

On the notion of uniqueness *

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Abstract

In the paper it is argued that for some linguistic phenomena, current discourse representation structures are insufficiently fine-grained, both from the perspective of serving as representation in NLP and from a truth conditional perspective. One such semantic phenomenon is uniqueness. It is demonstrated that certain elements are forced to have a unique interpretation, from a certain point in discourse onwards. This could be viewed as the semantic counterpart of surface order. Although it has always been acknowledged that the left-to-right order of constituents influences the meaning of an utterance, it is, for example, not reflected in standard Discourse Representation Theory ([Kamp, 1981]). In the paper, an alternative representation for unique constituents will be proposed, resulting in asymmetry of certain conjoined conditions in a DRS-representation.

Introduction

Logic-based discourse theories are in many respects not sufficiently fine-grained. This becomes particularly obvious when we consider adopting such a representation as an interface in an NLP system.

Suppose we have a discourse as in (1), and assign it a DRT-like representation as in (2):

- (1) John owns two talking parrots.
Anne feeds them.
- (2) $\exists_{x,y,Z} [\text{John}=x \ \& \ \text{Anne}=y \ \& \ \text{parrot}(Z) \ \& \ |Z|=2 \ \& \ \text{owns}(x,Z) \ \& \ \text{talk}(Z) \ \& \ \text{feed}(y,Z)]$

When we take take this representation as a starting point for generation, we end up with at least the following discourses:

- (3) a John owns two talking parrots.
Anne feeds them.
- b Anne feeds two parrots, which talk.
John owns them.
- c There are two parrots. They talk.
John owns them and Anne feeds them.
- d John owns two parrots, which talk.
Anne feeds them.
- e John owns two parrots that talk.
Anne feeds them.

The multiplicity of solutions in generation from semantic representations has often led to the conclusion that a purely logical representation is too weak to guide a generation process. This problem is often 'solved' by incorporating syntactic knowledge in the semantic representation, or having the generation process be guided by more than one source of knowledge. In many NLP-systems, for example, the semantic representation reflects the syntactic constituent structure of the string. One could also think of processing by correspondence (as proposed by [Kaplan *et al.*, 1989]), using different sources of information to guide the task. Below, it will be argued that these semantic representations are indeed too weak, but not only from the point of view of Natural Language Processing. Some linguistic phenomena are not analysed adequately from a truth conditional perspective either.

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The phenomenon described in this paper, and exemplified in (3), touches on the notion of restrictive modification versus non-restrictive modification. I will demonstrate in what way the analysis of these cases in DRT-semantics is not adequate. It fails to assign different representations to discourses that do differ in truth conditions. The paper will propose an alternative representation and interpretation for this phenomenon. The main effect of the proposal is that the notion of constituent unit is reinstated. This notion is motivated semantically, i.e. on the basis of truth conditions. The reinstatement of units in the semantic representation is a first impulse to semantic representations that are strong enough to guide NLP-processes.

The paper is organized as follows. In section 1, the problem of uniqueness will be introduced. There are linguistic means to force uniqueness on the interpretation of a constituent. The prototypical example used throughout this paper is the non-restrictive relative clause. Second, uniqueness comes into play once we have completed a discourse. Neither disguise of the uniqueness phenomenon is recognized in DRT. In section 2, two proposals will be introduced which try to remedy these omissions. Section 3 will deal with the distinction between means to force uniqueness, means to force non-uniqueness and neutral cases. In section 4, the analysis is presented and finally, in 5, I will come back to the importance of the analysis in view of arriving at a more fine-grained semantic interpretation.

1 Restrictive and Non-Restrictive Modification in DRT

In Discourse Representation Theories ([Kamp, 1981; Kamp and Reyle, 1990; Heim, 1982]) no distinction is made between restrictive and non-restrictive modification. This assumption was challenged in e.g. [Sells, 1985] who argues for a distinction in meaning between the following minimal pairs:

- (4) a Anne owns two parrots, which talk to her.¹
 b Anne owns two parrots that talk to her.
- (5) a The talking parrots are happy.
 b The *talking* parrots are happy.

