

PALMYR: ANAPHORA IN NATURAL LANGUAGE

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GTS: Motivation

For a long time, the possibility of doing a formal approach to natural semantics has been considered as an unfathomable task: too many factors involved at the moment of the interpretation, too many “ambiguities and unruly exception”¹. In short, a task impossible to be accomplished unless perhaps by using simplifications which can denature the very essence of natural language. The formal study of semantics was therefore consigned to the formal languages, while at the same time studies on natural languages concentrated themselves towards syntax.

Montague initiated a new way to perceive natural semantics through his works published in the sixties and the seventies: “I reject the contention that an important theoretical difference exists between formal and natural languages” (1970). In his article of 1973² (PTQ), Montague (in the line of previous works) “presents in a rigorous way the syntax and semantics of a certain fragment of a certain dialect of English” in three stages: 1.- Syntactic analysis (syntactic categories), 2.- Translation: English (analysis tree) - Formal language (intensional logic) and 3.- Interpretation of the formal expression (and then, indirectly also, of the associated english expression). That is, a thorough syntactic analysis can completely provide, through a particular recursive process, the semantic interpretation of any expression in a certain fragment of English. An interesting question here consists in realizing the close connection between this claim and the one which states that any seman-

¹Dowty, D., Wall, R. and Peters, S. (1981), *Introduction to Montague Semantics*. Holland: D. Reidel Publishing Company.

²Montague, R. (1973), “The Proper Treatment of Quantification in Ordinary English”

tic attribute has in fact a fixed and uniform syntactic sign in language. But do semantic attributes really have always such kind of sign?

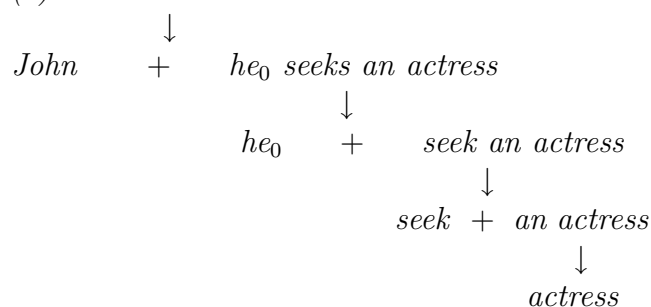
In Hintikka’s view, the work of Montague suffers from the (so called by the author³) “recursive paradigm” which, as in the case of Chomsky’s generative grammar, also governs the semantics of the first one. That is, “language considered as a rule-governed process. In the simplest case, language studied by means of recursive rules”. According to Hintikka, it is a mistake to submit language theory to such a paradigm and this can be attested by considering the informational independence phenomena, a ‘crosscategorical phenomena’ that lacks (like the most of the rest of ‘crosscategorical phenomena’) the associated syntactic sign (Syntactic Silence Thesis).

The natural question at this point is: If there really are semantic attributes without any corresponding sign in syntax, how to interpret the sentences in which these attributes are present? How is it possible that a semantic attribute doesn’t have any syntactic codification in such a way that (as Hintikka points out) “the clues to crosscategorical phenomena (...) have to be derived from other sources, for instance, from a logico-semantical analysis of linguistic phenomena”? Here, I think, the natural answer would be the following: *It is in the very interpretative process that these semantic attributes come up. They constitute the semantic contribution from internal process to the expression meaning.* In other words, *the sentence processing has, in itself, expressive power.* It is just in this context that Hintikka’s game theoretical semantics seems to make more sense. When a sentence is associated with a game under the frame of GTS, it is achieved a explicit expression of a part of the process, the one responsible of dependencies.

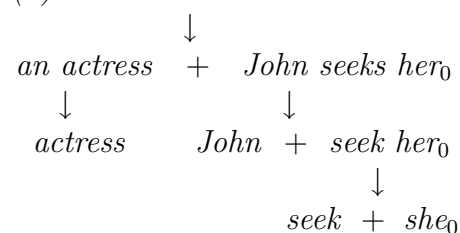
We shall now compare, through a pair of examples, the respective approaches to meaning of PTQ and GTS:

1. *John seeks an actress*

(b) *John seeks an actress*



(a) *John seeks an actress*



³Hintikka, J. (1990), “Paradigms for language theory”, in *Acta Philosophica Fennica* 49,181-209

PTQ approach: After the corresponding analysis, we can observe that sentence 1. has associated two possible syntactic trees. Each of them is translated into only one formula of intensional logic (together with its respective semantics interpretation). We get the following readings:

(a) *de re reading:* It is the case in which we know precisely who is the actress. That is a particular actress being seeked by *John*.

