A CATEGORICAL VIEW OF NOUNS IN THEIR SEMANTICAL ROLES

Marie La Palme Reyes and John Macnamara*
(McGill University)
Gonzalo E. Reyes and Houman Zolfaghari
(Montreal University)

1. Prototypical CNs and MNs

All natural languages seem to distinguish at the semantic level between count nouns (CNs) and mass nouns (MNs). Some natural languages, like English, mark the distinction at the syntactic level. Prototypical of Cns is "dog" and of MNs is "matter" (in the sense of physical stuff). One syntactic difference is that CNs take the plural ('dogs') whereas MNs do not. Other syntactic distinctions relate to the determiners and quantifiers. One can say *a dog, another dog, many dogs, two dogs*, etc.; one cannot correctly say **a matter, *another matter, *many matter, *two matter*, etc. It seems that the distinction in English grammar was introduced by Jespersen (1924, p. 198).

Languages differ in morphology, agreement rules and phrase structure, so one does not expect to find in every natural languages a count/mass distinction with the same linguistic correlates as in English. While many European languages are like English in this connection, not all are. Irish and Latin, for example, lack the idefinite article, and so one cannot distintiguish CNs from MNs in those languages by the possibility or impossibility of adding the indefinite article to the noun. If we inquire what guides linguists to the decision that there are a count/ mass distinction in languages, the answer cannot simply be grammar. Grammar varies greatly from language to language. Something other than grammar must be contributing to the decision. We submit that the type of reference for prototypical words plays a major role. We think that across variations in grammar there is a semantic uniformity in the interpretation of at least such prototypical nouns as the counterparts of *dog* and *matter* and that this semantic uniformity is a good guide to the relevant grammatical facts in each language. We propose to exploit the semantic uniformity as far as possible.

This should not be taken as an assumption that the perceptual experience of a noun's extension determines whether a noun applied to it is count or mass. It cleary does not. The very same perceptual expercience that licenses the application of the MN *gravel* licenses that of the CN *pebble*. Moreover languages vary in what they choose to present in the first instance as mass and what as count. French speakers, for example, apply the CN *meuble* where English speakers would normally apply the MN *furniture*. Notice that *furniture* does supply natural units, or as we say articles of furniture (chairs, tables, lamps, etc.). The importance of the prototypical examples also shows up in work on child language learning. Young children tend to take a new word taught them for a stuff that is like sand in its consistency as a MN, and a word for unfamiliar creatures reminescent of animals as a CN (see especially McPherson [1991] and Soja et al [1991]).

Pelletier and Schubert [1989] document the difficulty in deciding what precisely falls under the classifications mass or count: noun phrases, adjectives and adjectival phrases, verbs and verb phrases, or adverbs and adverbial phrases? Even if one could settle on the relevant

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syntactic category or categories, there is still the issue of what precisely in those categories is mass or count: the expressions themselves, their senses, or their occurrences? All this in addition to the problem of how to decide whether something, whatever that something is, is mass rather than count. But notice that to start work on these questions assumes that we understand the mass/count distinction. On the basis of the prototypical examples discussed above, we take the view that this distinction applies to nouns, whether or not it applies to other grammatical categories. Our work is concerned only with the mass/count distinction for nouns, whose solution is presupposed in formulating some of the previous questions. Despite their obvious interest, those questions we do not propose to tackle.

2. Cumulative and distributive reference

The usual way of distinguishing MNs from CNs is by specifying semantical properties that MNs have but CNs lack.

Two or more dogs do not together constitute a larger dog; whereas two or more quantities of matter together constitute a larger quantity of matter. It is customary, following Quine [1960, p91], to refer to this property of the extension of MNs as *cumulative reference*. Likewise, a (proper) part of a dog is not a smaller dog, whereas a part of matter is matter in the sense that a part of a portion of matter is a smaller portion of matter. Many writers refer to this semantic property of MNs as *distributed (or divided or divise or homegeneous) reference*. All the authors that we have consulted accept the cumulative reference (as we do) but the property of divisiveness of reference divides them!