The examples in a) concern non-restrictive modification. Example (4)a makes a claim about all the parrots that Anne owns: there are two and they talk to her. She owns no others, talking or non-talking. In (4)b on the other hand, no such uniqueness claim is made. She may own other parrots, especially non-talking ones.

¹Note that 'which' can also be used in the restrictive sense but in this paper, it is reserved for the non-restrictive reading, to avoid confusion.

If we consider continuations of these sentences as in (6) and (7), or a linguistic context as in (8), the distinctions show more clearly:

- (6) a Anne owns two parrots, which talk to her.
 * The others ..
 b Anne owns two parrots that talk to her.
 The others never say a word.
- (7) a The talking parrots are happy.
 * The others ..
 b The *talking* parrots are happy.
 The others look depressed.
- (8) Anne owns a lot of parrots.
 a * She has two parrots, which talk
 b She has two parrots that talk.

The NPs in the a)-examples should be interpreted as 'the one and only set X such that all members $x \in X \rightarrow \text{Pred}(X)$ ', rather than 'there is a set X etc'. This phenomenon has received much attention in the literature, and is known as uniqueness ([Heim, 1982; Kadmon, 1987]), maximality ([Sells, 1985]) or the E-type effect ([Evans, 1980]).

In DRT, non-restrictive pronouns, restrictive pronouns and ordinary pronominals are all represented the same. The representation for all the variants in (9) is (10):

- (9) a Anne owns two parrots, which talk.
 b Anne owns two parrots that talk.
 c Anne owns two parrots. They talk.
- (10) $\exists_{x,Z} [\text{Anne}=x \ \& \ \text{parrot}(Z) \ \& \ |Z|=2$
 $\ \& \ \text{own}(x,Z) \ \& \ \text{talk}(Z)]$

A function verifies the representation in (10) iff there is a set of two parrots that Anne owns and that talk. If Anne in fact owns 5 parrots, and 3 of them talk, all sentences in (9) are equally true in DRT.

There are two interpretation aspects related to these examples that DRT does not acknowledge. First, if we utter sentences like (9) and that's all we say about those parrots, then most people actually think that Anne owns two talking parrots, not seven or hundred. We take this set of two talking parrots owned by Anne to be unique. Second, in an example like (9)a, the uniqueness-effect is brought about even before 'closing the discourse'. The non-restrictive relative clause has the effect of uniquely determining two parrots that Anne owns. And all of these parrots talk.

2 Other Proposals

In the following, two proposals will be discussed that aim at (partially) solving the uniqueness problem. In [Sells, 1985] non-restrictive and restrictive pronouns

get different interpretations. [Zeevat, to appear] re-lines DRT-interpretation in another way: certain parts of the discourse representation are 'closed', the effect of which is that the reference markers in that part of the discourse get a unique interpretation.

2.1 Maximality

In [Sells, 1985], it is argued that a distinction needs to be made between restrictive and non-restrictive modification. Sells proposes an alternative interpretation for non-restrictive relative pronouns, in which the pronoun is evaluated with respect to every way the antecedent was satisfied.

- (11) a John owns some sheep, which graze
 (11) b $\exists_{x,Y,Z} [\text{John}=x \ \& \ \text{sheep}(Y) \ \& \ \text{owns}(x,Y) \ \& \ [Z \rightarrow Y] \ \& \ \text{graze}(Z)]$
 (11) c In a DRS K' , an extension of a DRS K , the non-restrictive interpretation of $[Z \rightarrow Y]$ is:

The function g verifies K' iff
 $\forall f$ verifying K ,
 $\forall a [a \in f(Y) \rightarrow a \in g(Z)]$

So, for each and every sheep that John owns, it must hold that the sheep grazes. This contrasts to a restrictive interpretation, in which case the pronoun is evaluated with respect to the one particular embedding function currently specified for the antecedent.

