Studies in Language 11-2. 469-502 (1987).

REVIEWS

Harry C. Bunt. 1985. *Mass Terms and Model-Theoretic Semantics*. Cambridge: Cambridge University Press.

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0. *Introduction*

Until the early eighties formal semantics had been dominated by a basic conception that can be traced back to Russell and the way he considered predicate logic to be applied in the semantic description of natural language sentences. According to his view (cf. Russell 1919, ch. 15,16), NP+VP sentences correspond to predicate logic formulae in the following way: simple proper names, personal pronouns and definite descriptions[1] with count noun heads are individual expressions. Plural definite descriptions denote sets (or classes) of individuals. VPs, again, denote sets and apply to simple individuals: application being identical with set-membership.

Russell's ideas were adopted by the main stream tradition of formal semantics including e.g. Montague Grammar. The approach, however, did not offer any obvious possibility to treat plurals and mass terms. Mass terms, on the one hand, did not fit into the underlying conception of individuals. Plurals, on the other, could only be handled at the price of assigning them logical types different from those of singular count NPs.

Some plural NPs appear to refer to a set of single individuals, others to a group of individuals taken as a whole, and yet others to a group divided in several subgroups. Accordingly, the predicates combining with the NPs of different kinds had to be assigned different types, too. Thus, e.g., *play* in (1a) would denote a set of individuals, in (1b) a set of sets of individuals, whereas *melt* in (2) denotes neither kind of sets.

(1) a. *John plays a tune.*
b. *John, George, Paul, and Ringo played "A hard day's night".*

(2) *The snow will melt.*

Another consequence of this conception was the necessity to consider those determiners as ambiguous which can occur with all three kinds of nouns, e.g. the definite article, demonstratives, or *some, no, any*. Intuitively, all these theory-induced distinctions are very unsatisfactory. There is not the slightest difference in meaning between, say, *the* in *the man* and *the* in *the men* or in *the water*. And likewise *play* has the very same meaning in (1a) as in (1b).

Hence what we need is an alternative theory which allows a uniform treatment of singular and plural count terms and mass terms, along with an integrated analysis of grammatical number, nominal determiners, and quantification, which no longer treats the three basic possible cases as corresponding to different logical types. Both intuition and crosslinguistic evidence — in particular from languages without grammatical number and mass/count-distinction — demand a uniform interpretation.

Harry Bunt's monograph "Mass terms and model-theoretic semantics" promises to offer "an original and detailed solution" (jacket text). We will see if, and how far, it carries us towards an adequate analysis.

Of the book, about one half is devoted to the discussion of the theoretical framework. The other half is concerned with linguistic questions. I will start from the first and turn to the latter later.

1. *Ensemble theory*

Bunt's approach is an extension of the Russellian analysis. As far as count terms, singular or plural, are concerned, he maintains the basic view that identifies singular terms with individuals and plural terms with sets of individuals. In addition, mass terms will refer to "continuous" entities. Bunt subsumes all these conceptions of entities, i.e. individuals in the classical sense, sets of individuals, and continua, under the general concept of "ensemble". This notion is defined in the formal framework of "ensemble theory" (henceforth abbreviated *ET*), an axiomatic system which determines the essential properties of ensembles.

Ensemble theory can best be understood as a generalization of the system ZF, the Zermelo-Fraenkel set-theory, which today is the standard axiomatic system for set-theory in mathematics. In ZF, a first order predicate system, the individuals are all sets. The members of sets are sets, too. All sets are ultimately built up from the empty set by repeated applications of elementary set-theoretical operations. This suffices for mathematical purposes. Numbers, e.g., can easily be defined starting from the empty set. There is only one primitive relation in ZF, the set-membership $\in$.