What is our position in this debate? In fact, if in accordance with the test of cumulative reference we interpret a MN as a sup-lattice M, then it makes no sense to ask wheter *a part* of an element of M is again an element of M. What could be a part over and above the elements of m? We believe that this discussion presupposes (perhaps inadvertently) a universal substance S, a sup-lattice containing every interpretation of a MN as a sub su-lattice. Whit such a substance it makes sense to ask whether every element of S which is a part of an element of M is an element of M. We reject the notion of a univesal substance, however, and so we are led to reject the whole debate as meaningless. This position, however, seems to go too far: take for instance the MN 'footwear'. It applies to a shoe ant to any collection of shoes, but does not apply to a proper *part* of a shoe. A shoe's heal is certainly not footwear and a leg of a table is not furniture. Thus, there is a truth of the matter whether a *part* of a shoe is a shoe and a part of a table is a table. All of this seems perfectly meaningful and such knowledge is assumed in the everyday use of the language. Indeed, we introduce a notion of substance relative to a system of interpretations of nouns (like 'heal' and 'leg') and these questions will in fact become meanigful. The answer will depend of course on the system of interpretations considered. For more details including mathematical developments see La Palme Reyes et al [to appear].

Notice that a related, although different question may be formulated meaningfully without invoking a universal substance: is the sup-lattice M atom-less? This is so because the notion of an atom (or primitive element) is definable in any sup-lattice. We belive that these two questions have sometimes been confounded, and this has obscured the fact that the first can be formulated only if a universal notion of substance is assumed. At any rate, under the assumption of a universal substance, divisiveness of reference implies that the extensions of MNs are atomlees. This is the only issue that we will address at this point.

Several authors, ter Meulen [1980], [1981], Roeper [1983], Lonning [1987], Bunt [1985], among others, have erected divisiveness or reference into a characteristic of MNs. Bunt [1985,

pp. 45-46], for example, allows that in the actual physical extensions of many MNs there are minimal parts, but dismisses the fact as linguistically irrelevant. Quine [1960], Parsons [1970], Gillon [1992] and others reject this claim for the reason that we formulate as follows. It may well be that for many centuries users of the English word *water* did not realice that there are minimal portions of water, namely molecules, whose parts are not water. (Notice how both problems are here confound). The effective use of the word does not depend on knowledge of that scientific fact. This seems to have lead some writers to the conclusion that the facts of the matter have no beaning on the extensions of common nouns. But extension is extension, independent of our knowledge. There is a truth of the matter that there are minimal parts in extensions of some MNs at least: witness the examples of 'footwear' and 'funiture' already discussed. Thus, we do not see reasons to set limitations *a priori* to extensions of MNs. Furthermore, excluding atomic extensions would rule out the possibility of considering plurals as MNs. Not only there is linguistic evidence to do so, discussed by Carlson and Link (see below), but we will see that the plural construction may be viewed as a basic link between CNs and MNs.

3. Categories of nouns and their interpretations

One of the main novelties of our approach is to take into account the connections beween MNs, the connections between CNs and the ways that MNs can be transformed into CNs and viceversa. For instance, there is a connection between the MN *iron* and the MN *metal* described in colloquial language by the sentence *iron is metal*, analogous to that between *dog* and *animal* that we studied in La Palme Reyes et al [1994b]. Furthermore, there must be some way of connecting the MN *metal* and the CN *a metal* to validate some arguments involving both expressions. This net of connections may be organized in an objective way by means of system of categories and functors: the nominal theory. This system includes the category *CN* whose objects are CNs and whose morphisms are axioms of the form 'a dog is a mammal', 'a mammal is an animal' which may be thought of as a system of identifications. By composing those axioms we obtain the new identifications 'a dog is an animal'. In a similar vein, the nominal theory includes the category *MN* of MNs such as 'iron', 'metal' and whose morphisms are axioms such as 'iron is metal'. The transformations mentioned before between CNs and MNs are described by functors. One example is the plural formation that takes the CN 'dog' into 'dogs'. Since the extension of this term obviously has property of cumulative reference, we categorize 'dogs' as a MN. Carlson [1977] and then Link [1981] called attention to the affinity between plurals and MNs. In fact this affinity even extends to the syntax of both expressions. As an example, plural CNs just like MNs do not take the plural. Also on a par with MNs, such combinations as **a dogs *another dogs* are ungrammatical.