(b) *de dicto reading:* *John* doesn't seek a particular woman but a property in itself: the property *actress*. So, it can be the case that no *actress* is the one being seeked by *John*, that is, he isn't perhaps seeking any of the extensional realizations of the predicate *actress* and however he actually seeks an *actress*.

GTS approach: As before, we have at our disposal two possible interpretation of the sentence which are analogous to the corresponding one for PTQ:

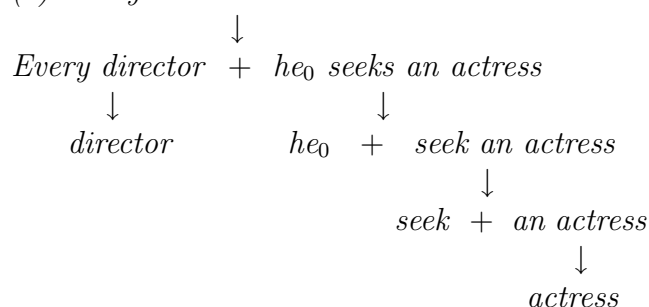
(a) *de re reading:* The meaning is taken out of a game according to which the *verifier* plays the first move by selecting an actress out of the whole of them. It's a game in which it exists for the *initial verifier* (*abstract meaning*) a winning strategy.

(b) *de dicto reading:* Again, the meaning is taken out of a game in which the *verifier* plays the first move by selecting an *actress*. The difference with the *de re reading* lies in the lack of a winning strategy for the *verifier* and also for the *falsifier*.

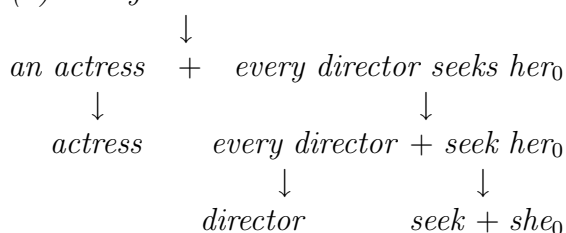
Both approaches manage to extract the two intuitive readings of sentence 1.. But what about replacing *John* with (for example) *every director*? We repeat the previous process:

2. *Every director seeks an actress*

(b) *Every director seeks an actress*



(a) *Every director seeks an actress*



PTQ approach: Again the same mechanism suggest two possible interpretations:

(a) *de re reading:* The corresponding interpretation can be summarized in the fol-

lowing expression: ‘the *actress* who is being seeked by all *directors*’. Every *director* seeks the same *actress*.

(b) *de dicto reading*: In this case, each *director* seeks the property *actress*. But that, as before, is not enough to claim that each one of them seeks one specific *actress* in the extension of the predicate.

GTS approach: Intuitively our sentence has nevertheless another reading, one according to which every director knows exactly the *actress* he wants for his film, an *actress* that furthermore can be potentially different in each case. PTQ, as we have just seen, does not seem able to produce such an interpretation. But, on the contrary, GTS does so:

(a) *de re reading*: The meaning is taken out of a game in which the *verifier* plays the first move by selecting an *actress*. After that, it is the *falsifier* who moves. He tries to win the game by choosing among directors the one who possibly is not seeking the particular *actress* selected by the *verifier*. In this game the *initial verifier* has a winning strategy.

(b) *de dicto reading*: This is the case where neither *verifier* nor *falsifier* have a winning strategy. This time, the *falsifier* plays the first move. He selects an individual from the set of *directors*. Then, to win, the *verifier* must try to find an *actress* being seeked by the director in question. But the *verifier* can fail. He hasn’t got enough information to do a good choice.

(c) *new reading*: The meaning is taken out of a game that is the same as the previous one. *Falsifier* plays first by selecting an specific *director*. *Verifier* must then work to find an *actress* being seeked by him. The difference with *de dicto reading* lies in the existence of a winning strategy for the *initial verifier*.

The interesting thing here is that PTQ has not been able to effectively deal with the dependence relation between *director* and *actress* which makes the latter a new reading. And that is, as Hintikka points out, because dependence is not directly codified in natural syntax.

Anaphora and GTS

In the words of J.C. King ⁴: “Anaphora is sometimes characterized as the phenomena whereby the interpretation of an occurrence of one expression depends on the interpretation of an occurrence of another or whereby an occurrence of an expression has its referent

⁴King, J.C. (2004), “Anaphora”, *Stanford Encyclopedia of Philosophy*, <http://plato.stanford.edu/entries/anaphora/>

supplied by an occurrence of some other expression in the same or another sentence.” However, as the same author also points out, “these are at best very rough characterizations of the phenomena, since things other than anaphoric expressions satisfy the first characterization and many cases of anaphora fail to satisfy the second”. We will concentrate on a particular case of anaphora: the anaphoric pronouns.

