

Individuation and Quantification

Chris Barker

Department of Linguistics, University of California, San Diego

Judging from the way people talk, the number of entities in a given situation that get recognized as distinct individuals seems to depend on the specific communicative goals of a particular discourse. Admitting that semantic interpretation needs to provide a limited degree of ontological variability can resolve some empirical difficulties associated with Krifka's (1990) treatment of examples like (1).

(1) 4000 ships passed through the lock last year.

The proposition expressed by this sentence will be true in any situation in which there are 4000 distinct ships, each of which passed through the lock during the previous year. However, as Krifka points out, (1) can also be used to describe a situation in which there are fewer than 4000 ships involved, provided that some of the ships pass through the lock more than once and the total number of lock traversals is at least 4000.

We'll need a way of talking about the two types of construals that is neutral with respect to the theoretical status of the objects being counted.

- (2) a. One-to-one reading: one ship for each counted thing.
- b. One-to-many reading: one ship for several counted things.

The one-to-one reading is what any garden-variety theory of semantics would predict for (1). The one-to-many reading is a problem, however. Krifka (1990) gives a compositional analysis on which the readings of (1) arise from a polysemous zero determiner. As an alternative, following the lead of Gupta (1980), Carlson (1982), and Nunberg (1984), I will propose that what is going on here is a form of ontological variability: the semantics

allows operators to quantify either over individuals or over stages of individuals, subject to pragmatic appropriateness.

In what follows, I will describe Krifka's account, point out two empirical shortcomings, motivate a stage-based story, respond to Krifka's objections to stage-based approaches, and explain how the proposed analysis solves the two empirical puzzles.

1 Krifka's analysis

I take Krifka's (1990) main hypothesis to be that a number phrase such as *4000 ships* can either be used to identify entities in the normal fashion (the one-to-one interpretation), or it can denote a degree of a measure function, in which case it does not describe entities directly. When construed as specifying a degree, number phrases can be coerced into measuring entities such as lock traversals that are not in the domain of the original measure function (which measures ships), provided there is a systematic relation between the measured objects and the objects in the original domain. If so, then the one-to-many interpretation is just another example of a natural language construction exploiting a systematic correspondence between the ontological structure of objects and events.

In Krifka's specific analysis, the coercion work is accomplished through the mediation of a determiner meaning.

(3) $[\emptyset_{\text{Det}} [4000 \text{ ships}]_{\text{Nom}}]_{\text{NP}} [\text{pass through the lock}]$

The syntactic structure for both readings is sketched in (3). The zero determiner is hypothesized to be polysemous, having the two interpretations given in (4). (As explained below, OEMR stands for Object-induced Event Measure Relation.)

- (4) a. Object-related zero determiner: $\lambda Q \lambda R \lambda e \exists u [R(e, u) \wedge Q(u)]$
 b. Event-related zero determiner: $\lambda Q \lambda R \lambda e [\mathbf{OEMR}(R)(e, Q)]$

- (5) a. One-to-one reading: $\lambda e \exists u [\text{pass_through_the_lock}'(e, u) \wedge \text{ship}'(u) = 4000]$
 b. One-to-many reading: $\lambda e [\text{OEMR}(\text{pass_through_the_lock}')(e, \lambda u [\text{ship}'(u) = 4000])]$

Applying the definitions in (4) to the example in (1) yields the interpretations in (5). The nominal property Q is instantiated in (5) as the property of being an ontologically complex entity whose parts are (sets of) ships and which has a measure of 4000. R is a verb phrase meaning, which for Krifka is a relation between a subject argument and an event. Thus in (5), the VP denotation $\text{pass_through_the_lock}'$ holds of u and e just in case u is the subject of a passing-through-the-lock event e .

The first determiner meaning in (4a) requires the existence of a (non-atomic) entity u which consists of 4000 distinct ships and which collectively passes through the lock (Krifka gives a semantics for complex events). This produces the one-to-one reading in (5a). The second determiner meaning given in (4b) appeals to the operation **OEMR**, which takes a normal verb phrase meaning and returns an Object-induced Event Measure Relation: if R is the verb phrase relation of passing through the lock, then **OEMR**(R) is a relation between an event e and a quantized measure Q which is guaranteed to hold if e can be decomposed into non-overlapping subevents whose measures add up to the measure specified by Q . That is, if there are 2000 distinct ships which passed through the lock from January to June, and there are also 2000 distinct ships which passed through the lock between July and December, that is sufficient to satisfy the truth conditions given in (5b), even if there is no set of 4000 distinct ships which passed through the lock.