In ET, now, all individuals are "ensembles". ET, again, is a first order theory. $\in$ is a primitive relation and means set-membership here, too. Some ensembles are sets. The sets are, however, not all built up from the empty set, but can also have members which are not sets. Thus, in ET we have something like so-called urelements. They can be thought of as those objects which play the role of individuals in the traditional model-theoretic approaches: e.g. persons, sausages, but also quantities of some substance such as water. So far we have two kinds of ensembles: sets and elementary non-sets. Bunt calls the sets "discrete ensembles" and the latter kind "continuous ensembles". This notion comprises in particular those kinds of objects which are referred to with mass terms.

For the semantic analysis of mass terms, now, it is essential to be in a position to talk of parts of what mass terms refer to. Hence one needs a part-whole relation between the continuous ensembles. For this purpose, in ET the part-whole relation $\subseteq$ of set-theory is extended to cover also a part-whole relation between continua. In contrast to ZF, Bunt therefore uses $\subseteq$ as a second primitive relation in addition to set-membership. For sets, $\subseteq$ is just set-inclusion, for continuous ensembles it is subcontinuumship. Discrete ensembles and continuous ensembles can be united to form "mixed" ensembles. Ensembles, in general, can be thought of as consisting of a discrete half and a continuous half, one or both of them possibly being empty. A mixed ensemble is part of another ensemble, if the respective components of the first are parts of the latter.

In set-theory, set-inclusion can be defined as the relation which holds between A and B if and only if all elements of A are also elements of B. In ET, only one half of this biconditional is postulated:

(3) $A \subseteq B \quad \Rightarrow \quad \forall x(x \in A \rightarrow x \in B)$

Consequently, the converse need not be true. In particular, A and B can have the same elements and yet be different. This is the case if they differ in their continuous components. Instead of the converse of (3), the weaker "axiom of unicles" holds in ET, according to which singleton sets, i.e. sets with one element, have no other parts than themselves and the empty set.

The consequence of this axiom — which of course also holds in ZF — is the very important feature of ET that the two notions of "part-of" covered by $\subseteq$ do not merge. The part-whole relation of ET obtains either between two discrete ensembles or between two continuous ensembles or between the respective components of mixed ensembles. Discrete ensembles cannot have continuous ensembles as parts (although as elements!) and continuous ensembles do not have sets as parts. An example may illustrate this point.

Let "the furniture of this room" consist of just one chair c and one desk d. If "the furniture in this room" is conceived of as a discrete ensemble f = {c,d}, then it has exactly four parts, namely the sets {c, d}, {d}, {c}, and the empty set Ø. To be sure, c and d have infinitely many parts. E.g., d may have a drawer dr with a handle h. Thus we can build a chain

(4) $\ldots \subseteq h \subseteq dr \subseteq d$

but we cannot continue this chain of part-whole relationships to arrive finally at f, because d (and c) are not parts but elements of f. Not c and d, but only {c}, and {d} are parts of f. Due to the axiom of unicles. {d} has only two parts, itself and the empty set. In particular, neither d nor dr nor any parts thereof are parts of {d}. Any possible chain that links the parts of d with the furniture f would be interrupted by an instance of set-membership, e.g.:

(5) $\ldots \subseteq h \subseteq dr \subseteq d \in \{d\} \subseteq f.$

To the left of $\in$ the part-of symbol means subcontinuumship and to the right of it set-inclusion.

The axiomatic system ET is thus obtained from ZF by weakening the condition which relates set-membership and the part-whole relation $\subseteq$. Conversely one could add the converse of (3) to the axioms of ET and obtain ZF. It is hence a trivial fact, that ZF can be embedded in ET and that ET is consistent with ZF.

Bunt, however, takes up some ninety pages on the discussion of ET. This part of the book contains a lot of unnecessary formalism, e.g. a chapter in which he proves the consistency of ET with ZF by constructing an alleged model which adds nothing to the understanding of his system.[2] Another chapter is devoted to the discussion of the relationship between ET and ZF. Although mathematical soundness is certainly desirable, the formal discussion could have been restricted to at most one third of the room it takes in the book. Instead, the reader will miss a more perspicuous explanation of the underlying intuitions.