Traditionally, one of the most expanded conception has been the one which considers pronouns as bound variables. So, according to this idea, a sentence like: “A man smiles. He is happy”, should have the following logical form (expressed in ordinary first order logic): $\exists x(Mx \wedge Sx \wedge Hx)$. That is, in fact, a very natural way of thinking about a formal representation of the anaphoric pronoun, given the strong link between pronoun and antecedent. The underlying idea is that the whole of elements having the same antecedent must constitute a single element. And so they must always share what wherever in discourse is predicated. In principle this seems a reasonable idea. Nevertheless, we can observe that in certain cases it raises problems. Consider, for example, the so called *donkey sentences*. Let’s take the following example (well known in literature):

3. *If John owns a donkey, then John feeds it*

Except in the case in which we give this sentence the so called *Partee’s reading*, (according to which the respective logical form would be: $\exists x [(D(x) \wedge O(J,x)) \rightarrow F(J,x)]$) there isn’t any other way to maintain the conception of pronoun as bound variable that doesn’t entail a transformation (not at all obvious) of the involved quantifier: $\forall x [(D(x) \wedge O(J,x)) \rightarrow F(J,x)]$ (*ordinary reading*). However it would seem natural to associate this sentence with the following logical form: $\exists x (D(x) \wedge O(J,x) \rightarrow F(J,x))$ where the conditional is the principal connective and the existential quantifier links the variables in antecedent and consequent. Why does it not work conceptually? The difficulty here, is what is predicated about x , that is, not a conditional but: ‘ x is a donkey’, ‘John owns x ’ and ‘John feeds x ’. But if x must always be seen as the one owning all predicates having been claimed about it, we obtain a nonsense result: a conditional in which already in antecedent is predicated the consequent. The moment in which something is actually predicated seems to be really important.

Lepore&Garson⁵, as later on Hintikka⁶ did too, understand the problem as a confusion about the quantifier scope notion. In particular, in the words of Hintikka (1997), it is the confusion due to the “attempt to express two entirely different ideas by one and the same notational device”. So, the author distinguishes what we could call two different ‘interpretative moments’ for quantifiers: a first moment in which the quantifier is interpreted as a logical expression (and so dependent on its relative *scope* with respect to the rest of the logical expression in the sentence, *priority scope*); and a second one in which

⁵Lepore, E. and Garson, J. (1983), “Pronouns and quantifier-scope in english”, *Journal of Philosophical Logic* **12**, 327-358

⁶Hintikka, J. (1997), “No Scope for Scope?”, in *Linguistics and Philosophy* **20**, 515-544

it is interpreted as the ‘head’ (or antecedent) of some of the pronouns which will appear through discourse (*binding scope*).

We’re going to concentrate on this second moment. Since the treatment of pronouns as bound variables proves to be problematic because of being so strict, one could think about a new kind of approach that takes priority over freedom. But too much freedom may also be an inconvenient. That is, each pronoun in discourse may be interpreted as a free variable referring to something known but not specific. This kind of approach is not a realistic one. During natural discourse, the level of incertitude is never so high. What then? We will have to restrict the possible options of reference. There are at least two ways to do that: one uses the information in the pronoun itself, the clues that it gives in the research of its antecedent; the other one encodes the idea that the reference of pronouns moves over a set of accessible information having been introduced in a previous moment of discourse.

Hintikka and associates translate the first of these ways by the following claim: “The basic idea of the theory of pronouns in GTS is that a pronoun is essentially like a hidden definite description (...).” “(...) they are free singular terms not unlike definite descriptions. The logic of ‘he’ is essentially that of ‘the male’, (...).”⁷

The second way can be translated in the use of a special set, *choice set*, that “actually codifies the context available to the players when making their moves” (Sandu, 1997)⁸. As in the case of the DRT, our *choice set* (I) is not a fixed set. On the contrary, it updates itself through the right application of the corresponding *game rules*. We can find a technically precise description of the treatment of anaphora in GTS in Sandu (1997). We shall now observe the following example:

4. *Every student must read a book. He can pick anyone he likes*

Here we can observe a first problem for GTS, a problem which is shared by other theories using a similar approach to anaphora (like DRT). Since, as Sandu points out, “with the exception of individuals introduced as values for proper names, the individuals put into I are the individuals chosen by *Myself* in the semantical game in question”, and given that it is Nature, who introduces in the game the reference of *every student*, the pronoun *he* won’t have any good reference in the *choice set*. On the contrary, since it is *Myself* who introduces this time in the game the reference of *a book*, *anyone* will now have access to the respective antecedent.