Krifka 1990 makes many deep and genuine contributions, not least among which is noticing the importance of examples like (1) in the first place. Nevertheless, Krifka's

specific explanation for the phenomenon illustrated in (1) has at least two empirical problems that motivate considering an alternative account.

The first problem, also discussed by Krifka (1990:516), is the problem of discourse anaphora. Consider the short discourse in (6) under a one-to-many interpretation:

- (6) a. 4000 ships passed through the lock last year.
b. They each tooted their horn when they cleared the last gate.

What does the pronoun *they* refer to? Under the OEMR analysis, (6a) can be true even if there are only 2000 ships in existence worldwide. If so, then given Krifka's ontological assumptions, the largest collection of ships that the pronoun can refer to numbers at most 2000. Yet intuitively (6b) requires at least 4000 tooting events, one for each of the passing-through events entailed by (6a). Krifka tentatively suggests that pronouns like *they* in (6b) can refer to the concept of ships, rather than to specific ships; yet the distributive *each* and the nature of the predicate (tooting) indicate that there must be some way to get from the referent of the pronoun to actual ships. This is by no means an insurmountable difficulty for the OEMR account, but at the very least requires extending the analysis in a way that is not immediately obvious.

The second problem involves adjectives like *different*. As far as I know, this problem has not been observed before:

- (7) 4000 different ships passed through the lock last year.

According to Krifka's semantics, the nominal expressions *4000 ships* and *4000 different ships* must denote the same property. In particular, even without the adjective *different*, the predicate *4000 ships* will be true of an entity x only if x consists of 4000 distinct ships. This is an entailment of Krifka's additivity requirement on measure relations (page 494,

example (5d); see also page 504). Indeed, if the ships weren't required to be distinct at the level of the nominal meaning, the one-to-many reading of (1) wouldn't be a problem in the first place, since the nominal predicate *4000 ships* could simply be true of some smaller number of ships. In some sense, then, the goal of Krifka's analysis is to provide a way of circumventing the distinctness requirement under certain controlled circumstances.

But the same mechanism that provides the one-to-many reading for (1) also predicts that (7) ought to have a one-to-many reading. However, intuitions are quite clear that such a reading simply is not available. That is, (7) can be true only if there are at least 4000 distinct ships in the world that each passed through the lock.

As a referee puts it, what we would like to say is that *different* somehow blocks the OEMR interpretation. Unfortunately, the fact that Krifka locates the ambiguity of (1) in the determiner means that there is no way to do this without violating the principle of compositionality. That is, the only compositional way for the presence of *different* to affect the interpretation of the larger noun phrase (and therefore the sentence) as a whole is if the nominal *4000 different ships* is capable of denoting something different from *4000 ships*, contra Krifka's explicit analysis.

2 Individuation

So how can we explain the variance in the interpretation of (1) without running into the problems just described? Consider a simple one-to-many interpretation of (1): there are only 2000 ships in the world, and they each pass through the lock twice: once in the spring and once in the fall. When we assert (1), we speak as if there were 4000 distinct ships. I

want to suggest that this is exactly what we are doing: we evaluate (1) against a model in which there are 4000 ship entities.

What determines how we individuate ships? Nunberg (1984:207) provides a target to aim at: “the unified concept of identity that we are after is not hard to describe. When we say that *a* and *b* are “the same”, we mean simply that they are “the same for purposes of argument”: that the differences between them are not material to the point we are after.” Nunberg makes these remarks in connection with a related but different phenomenon, what we might call a many-to-one reading: why is the definite article in *My dog bit the postman’s leg* felicitous in a situation in which the postman has two legs? Despite differences in many particulars, the approach advocated here is very much in the same spirit as Nunberg’s.

I will lead up to a more specific proposal by way of some previous work that approaches what I would like to suggest without quite arriving at it. Gupta (1980), following Geach (1962:63), argues that we must distinguish between predicates that merely specify a property of individuals versus “substantial” predicates. Only substantial predicates are suitable for expressing the meanings of common nouns. These predicates supply two independent sets of criteria:

- (8) Criterion of application: necessary and sufficient conditions required for membership in the extension of a property
- Criterion of identity: necessary and sufficient conditions required for determining whether two entities in the extension of a property are the same or are distinct.

In general, criteria of identity can be quite complex. For instance, the criterion of identity for the common noun *river* must be capable of recognizing the body of water we are rowing on today as the same river as the body of water we rowed on a year ago even though it

consists of an entirely new collection of water molecules, and may even have changed its width and course. (For a philosophical introduction to these issues, see, e.g., Brennan (1988).)