2. *Mass terms*

2.1 *The basic treatment*

Besides syntactic differences concerning the distribution of determiners (pp. 9-15), Bunt considers the semantic properties of both cumulative and distributive reference as characteristics of mass terms. A term *m* refers cumulatively if any sum (or union) of parts which are "m" is also "m". This property unites mass terms and plural terms: if A is coffee/beans and B is too, so is the union of A and B.

Distributive reference is the property of a term to apply to an object A if and only if it applies to all parts of A. If A is water, e.g., all parts of A are water again. This does not hold for singular count terms, the parts of "a hand", e.g., are not hands. But it holds (roughly) for plural count terms. The two properties of cumulative and distributive reference, hence, do not suffice to distinguish mass terms from count terms. The crucial difference is apparently that count terms presuppose the existence of units of some kind, in contrast to mass terms.

At a first glance, this assumption appears to be at variance with the meaning of mass terms such as *furniture* for which there are characteristic minimal parts — a fact which also seems to contradict the distributivity hypothesis.

Many authors, including Quine (1960), have raised the argument against the distributivity assumption that for *all* concepts there are minimal parts to the parts of which the concept does not apply. E.g. parts of my furniture may have parts which are not parts of my furniture again. Even continuous concepts such as "water" appear to represent cases where it is not possible to assume that there is an infinity of ever smaller parts.

The minimal parts objection, however, does *not* invalidate Bunt's basic approach. Rather, in his framework, it turns out that the argument confuses two different part-whole conceptions. The objection is based on the assumption that there are part-of chains involving both subcontinuumship and set-inclusion. And that is exactly the kind of chains impossible in ET, as we have just seen.

In case of water it can be argued that there are different conceptions of "water" which must be kept apart. The chemist's H_2O conception is discrete, but the everyday conception is continuous. Normally we do not think of water as a quantity of H_2O molecules, but as a homogeneous mass without any discernible parts. And, in fact, as long as we confine ourselves to everyday procedures, we *can* go on and divide a given quantity of water into ever smaller water-parts. Hence Bunt is able to maintain his *homogeneous reference hypothesis* (p. 46) "Mass nouns refer to entities as having a part-whole structure without singling out any particular parts and without making any commitments concerning the existence of minimal parts". Consequently, he assigns all NPs ensemble interpretations. Count NPs always denote discrete ensembles, whereas mass terms may refer to any possible kind of ensemble.

2.2 *Two level semantics*

Semantics, Bunt argues, should on the one hand provide an interpretation of natural language sentences which accounts for those and only those meaning structures which are explicitly expressed. This conception of semantics leads to what he calls the "formal level" of interpretation. On the other hand, he argues, there is a further semantic level, the "referential level", where we choose out of the general potential of the formal meaning those more specific interpretations which result from constraints in the actual discourse domain.

The distinction between the formal and the referential level of interpretation, in general, is designed to handle ambiguities of different kinds in a way that, on the formal level, all possible interpretations are merged to what is formally one meaning. In the transition to the referential level the actual interpretations are filtered out of the formal meaning.

Bunt provides a syntactic fragment as is done in Montague Grammar, which is translated in a first step into an ensemble logic language EL_f. The result is a formal interpretation, which is formally unambiguous, but contains lexically ambiguous expressions. These are disambiguated in a second translation step into a language EL_r. This step, then, produces possibly more than one final interpretation. The EL_f-representation may contain several ambiguous subexpressions, and every combination of alternatives admitted by the actual discourse domain yields a possible EL_r-interpretation. Where Montague Grammar has one intermediary translation step between the natural language expressions and the model, Bunt has two.