- (12) a John owns some sheep that graze
 (12) b $\exists_{x,Y,Z} [\text{John}=x \ \& \ \text{sheep}(Y) \ \& \ \text{owns}(x,Y) \ \& \ [Z \rightarrow Y] \ \& \ \text{graze}(Z)]$
 (12) c In a DRS K , the restrictive interpretation of $[Z \rightarrow Y]$ is:

The function f verifies K iff
 $\forall a [a \in f(Y) \text{ iff } a \in f(Z)]$

The restrictive interpretation requires that there be a set of sheep for which it holds that every sheep in the set grazes and is owned by John. There is no maximality (or uniqueness) effect with restrictive modification.

This approach predicts that one cannot utter (13) when John owns ten sheep, of which only 5 graze:

- (13) John owns 5 sheep, which graze

There are ways in which the antecedent is verified but the anaphoric extension is not. However, note that, according to this proposal, (13) is a correct utterance in case John owns 10 sheep, and all of them graze. This prediction will be discussed more extensively in section 2.3.

2.2 Exhaustiveness

In [Zeevat, to appear] the notion of exhaustiveness (cf. [Groenendijk en Stokhof, 1984]) is used, to account for the maximality effect. Zeevat expresses exhaustification as a condition on truthful embeddings.

- (14) A function f embeds a DRS A exhaustively iff:
 f embeds A and $\forall h =_{dm(A)} f$:
 $[h \text{ embeds } A \Rightarrow \forall x \in dm(A) \ h(x) \subseteq f(x)]$

The function f will assign sets of the domain of individuals to the discourse markers. These sets must be such that there are no other sets - to be assigned by any other function h - that have the same properties but are not contained in the sets assigned by f .

Take the following examples:

- (15) a Bill owns sheep. John shears them.
 b There is a doctor in London. He is Polish.

The exhaustive verifying function necessarily picks the maximal set of sheep Bill owns (else there would be other another set chosen by some function h that would contain the current set). All of these sheep are sheared by John. Similarly, 'a doctor' in b) necessarily refers to a unique individual who is a doctor in London. That explains the weirdness of (15)b since we expect London to have more than one doctor.

2.3 Discussion

In this subsection I would like to summarize some of the predictions made by the approaches discussed above.

One major distinction between Sells' approach and Zeevat's is that Sells 'blames' the anaphor for the maximality effect whereas in Zeevat's approach, constituents have a unique interpretation by virtue of their being in focus.

In Sells' theory, the antecedent is evaluated in the same way as in the original DRT-analysis. So, for a discourse as (16), this means that Anne may have more than two bikes. Furthermore, Sells claims that for all of the bikes Anne has - even if she has 15 - it must be true that she got them from her brother. In my opinion, this is not the interpretation of (16). Indeed, it is possible that Anne has more than two bikes - bikes we don't care about in this story - but these bikes were not necessarily from her brother. On the contrary, the preferred reading is that they were not.

- (16) Anne has two bikes. She got them from her brother.

In Zeevat's approach, exhaustification of the antecedent is induced independently of the nature of the anaphor. If an NP is (in) a focussed constituent, it is maximized. Let us consider the example that

motivated this analysis, (15)b, repeated here.

(15) b There is a doctor in London. He is Polish.

Now suppose I am addressing a friend of mine, who is Polish and very ill. She's telling me that she dreads going to a doctor in England, everything being unfamiliar to her etc. I think in such a situation, it is completely natural to tell her the following.

(17) There is a doctor in London. He is Polish.
It seems best that you go and see him.
You can talk to him in your own language.
I'm sure he'll understand you.

Summarizing, the idea of exhaustification accounts for uniqueness by demanding that the verifying embedding is unique. The problem is to explain why it should uniquely verify the DRS related to the first sentence in (15)b - to explain the weirdness - but not so in (16). Sells' maximality proposal accounted for uniqueness claims imposed by anaphora, but has some undesirable empirical consequences.