Gupta expresses these notions formally in terms of individual concepts, which are usually treated as functions from world/time pairs to individuals. For present purposes, we can factor out possible worlds, in which case we are left with relations over times and individuals. As we will see, members of such relations can be interpreted as stages of individuals. Like Gupta, Carlson (1982) argues that stages are crucial for distinguishing the meanings of some common nouns. Consider the difference between nouns like *player* and *batter*: in a typical game of baseball a pitcher might face 35 batters, even though there are only nine players on the opposing team. Thus the set of batters corresponding to a particular player are stages of that individual. Carlson suggests that some nouns have stages in their extension rather than individuals.

At first glance, such contrasts are reminiscent of the phenomenon we are trying to explain. But as Krifka notes (p. 488), they depend on a difference in lexical meaning between two different nouns. If we wanted to use such distinctions to explain the two uses of (1), we would have to suppose that the noun *ship* is ambiguous, which is not plausible.

3 Counting stages

What I would like to suggest is that although criteria of application are determined by the lexical meaning of a noun (modulo vagueness), criteria of identity are partly determined by lexical meaning (as for *passenger* or *batter*) and in addition at least partly determined by context.

- (9) *ship*: Criterion of application: must float, must be big, etc.
 Criterion of identity: [lexically unspecified]
- (10) Additional possible criteria of identity supplied by semantics:
 One-to-one reading (general default): long-term self-identity in the real world
 One-to-many reading: stage-identity in the real world

The one-to-one reading results when context supports keeping track of which ship is which over several months' time. The one-to-many reading arises when context favors (as discussed below) considering two stages of the same ship as distinct entities. In both cases, there must be 4000 ship entities present in the model---but several of those discourse entities (stages, if you prefer) may correspond to the same ship in the world of experience.

Krifka cautions (p. 489) that counting stages can be a tricky business. If the ship Eleonore passes through the lock twice, we not only have stages s_1 and s_2 (one for each traversal), we also have $s_3 = s_1 + s_2$, the complex stage corresponding to the mereological sum of the individual stages. But this is no different from the perils of counting plain individuals: if Link's twin girls made a mess in his living room, the number of children is two (one for each girl), not three (spuriously counting the sum of the twins as a third participant). The solution in this domain is the same as well: cardinals and other quantifiers presuppose (at a minimum) a partition on the set of entities they quantify over, whether those entities are individuals or stages. More specifically, suppose we model a stage as an ordered pair $\langle x, e \rangle$ associating an individual x with a specific (possibly stative) event e . Then if $s_1 = \langle El, e_1 \rangle$ and $s_2 = \langle El, e_2 \rangle$, where El is the ship Eleonore and e_1 and e_2 are non-overlapping events of passing through the lock, we have $s_3 = s_1 + s_2 = \langle El, e_1 + e_2 \rangle$, where $e_1 + e_2$ is the mereological sum of two events. Just as the sum of Link's children does

not count as a third distinct individual, the stage s_3 is not distinct from s_1 or s_2 , because its characterizing event $e_1 + e_2$ overlaps the events that characterize s_1 and s_2 .

But there is still a problem: how do we know which events to use for distinguishing stages? The explanation in the previous paragraph works correctly only if we choose lock traversals as our stage-characterizing events e_1 and e_2 . In Krifka's analysis, the fact that lock-traversals are the relevant events comes compositionally, based on the meaning of the verb phrase. In any case, (1) simply cannot be true in a world with fewer than 4000 lock traversals, and any responsible semantic analysis should guarantee this (as does Krifka's).

Fortunately, this constraint follows from well-known logical properties of cardinal determiners. For instance, Barwise and Cooper (1981:189--91) classify cardinals as having the intersection property (often discussed in later work under the rubric of symmetry): if \mathcal{D} is the denotation of a cardinal determiner, then \mathcal{D} satisfies the intersection condition just in case $\mathcal{D}(P)(Q) = \mathcal{D}(P \cap Q)(Q)$ for all choices of P and Q , where P is the property denoted by the nominal and Q is the property denoted by the verb phrase. (Note that the intersection condition is the mirror image of conservativity, the property that Barwise and Cooper call "lives on".) The fact that cardinals obey this condition explains why the following two sentences have identical truth conditions:

- (11) a. 4000 ships passed through the lock.
b. 4000 ships that passed through the lock passed through the lock.

In the present context, P and Q must be properties of stages (as defined above) rather than properties of plain individuals, but that is straightforward enough. In effect, the semantics of the cardinal determiner discards ship stages whose characterizing event is not either a lock-traversal or an event containing a lock-traversal as a subpart. Thus any account that

gets the basic semantics of cardinals right will predict that the verb phrase denotation in effect supplies the set of relevant nominal stages.