As we have said before, that is one of the problems occurring in connection with GTS

⁷Hintikka, J. and Sandu, G. (1997), “Game-theoretical semantics”, in *Handbook of Logic and Language*, J. van Benthem and A. ter Meulen (eds.), Elsevier Science Publishers B.V., 361-410

⁸Sandu, G. (1997) “On the theory of anaphora: dynamic predicate logic vs. game-theoretical semantics”, *Linguistics and Philosophy* **20**, 147-174

but not the only one. So, in their 1983 article, Lepore&Garson analyse what they consider to be a serious difficulty for the theory: “Notice that the theory requires that the game for the antecedent be placed out entirely; otherwise, we will lack names that determine the referents of the pronoun in the consequent.”

In particular, these authors analyse the case of *backwards pronominalization*. The example they work out is the following:

5. *If a man can find the money to pay for it, he will buy a fancy car*

The difficulty consists in assigning an appropriate ‘head’ to the anaphoric pronoun *it*. The problem is that the natural antecedent of *it*, *a fancy car*, appears in the game only after that the pronoun does so, hence GTS lacks the necessary mechanisms to treat *it*. As Lepore&Garson point out, one could “try to avoid this difficulty by adopting a transformation rule which exchanges pronouns with their antecedents so that all general terms will turn up in the antecedente of a condicional.” The resulting sentence after the application of such a transformation rule would be:

6. *If a man can find the money to pay for a fancy car, he will buy it*

The problem here is that such an action has the undesirable consequence of identifying two sentences (5 and 6) that intuitively have different meanings.

Arbitrary objects

To conclude, we will see that the two problems (for GTS) just seen in the last point, in fact constitute a possible motivation for another formal approach to natural language processing, one that builds over Fine’s theory of arbitrary objects⁹. According to this theory the classical model will be expanded to a new one by means of three new components: a set of arbitrary objects disjoint from the domain (set of individuals, D): A , a relation of dependence in A : \prec and a non empty set of partial functions from A into D : V ; all of them being subject to certain conditions which make it an *actual A-model*. We will use the same examples as in the last section:

(4) *Every student must read a book. He can pick anyone he likes.*

In this case we had an accessibility problem from the pronoun *he* to its antecedent,

⁹Fine, K. (1985), *Reasoning with arbitrary objects*, New York: Blackwell

every student. From the perspective of the arbitrary objects, what we do is introduce an arbitrary object (independent) for *every student* ($s \in A$) and another one (dependent) for *a book* ($b \in A$), both linked by the dependence relation $b \prec s$ (b depends on s). In this case, it could be understood that the pronoun *he* refers to s and that *anyone* refers to b . That eliminates the accessibility problem but yet it gives rise to a new one (that we didn't have neither in DRT nor in GTS): How could we now justify the agrammaticality of the following sentence?

7. *Every student must read a book. He is handsome.**

Something that is perfectly clear in DRT and GTS, now seems to be a serious difficulty. But if we understand the anaphoric pronoun not as an element of A but as an element of D , the accessibility problem then translates into the problem of choosing the particular element of V . Once the dependence relation is established, the predications are over it (not over a particular element of the relation), that is, we predicate over the elements of V . Unless an isolated member of the relation takes only one value of D , for all $v \in V$, we will find a case of agrammaticality when the reference is over such an isolated member. For example:

8. *Every student must read a book. It is interesting.*

The only possible interpretation here is the one in which the speaker refers to the obligatory reading of a particular book.

(5) *If a man can find the money to pay for it, he will buy a fancy car.*

We assume the hypothesis that all anaphoric pronoun (including *backwards pronominalizations*) have an antecedent in discourse that could be not directly explicited. Therefore the reference of *it* in the example will have to be given by a previous element. But, which one? If we consider the formal representation of an element as the very element together with the dependence structure associated, it seems natural to think that the pronoun finds its antecedent in an element that depends on *a man*. The concret element is given in the next sentence: *a fancy car*. So, we have not only identified the reference of the pronoun but also established a dependence relation between *a man* and *a fancy car*. One of the advantages of this approach is that it allows us to explain why (5) and (6) have different meanings: the reading of (5) is 'every man with the money to do it, will buy a concret fancy car'; and the reading of (6) 'every time that a man has the money to do it, he buys a fancy car'. In (6) we don't find any reason to think that there exists a dependence relation between *a man* and *a fancy car*. So, as is pointed out by Lepore&Garson, "(...) a car will be given the universal interpretation when [(6)] is processed".