3 An alternative account

We have discussed two proposals that made an attempt to clarify the uniqueness problem. In one approach, it is the anaphor that imposes a unique interpretation on the antecedent. In the other, the closing off of (partial) DRS's causes this effect. Below it will be claimed that these two ideas should be combined (and modified) to yield correct results.

I assume that the uniqueness effect stems from two sources:

- the closed world assumption (implicit)
- linguistic means (explicit)

These assumptions will be discussed in the sections to follow.

3.1 Closed World

The closed world assumption has the effect that, for a discourse as a whole, the reference markers are maximized. Consider the following paradigm:

- (18) I dropped a wine glass last night.
(19) I dropped a wine glass last night.
It was very expensive.
(20) I dropped a wine glass last night.
It was very expensive.
The glass was dear to me,
I inherited it from my grandmother.

If someone drops a line as (18), it creates the impression she dropped one and only one wine glass. If, on the other hand, (19) is uttered, it may be that she dropped an entire tray of glasses. But, only one of them was expensive. Similarly, in

(20), the thing that is unique is the x such that $\text{wine_glass}(x) \ \& \ \text{expensive}(x) \ \& \ \text{dear_to_me}(x) \ \& \ \text{inherited_from_my_grandmother}(x)$.

So, this sense of uniqueness is not triggered by anything in particular in the discourse. It is a side effect of closing off the discourse.

3.2 Explicit Uniqueness

As Sells has observed correctly, there are linguistic means to mark uniqueness explicitly. We present some examples in this subsection.

Nonrestrictive modifiers Uniqueness, or maximality, is forced by non-restrictive modification, as can be the case in relative clauses and adjective-noun phrases.

- (21) a I caught a glimpse of two players, who were training for the match
b (cf. I caught a glimpse of two players that/who were training for the match)
(22) a The aggressive police officers were to blame for the incident
b (cf. The *aggressive* police officers were to blame for the incident)

In both a) examples, one is forced to conclude that there is a unique set of people - two players, police officers respectively - of which all of its members were involved in the action reported on.

Focusing Adjuncts

- (23) a Only John knew how to behave
b (cf. Even John knew how to behave)

Here, in the a) example, the only x such that x knew how to behave is John. In b), on the other hand, it is implied that others knew how to behave, too.

Structural Focusing

- (24) a It was John who gave a present to Mary
b It was to Mary that John gave a present
c It was a present that John gave to Mary

None of the above are logically equivalent. As for a), John could easily have given presents to girls other than Mary. This in contrast with b), which claims that Mary was unique in receiving a present from John. And vice versa, b) is compatible with Mary getting presents from other boys, whereas a) is not. And c) is again different, for similar reasons.

4 The Analysis

4.1 Uniqueness of Discourse

For the closed world assumption, we adopt exhaustiveness for discourses along the line of [Groenendijk

en Stokhof, 1984] en [Zeevat, to appear]. Exhaustification applies to the verification of the entire discourse, and as such, it is more natural to define the condition on the function that embeds the discourse (as in Zeevat) than in the grammar (as in Groenendijk & Stokhof).

- (25) The embedding function f uniquely verifies the DRS K in M iff:

$$f \text{ verifies the conditions in } M \text{ and} \\ \forall h [\forall x \in \text{rm}(K) \Rightarrow h(x) \subseteq f(x)]$$

Note that uniqueness is a property of closed off discourses (or discourse units).

Let me explain the unique verification in view of the following examples:

- (26) a I spoke to two students yesterday.
They thought the exam was too difficult.
b I spoke to at least two students yesterday.
They thought the exam was too difficult.

If I spoke to exactly two students who thought the exam was too difficult, a) en b) are both true. The verifying function maps the reference marker onto the maximal set of students, 2 in this case. Both a) and b) are also compatible with the situation where I spoke to many students during that day but only two of them thought that the exam was too difficult. What discriminates a) from b) is when I spoke to 5 students who reported this complaint about the exam. In a), f maps the reference marker onto a set of two students who complained about the exam. There are other sets with the same properties, though, sets that are not contained in the set verified by f . Discourse b) can in this scenario not be understood as referring to only 2, 3 or 4 students. The embedding function must map the reference marker onto the maximal set, i.e the set of 5 students.

