the entity evoked by the existential can be identified as

$iy: \text{Donkey } y \ \& \ \text{Own } u, y \ \& \ \text{evoke } S_{6.1, u}$
"the just-mentioned donkey that u owns"
<*13>

As I mentioned above, the semantics of restricted quantification is such that the variable of quantification, here x , satisfies the predicate in the restriction. Thus if x satisfies $\lambda(u: \text{Man})[(\exists y: \text{Donkey}) . \text{Own } u, y]$, there must be an entity identifiable as

$iy: \text{Donkey } y \ \& \ \text{Own } x, y \ \& \ \text{evoke } S_{6.1, y}$
"the just-mentioned donkey x owns"

This is a parameterized individual - parameterized by the variable in $(\forall x: \dots)$ - that is a possible referent for "it" in the matrix sentence - i.e.,

$(\forall x: \lambda(u: \text{Man})[(\exists y: \text{Donkey}) . \text{Own } u, y])$
Beat $x, iy: \text{Donkey } y \ \& \ \text{Own } x, y$
& evoke $S_{6.1, y}$
"Every man who owns a donkey beats the just-mentioned donkey-he owns"

I noted above that a sentence like "Every man who owns a donkey beats it" could sensibly be followed by a sentence like "However, the donkeys are planning to get back at them" (cf. example 18). Given that I have shown how to account for the referent of "it" in the first sentence in terms of discourse entities and their formally derivable descriptions, can the referent of "the donkeys" be account for in the same way? <*14>

To show that it can, I need to present the rule for dealing with class dependent definite descriptions that I mentioned in footnote 8. This rule is motivated by examples such as 21, where the referent of "them" is presumably the discourse entity evoked by the noun phrase "the flower she picked", where "she" stands for the variable bound by "each girl in the class".

<*13>. In labeling each clause of a complex sentence, I use the following convention: if the matrix clause is labelled S , its leftmost embedded clause will be labelled $S.1$, the leftmost embedded clause in $S.1$ will be labelled $S.1.1$, etc.

<*14>. I shall not take the time here to discuss the path from the phrase "every man who owns a donkey" to the discourse entity informally describable as "the set of men, each of whom owns a donkey", since it is rather straightforward, cf. Webber [1978a]. This entity is a possible referent for "them" in sentence 18b.

- 21a. Each girl in the class gave Ivan the flower she picked.
- b. He arranged them artfully in an empty Glenfiddach bottle.

This is a definite noun phrase, but because of its binding to the distributively quantified noun phrase "each girl", it will evoke a discourse entity with the properties of a set rather than an individual (cf. example 8). In this case, it will be "the set of flowers, each of which was the flower that some girl in the class picked". Simplifying for brevity here, this rule can be written

$(\forall x:K) . P x, iy:C x,y \implies$
 $(\exists z) . z = \{u | (\exists x:K) . u = iy:C x,y\}$

where K represents an arbitrary unary predicate which x satisfies and both P and C represent arbitrary binary predicates. The right-hand side of this rule implies that in case the left-hand side matches some sentence, there will be a discourse entity roughly describable as "the set of u's, each of which is the thing that stands in relation C to some member of K".

Notice now that after the "it" is resolved in "Every man who owns a donkey beats it" (see above), the sentence matches the left-hand side of the above rule - i.e., "Every man who owns a donkey beats the just-mentioned donkey he owns. Thus it follows that there is a discourse entity describable as "the set of donkeys, each of which is the just-mentioned donkey that some man who owns a donkey owns" - i.e.,

$\{w | (\exists x:\lambda(u:Man) [(\exists y:Donkey) . Own u,y])$
 $w = iz: Donkey z \ \& \ Own x,z$
 $\ \& \ evoke S_{18},z\}$

This is a possible referent for "them" in sentence 18b.

3.2 Disjunction

The other class of problematic examples that I want to discuss here in terms of discourse entities and their descriptions is one I first encountered in Karttunen [1977]. Karttunen presents examples like the following.

- 22. If Wendy has a car or Bruce has a bike, it will be in the garage.
- 23. Bruce can have either a bike or a car, but he must keep it in the garage.
- 24. Either Bruce has a new car or he has borrowed his brother's. In any case, it is blocking my driveway.
- 25. Whether Bruce buys a car or his brother buys a bike, he will have to keep it in the garage.

The problem is again to determine just what it is that "it" refers to.

I see two ways of approaching this problem in terms of discourse entities and their IDs. One way holds that in each sentence, each term of the disjunction evokes a different discourse entity into DM_L , each with a different ID:

- (22) "the car that Wendy has (if she has a car)"
 "the bike that Bruce has (if he has a bike)"
- (23) "the bike that Bruce will have (if he chooses a bike)"
 "the car that Bruce will have (if he chooses a car)"
- (24) "the new car that Bruce has (if Bruce has a new car)"
 "Bruce's brother's car"
- (25) "the car Bruce will have bought (if he buys a car)"
 "the bike Bruce's brother will have bought (if Bruce's brother buys a bike)"

The truth of the disjunction (which seems in each case to be interpreted as exclusive "or") then guarantees there being one and only one entity in the model to which "it" refers. Notice that if the terms were conjoined rather than disjoined, the truth of the conjunction would imply the simultaneous existence of two entities within the model. In that case, either the referent of "it" would be ambiguous or the sentence would just be bizarre.