We are now in a position to address the first of the two empirical difficulties mentioned above in connection with the polysemous-determiner account. The anaphora displayed in (6) now has a natural explanation: the pronoun *they* simply evokes the witness set that verifies (6a). This turns out to be a collection of (at least) 4000 ship stages, each of which tooted its horn immediately after clearing the last gate of the lock. Difficulties remain; for instance, it is not clear how far beyond the minimal lock traversal the component events in the ship stages may extend (for instance, consider the continuation *They each had to pay a fee at the next harbor*). Nevertheless, the stage approach seems to have a head start on explaining this type of anaphora over the OEMR account.

When will a situation favor a stage-level criterion of identity? One rule of thumb seems to be that an interpretation should fail to recognize that two entities are stages of the same individual roughly in the same situations in which a human being might plausibly fail in the same way. It is no accident that the best examples of this phenomenon concern situations in which there are too many individuals to easily keep track of; in which the individuals involved are so similar that they are difficult to distinguish; or in which events are typically widely separated in time from each other or from the utterance time. In (1), for example, logistical facts guarantee that a given ship will next return to the lock only after several weeks' worth of similar vessels have passed through. It is much more difficult to get a many-to-one reading of (1) when there are only a small number of ships involved. A referee suggests considering the Chicago river-lake Michigan sightseeing route, which

we can assume is plied by just four sightseeing ships. It would be odd to say that *4000 sightseeing ships passed through the lock last year* even if each of the 4 ships did go through 1000 times. This asymmetry is a mystery if the readings arise from a polysemous determiner---why should the availability of the event-based determiner meaning depend on the number of ships involved? On the explanation given here, in contrast, the connection between semantic individuation and individuation in the world of experience is the very foundation of the analysis.

This leads us to an explanation for the second empirical problem discussed above, namely, the need to account for the truth conditional effect of *different*.

- (12) If a common noun phrase *N* has criterion of application *C* and criterion of identity *I*, then the common noun phrase [*different N*] has criterion of application *C* and a criterion of identity which is the disjunction of *I* with the property of long-term self-identity in the actual world.

According to (12), the presence of *different* enforces a relatively coarse-grained condition of self-identity. The effect of (12) on nominal extensions will be to clump stages together into equivalence classes. Assuming that what cardinals (and quantifiers in general) count are equivalence classes, (12) guarantees that in the presence of *different*, there will be at most one equivalence class per long-term individual. Thus quantifiers rely on conditions of identity in order to know what to count.

In sum, recognizing that nominal identity conditions sometimes are determined lexically, and sometimes semantically and pragmatically, provides a simple and direct account of the ambiguity of (1) without postulating multiple meanings for a silent determiner. Unlike Krifka's (1990) analysis, it also provides a natural account of the anaphora facts, and gives adjectives like *different* appropriate truth-conditional work to do.

Note

I first presented a version of this material at the 1994 LSA meeting in Boston. I gratefully acknowledge valuable comments from Manfred Krifka, Louise McNally, and two anonymous *LI* referees. Unfortunately, I only become aware of Doetjes and Honcoop 1997 in the final stage of revision. In the course of extending and revising Krifka's (1990) analysis, they conclude that the many-to-one reading involves quantification over ordered pairs consisting of an individual and an event, a result that is strikingly similar to the position advocated here. However, unlike me, they do not associate these pairs directly with nominal denotations, nor do they interpret them as stages (though see their fn. 17). Consequently they inherit from Krifka's analysis both of the empirical difficulties discussed below; see especially their notions of standardization and generalization, which they explicitly intend to do the work of Krifka's additivity requirement.

References

- Barwise, Jon and Robin Cooper. 1981. Generalized Quantifiers and Natural Language. *Linguistics and Philosophy* 4:159-219.
- Brennan, Andrew. 1988. *Conditions of Identity*. Oxford: Clarendon Press.
- Carlson, Greg. 1982. Generic terms and generic sentences. *Journal of Philosophical Logic* 11:145-181.
- Doetjes, Jenny and Martin Honcoop. 1997. The semantics of event-related readings: A case for pair-quantification. In *Ways of Scope Taking*, ed. Anna Szabolcsi, 263-310. Dordrecht, Holland: Kluwer.
- Geach, Peter. 1962. *Reference and Generality*. Ithaca, New York: Cornell University Press.
- Gupta, Anil. 1980. *The logic of common nouns: an investigation of quantified modal logic*. New Haven, Connecticut: Yale University Press.
- Krifka, Manfred. 1990. Four thousand ships passed through the lock: object-induced measure functions on events. *Linguistics and Philosophy* 13: 487-520.
- Nunberg, Geoffrey. 1984. Individuation in Context. *WCCFL* 2, 203-217.