4.2 Uniqueness of Antecedents

For the analysis of uniqueness forced by linguistic means, I distinguish three cases:

- marked uniqueness
- marked non-uniqueness
- neutral cases

The a) examples of (21)-(23), and (24)a-c all explicitly mark uniqueness: (21) by the non-restrictive clause, (22) by the lack of stress on the modifier, (23) a focusing adjunct, and (24)a-c, uniqueness is forced by the clefting construction. Similarly, the b) examples in (21)-(23) mark non-uniqueness. In (22)b, for example, the stressed modifier 'aggressive' indicates that there were non-aggressive police officers - else we should have uttered (22)a.

Note that this list of linguistic 'tools' to mark (non)uniqueness is, of course, far from exhaustive.

The point I want to make is that sometimes the context forces a (non)unique interpretation, but in absence of such explicit indicators, the interpretation is vague about (non)uniqueness.

The neutral counterparts of (21)-(23) are the following:

- (21) c I caught a glimpse of two players.
They were training for the match.
(22) c The aggressive police officers were to blame for the incident ²
(23) c John knew how to behave
(24) d John gave a present to Mary

4.2.1 Neutral interpretation

For the neutral interpretation of pronouns, we adopt the standard DRT-analysis for anaphora. The Anaphora Condition below is logically equivalent to the interpretation of '=' in 'x=y' for anaphora in DRT.

Given a function f , and g an extension of f :

$$\exists f [\forall a \in f(X) \iff a \in g(Y)] \text{ (Anaphora)}$$

4.2.2 Non-restrictive interpretation

The non-restrictive interpretation is forced when we add to the anaphora condition that the antecedent is verified in such a way that there is no other set that has the same properties and is not a subset of the set denoted by the antecedent.

$$\exists f [\forall a \in f(X) \iff a \in g(Y)] \text{ (Anaphora)} \\ \& \\ \forall h [\forall a \in h(X) \implies a \in f(X)] \text{ (Uniqueness)}$$

Note that we need the Uniqueness Condition independently for precision adverbs such as 'exactly' in 'exactly 2'.

4.2.3 Restrictive interpretation

The non-uniqueness condition requires that besides the set that satisfies the antecedent for this contingent function, there is at least another element with the same properties.

$$\exists f [\forall a \in f(X) \iff a \in g(Y)] \text{ (Anaphora)} \\ \& \\ \exists h [\exists a \in h(X) \implies a \notin f(X)] \text{ (Non-uniqueness)}$$

²In spoken language, there would be no neutral form. The stress pattern would always indicate (non)restrictivity. In writing, which is what (22)c. refers to, it usually vague, or ambiguous between the two readings.

4.3 Further Predictions

First, note that my approach deviates from the traditional view that non-restrictive pronouns and ordinary pronouns should be interpreted equally.

So, the objection against the unique interpretation in examples like (25) does not hold for the analysis presented above. Pronouns could indicate uniqueness but do not so necessarily. (25) is not a counterexample, the pronoun can be used in this non-unique interpretation.

- (25) If a man is in Athens, he is not in Rome.

However, if we consider examples where both a unique and a non-unique interpretation are possible, the non-restrictive pronoun forces uniqueness, whereas the ordinary pronoun can be interpreted either way.

- (26) a If I want to marry a 16-year old, who I happen to love, then that's my business.
 b If I want to marry a 16-year old and I happen to love him, then that's my business.

The differences are subtle but (26)a seems to be appropriate only when there actually exists such a boy the speaker wants to marry or, in other words, there is a unique candidate in the world. (26)b could easily be uttered in a situation where there is no unique boy that fits the description. The discussion is about the age difference between lovers and (26)b is uttered not to report on an actual (unique) situation but to generalize over possible situations.