The other, I think nicer, way of approaching the problem holds that each sentence evokes only a single discourse entity into the model, with the indecision (i.e., the disjunction) embodied in its ID. That ID is of the form "A if P, otherwise B". For example, the entity evoked by sentence 22 would be describable as "the car that Wendy has (if she has a car) or the bike that Bruce has otherwise" that evoked by sentence 23 would be describable as "the bike that Bruce will have (if he chooses a bike) or the car that Bruce will have otherwise"; that evoked by sentence 24, as "the new car that Bruce has (if he has a new car) or Bruce's brother's car otherwise"; and that evoked by sentence 25, as "the car Bruce will have bought (if he buys a car) or the bike Bruce's brother will have bought otherwise".

One advantage to this approach is that additional properties which truthfully follow from either ID can be ascribed to the entity without committing oneself to one description or the other. This can be useful in anaphor resolution. For example, in sentence 24, the subject

of "block my driveway" must be a physical object, preferably large and somewhat mobile. This condition is satisfied by the discourse entity evoked by sentence 24, independent of which ID is appropriate.

Although there may be other ways to approach the problem of disjunction, the "donkey" problem, and the whole problem of definite reference in general, what I hope to have shown in these two sections is the robustness of an approach based on notions of a discourse model, discourse entities and their formally derived descriptions.

4. Conclusion

In arguing for the importance of description formation to both discourse model synthesis and reference resolution, I concentrated on how indefinite noun phrases evoke new entities into the listener's discourse model and how their appropriate initial descriptions (IDs) could be derived from a formal sentence-level representation of the text. There are many other ways in which discourse entities can be evoked, and many interesting problems in forming appropriate descriptions of them. I will conclude therefore with a brief discussion of deictically-evoked discourse entities and the problem of describing them appropriately.

The example comes from the children's book *Babar Loses his Crown* by Laurent de Brunhoff, and involves the following situation: Babar, King of the Elephants, decides to take his wife Celeste and his family on a trip to Paris. In packing for the trip

"Babar puts his crown in a little red bag." (p.3)

They travel by train and then by taxi to their hotel in Paris, and when they arrive

"Celeste opens all the bags. Last of all, she opens the little red one. 'Look!' she cries. 'What is this? A flute! Babar! This is not your bag!' " (p.10)

Before this point in the story, there should have been one little red bag in DM_L. Now there should be two. The first is the existentially-evoked discourse entity (say, e₄₃) - "the little red bag mentioned in sentence <x> that Babar put his crown in". However if "this" on page 10 is not that entity, then it must be some other one (say, e₄₈). How should it be described? Since "this" presumably points to the little red bag Celeste is opening, e₄₈ can appropriately be described as "the just-mentioned little red bag which Celeste is opening, which contains a flute and not Babar's crown,

and which is not equivalent to e₄₃". <*15>

The problem here is to be able to articulate clearly what each of these properties derives from since they do not come from a single sentence. In this case one must determine what things relevant to the story do or do not follow from e₄₈'s not being Babar's bag.

* * * * *

In this paper, I have tried in as brief a way as possible to reveal an aspect of understanding definite anaphora that precedes the more frequently discussed problem of "anaphor resolution". This aspect involves accounting for what it is that definite anaphors refer to and how such things become available. I moved from the notion of reference into a model to problems of how that model is synthesized, and in particular, how the entities in it are appropriately described. In this endeavor, I focused on the initial descriptions (IDs) ascribed to existentially-evoked entities, briefly touching upon deictically-evoked entities as well. This paper has just skimmed the surface of a very large problem. In particular, one must still account for, *inter alia*, reference to actions, events, processes, stuff, quantities of stuff, etc.; relativization of descriptions to the speaker's beliefs (cf. Cohen [1978], Prince [1978]); additional descriptions derived from the various roles in higher-level situations that an entity is assigned to; effects of tense, modality, negation, etc. on description formation; and how descriptions change over time. Some of these problems (as well as others) are discussed further in Webber [1978a&b], and much interesting work remains to be done.

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<*15>. Throughout this approach, I am making no assumptions about the separateness of discourse entities. That is, I am not assuming that two discourse entities are necessarily and for all times distinct, unless it is specified explicitly as was done here. Two discourse entities may have incompatible descriptions and as a consequence be assumed to be distinct. But I do not view it as impossible for two separately evoked discourse entities with different but compatible descriptions to later be found to be one and the same.

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