The intermediary translation level in Montague Grammar is not an uncontroversial matter in theoretical semantics. Arguments have been presented both in favour of and against the adequacy of that assumption in theoretical, linguistic, and psychological respects. If Bunt now proposes to assume yet an additional level, he should provide good reasons for such a step. But, in my opinion, his arguments are far from convincing and the two-level approach should better be abandoned.

Bunt's main point in setting up the two-level approach is his treatment of plural and mass terms. In connection with plurals there are basically two problems he treats. One is represented by the ambiguity of

(7) *These books are heavy.*

The sentence is ambiguous between a collective reading under which the books taken together are heavy, although the single books may be light, and a distributive reading, under which each of those books is a heavy book.

The second problem is represented by sentences such as

(8) *The crane lifted five boats.*

which are not explicit about how many boats were lifted at a time. Here too, one could talk of a collective reading (all five boats lifted together), and a distributive reading (one by one), but then there are further readings: a "group" reading (one or more quintuplets of boats), and a simply unspecific reading under which it is left open in what sizes of groups the boats were lifted in how many events of liftings. The latter ambiguity, however, is none. Apparently all the "different" readings are special cases of the unspecific reading, according to which there were one or more liftings involving a total of five boats. This is what sentence (8) means. If (8) is ambiguous, then every sentence is. We can always impose additional constraints which result in special cases of the general meaning. Bunt apparently regards these distinctions relevant because he sees something like a categorial difference between individuals and sets of individuals. This distinction, however, is pointless. It makes no difference if one considers the object of, say, *lift* to be a ship or a set consisting of one ship. (Does the crane leave the setbraces behind when it lifts the ship as an individual?) If we want to deal with sets (or ensembles) at all, we can just as well assume that the objects of liftings are sets of one or else more members. Furthermore, there is not even a formal argument for the distinction. In intensional logic, there is a type distinction between individuals and sets (or properties) or individuals. Bunt's ensemble theory, however, can be stated in first order predicate logic with all ensembles and sets just being individuals (and all individuals being ensembles).[3] Ensemble theory, then, offers the chance to treat all kinds of noun phrases as referring to objects of the same logical kind. But what Bunt actually does is maintain all the distinctions induced by the linguistically inadequate Russell line of approach and add even more. The logical type system of his EL languages is considerably more complex than that of intensional logic — although it could simply be that of a first order predicate language.

Bunt tries to capture these alleged ambiguities by assuming that predicates do not apply directly but via a "distribution" function to their arguments. In the case of (8), e.g., the distribution function takes the set of boats as argument and yields alternatively its elements, the set as a whole, a set of subsets of various size, or quintuplets of boats as arguments to which *lift* applies. In the transition to the referential level, it is then checked which of the alternatives are compatible with the actual state of affairs.

This approach is also applied to the other kind of ambiguity as represented in (7). The ambiguity in (7), however, is of a different and more substantial kind. The two readings are a real alternative and cannot be seen as special cases contained in a general case. There is nothing corresponding to the unspecific reading (8): (7) cannot mean that the books, weighed in arbitrary subsets of the whole, are heavy. What we have here is rather some kind of scope ambiguity involving the two predications "book" and "heavy" and the plural. Under the collective reading, there is one case of the predicate "heavy" applying to a plurality of "books". Under the distributive reading, there is a plurality of cases of the predicate "heavy" applying to one "book".

The ambiguity can probably only be resolved by a deep analysis of plural. It cannot, however, be accounted for in the way Bunt proposes. According to him, the formal level produces essentially three possible distributions: the distributive, the collective, and the unspecific, which differ in their logical type (individual, set, mixture). In the transition to the referential level, these three possibilities encounter two versions of "heavy": the distributive, and the collective, again of the respective types. Due to type argument constraints, trivially only the two desired readings survive. But this account is unmotivated. There is nothing like two semantically distinguishable meanings of *heavy*, one applying to individuals and one to sets of individuals. After all it is merely a matter of perspective whether something "is" an individual or a set. What *heavy* simply applies to is physical objects and they do not care what kind of logical status they might be assigned.