The categories *CN* and *MN* are unified by means of a third, *QN*, the category of quantitative nouns (QNs) which includes as objects the previous ones but also some native objects of its own. These we have not seen so categorized in the literature. Examples of such native QN's (besides collectives), are *steak*, *cloth*, *paper*, *drink*, *stone*, *space*, *time*, etc. To see what is distinctive of Qns, consider the phrase a *space* as applied for example to a room.

The room is a space which can be divided in two by, say, the diagonal joining two opposite corners. The room is thus the sup of these subspaces. But a square meter in one of the corners together with a square meter in the other corner do not together make a single space. It seems that to form a single space, subspaces must be contiguous. Thus, *a space* is not a MN phrase, since arbitrary subspace do not have a sup. On the other hand, it is not a CN phrase either, since a space may have another space as a proper part. The reader is invited to make a simi-

lar analysis for *a rope*. An example of a different kind seems to be the following, related to the noun *committee*. We may have one committee C having exactly two subcommittees A and B. To discuss reports from these subcommittees, a committee of the whole C' is created. This new committee differs from C because the minutes will record all the transactions of C but omit those of C'. This shows that conceptually, C' is different from C. We regard C and C' as 'formal' sups of A and B, a notion to be clarified in a forthcoming paper Besides these examples there are others such as *quantity of matter* which are important when dealing with functors among the categories of the nominal theory.

We interpret the nominal theory as follows: CNs are interpreted as situated sets (or kinds), namely, families of subsets of a given set indexed by situations. A subset indexed by a situation consists of all the members of the given set which are constituent of that situation. Situations are assumed to be pre-ordered by the relation of 'having more information' (not to be confused with temporal order), and hence there are obvious connections between the subsets of the family. Morphisms between CNs are interpreted as situated maps, i.e., set-theoretical maps preserving the relation of constituents of a situation into members of another set which are constituents of the same situation. Such maps we call *underlying*. MNs are interpreted as situated sup-lattices and morphisms as sup preserving situated maps. Finally, QNs are interpreted as situated sup-sketches, i.e., situated sets with a partial order relation and a set of distinguished formal 'sups'. Morphisms between QNs are interpreted as situated maps which preserve the distinguished 'sups'. Functors of the nominal theory are interpreted as functors of the corresponding interpretations. For instance, formation of the plural is interpreted as (an enriched) power set functor between *CN* and *MN*. A word about situations in our approach. We do not attempt to develop a theory of situations along the lines of Barwise and Perry [1983]. Instead we take situations as unanalyzed primitives requiring only of them that they be sufficient to ground the truth or falsehood of certain sentences, a completely intuitive notion. Such situations differ from possible worlds in that they need not ground the truth or falsehood of all sentences; only the sentences that may interest us.

For a more thorough philosophical discussion of the notion of situated set or kind the reader is referred to La Palme Reyes et al [1994 a]. We will only remark that it is a consequence of our approach that the underlying maps among kinds are not set-theoretic inclusions that are everywhere assumed in the literature. Such an inclusion assumes identity between, for example, a pup and the associated dog. Some underlying maps are not even injective. For example, an airline may count several passengers in association with a single person, it that person takes several trips with them.

4. Grammatical transformations and syllogisms

The nominal theory and its interpretation is used to decide the validity of syllogisms of the type discussed by Pelletier and Schubert [1989] and involving CNs MNs and predicables. To achieve this purpose, we need to build semantical counterparts to grammatical transformations of CNs into MNs, MNs into predicables and so on , extending our previous work La Palme Reyes et al [1994 b]. As an example, consider the syllogisms.