The analysis also explains why proper names can never be modified restrictively. After all, a proper name is mapped onto a unique element from the start. There is no way that a subset can be taken from that one element.

- (27) a *Yesterday I saw Rambo that I didn't like
 b Yesterday I saw Rambo, which I didn't like
 c Yesterday I saw the Rambo that I didn't like

Sentence (27)c is correct if there indeed are more Rambo-movies than the one I didn't like. The restrictive clause picks a subset from the set of movies.

A similar argument holds for "generic" uses of NPs:

- (28) a Cats, which are ugly, are not allowed in my house.
 b Cats that are ugly are not allowed in my house.

When uttering (28)a, I run the risk of offending all my cat-loving friends. There is no doubt that I

claim that all cats are ugly animals. It would be more diplomatic to utter b), where I only talk about a subset of cats (excluding, of course, my friends' cats ..).

5 Uniqueness and NLP

Let us return to the problem outlined in the introduction. If we disregard quantificational elements such as quantifiers, negation etc., a DRT-representation is just a large set of (unordered) conditions.

- (29) $Rm(x1) \ \& \ Rm(x2) \ \& \ Pred_a(x1) \ \& \ Pred_b(x2)$
 $\ \& \ Pred_c(x1,x2) \ \& \ x1=y1 \ \& \ x2=y2 \ \& \ |Z|=2$
 $\ \& \ Pred_d(y1,y2)$

These conditions constrain the assignments of sets to discourse markers, and the order in which this happens is without significance (as long as, roughly, antecedents are introduced before anaphors). I have shown in this paper that this is an unwanted result. There are phenomena in language that more or less indicate that the assignment to a discourse marker under discussion is fixed at a certain point. This means that the constraining conditions are not just interchangeable.

- (30) a The University fired 5 friends of mine, who were researchers.
 b The University fired 5 researchers, who were friends of mine.
 (31) a I know exactly two Spanish people. They live in my street.
 b I know exactly two people in my street. They're Spanish.

Both the non-restrictive clause and the precision adverb indicate the properties that exhaust the set we are talking about. A set consisting of all and only the Spanish people I know (who happen to live in my street) is not (necessarily) the same as the set of all people who live in my street (and who, by the way, all happen to be Spanish). The asymmetry of these predications over sets should be represented in the semantic representation, in order to account for the difference in truth conditions.

- (32) a I have two brothers, who would like to meet you.
 b $\exists_{x,y,z,w} [I=x \ \& \ you=y \ \& \ brothers(Z) \ \& \ have(x,Z) \ \& \ Z \rightarrow W \ \& \ would_like_to_meet(W,y)$

The interpretation of the arrow is given in section 4.2.2. From that definition it follows that the arrow is not symmetric. The conditions on the antecedent and the anaphor are therefore not interchangeable. This in turn means that we have reintroduced the notion of 'constituent' in our semantic representation.

The constituent is not motivated by the full stop, or any other syntactic or orthographic devices, but for semantic reasons.

6 Conclusion

In many logic-based discourse theories, the notion of constituent unit has largely disappeared (disregarding quantificational structures for the moment). These theories do, however, often respect the order in which constituents appear in the surface string, acknowledging that the left-to-right order of a string is of importance. This is not reflected in the discourse representation, though. In this paper, I have shown in what way exactly this left-to-right order influences the truth conditions.

When a discourse proceeds, the values to be assigned to the reference markers in the discourse are gradually constrained. If this is the case, then it makes no difference in which order we constrain the interpretation: the result will be the same. However, some linguistic markers fix the interpretation of a discourse marker at a certain point. It has been shown that in these cases, the order of constraints is to be preserved in order to capture the right truth conditions. In the proposal, unique constituents are analysed in such a way that they impose an asymmetric relation upon the conjoined conditions of DRS-formulae. As such, they add more structure to the discourse representation structures.

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