In the same way he treats plurals, Bunt also deals with corresponding ambiguities of quantification, mass term predication and adjectival mass term modification. Mass terms provide essentially the same problems as plurals: predicates and modifiers can be applied to the whole quantity, to all subquantities, or to minimal parts. Accordingly, the same objection applies to these parts of the theory: some of the distinctions separated are artificial and others are not really adequately dealt with. To my eyes, what he offers in his two-level approach is either non-solutions to problems or solutions to non-problems. He should have done with one level, close to what he calls the formal level, and offer a uniform treatment of the basic kinds of NPs in terms of just "ensembles". The result would have been a real simplification and generalization and might have offered a basis for the treatment of such problems as the ambiguity of (7), which neither he nor (as far as I can see) anybody else has solved so far.

Instead, Bunt presents a theoretical framework that, unnecessarily, is considerably more complex than Montague Grammar — which already lies beyond what many linguists are ready to accept.

From a linguistic point of view he has given away the chance to achieve a closer correspondence between the structure of natural language expressions and their semantic representations. But this does not seem to have been Bunt's major objective. He does not care, e.g., to look for a uniform interpretation of *some, no, all*, or *any* in connection with noun phrases of the different possible kinds. The representation and the discussion centre much more on the formal system than on the linguistic data. To be sure, it would be possible to use Bunt's ensemble theory as a framework for a semantic treatment of natural language NPs which would be much closer to the actual semantic structure.

Such an analysis is presented in Link (1983), a publication which presumably appeared to late to be taken into account in Bunt's book. Link (1983) uses a very similar system[4] but keeps much closer to the linguistic data. He takes all nouns to denote sets of individuals, which can either be continuous or discrete in the sense of Bunt. Grammatical number is treated as part of the semantic content of the noun. Thus singular nouns denote sets of atoms whereas plural (count) nouns denote sets of "sums" of two or more atoms. Determiners which can be used with different kinds of nouns, such as *the, some,* or *all*, receive just one interpretation for all cases. The result is a straightforward compositional analysis. This is the kind of treatment one would prefer from a linguistic point of view.

Bunt's book is hence not of unlimited interest to linguists. It does offer a framework in which it would be possible to treat mass and count terms uniformly, and also he presents a plausible solution to the minimal-parts problem. But the actual treatment of the more involved linguistic problems is not really convincing. Furthermore, the basic approach is often concealed behind an unnecessarily complicated formalism, from which it is a hard piece of work to extract the comparatively simple essential ideas.

NOTES

1) This is a slight simplification as far as definite descriptions (i.e. NPs consisting of a definite article and a noun) are concerned, but the difference is irrelevant here.

2) The existence of that "model" is meant to prove the consistency of ensemble theory. Since ZF can be embedded into ET, this would mean that Bunt is able to provide a model for ZF — something mathematicians have been dreaming of for generations. What Bunt in fact offers is less sensational. It is a proper-class model and not a set and therefore does not prove more than the trivial fact that ET is consistent *relative to ZF*, i.e. if ZF is consistent. (For the set-theoretician: Bunt uses set-induction to define the universe of his model, thereby incorporating the class of all sets.)

3) This is what he actually does in his formal discussion of ensemble theory (ch. 10f.).

4) Link (1983) has two kinds of atomic individuals, "portions of matter" — let us call them "poms" for short — and the individuals they constitute. (This is to distinguish, e.g. my ring from the gold which constitutes that ring.) Non-poms can be combined to complex individuals, so-called "sums". Poms combine with other poms to greater poms which are not complex in that sense, but again atomic. Poms have poms as parts, and non-poms non-poms. Poms can be identified with Bunt's continuous ensembles. In ET, a pom m would "constitute" the set {m}. Atomic non-poms in general would be singleton sets, and the sum operation could be modeled as the union of sets.

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