Claret is a wine, wine is a liquid, so claret is liquid.

In the first premise, 'claret' is a NP (as in the first) and 'is liquid' is a VP. The NPs in this example are, however, like PNs (proper names) or descriptions. Cross linguistic evidence suggests that 'claret' is not a PN. In fact, in French, one uses the expression 'le bordeaux' and French does not allow the definite article in front of a PN. This suggests to categorize 'claret'

as a descriptive noun phrase (DNP), i.e., as a noun phrase whose interpretation is a member of a kind. As in the paper cited above, we consider 'is a wine' as a predicable derived from the term 'wine', a CN as indicated by the occurrence of 'a'. The second premise can be analyzed in a similar way. On the other hand, we will assume that 'is liquid' in the conclusion is a predicable derived from the term 'liquid', an Mn as indicated by the absence of 'a'.

At the level of interpretation, these grammatical transformations (or derivations) will take us into computations of colimits of interpretations in our categories to define notions of relative entity, relative substance, etc.

5. Category theory versus set theory

A final word about the use of category theory (rather than set theory) in our work. (For a more thorough discussion, see Magnan and Reyes [1994]). A first observation concerns generality: sets themselves constitute a particular category. The use of category theory allows us to formulate semantics that are free of the particular determinations imposed by a too rigid adherence to set theory. From this point of view, we would like to emphasize that the semantics introduced in our paper is one among several possible ones. The fundamental property of the category that interprets CNs is to a be a *category of space*; while the fundamental property of that which interprets MNs is to a be a *category of quantity*, in the terminology of Lawvere [1992].

A second observation concerns abstractness. Contrary to a widespread belief set-theoretic semantics are more abstract than category-theoretic ones. This is easily understood when we compare usual set-theoretic semantics of CNs and MNs with our category-theoretic semantic. As we pointed out one of the main novelties of our approach is to take as the basic ingredients of our semantics the connection between dogs and animals, iron and metal, wines and wine, chicken and food, golden ring and gold, etc. These connections guided the choice of the categories used to interpret CNs, MNs and QNs.

To give an example, any sup-lattice is also an inf-lattice and thus, from a set-theoretical point of view, it makes no difference whether to work with sup-lattices or inf-lattices. On the other hand, morphisms of sup-lattices are quite different from morphisms of inf-lattices and the following example shows that underlying relations do not preserve the intersection in general: take a person who has traveled twice, say, and consider the underlying map u at the level of sets of persons (which are sup-lattices as well as inf-lattices) which associates with a set of passengers the underlying set of persons. Clearly u preserves arbitrary unions. On the other hand, u does not preserve binary intersection: let p, p' be the two passengers whose underlying person is John. Then if we take the intersection of the subset whose only element is p (P) with the subset whose only elements is p' (P'), we obtain the empty set and hence the image of this intersection by u is still the empty set. But if we intersect u (P) and u (P') we obtain the subset whose only element is John. Other examples of this kind can be given to justify our choice of categories.

From this point of view, the trouble with set-theoretical semantics is simply this: they are too abstract, since they abstract away these fundamental relations, which are therefore not properly represented (in these semantics). As a consequence, set-theoretical constructions are not contrained in a natural way: they are just too many and when a choice is required, extraneous principles, usually of a pragmatic nature, are brought in to decide the issue. On the other hand, categorical constructions are highly constrained through the use of universal properties: among all possible constructions one is distinguished as satisfying a universal property. Because of this feature, it has been argued that the theory of categories constitutes a theory of concrete universals, set theory being rather a theory of abstract universals (see Ellerman [1988]). This explains

the ubiquity of universal constructions in our work. In a more speculative way, we are tempted to believe that universal constructions may capture what is universal in the human mind including what is fundamental in human language.

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