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Proceedings of the Thirteenth Annual Meeting of the Berkeley Linguistics Society (1987), pp. 355-365

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The Annual Proceedings of the Berkeley Linguistics Society is published online via [eLanguage](#), the Linguistic Society of America's digital publishing platform.

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I take the major concerns of semantic theory to be (1) the form of the mentally encoded information that we call "concepts," and (2) the principles used in (a) performing inferences on the basis of this information and (b) relating this information to other forms of information used by the human mind, including not only linguistic representations but also visual information (a la Marr (1982)) and other sensory and cognitive faculties. A semantic theory must therefore include at least three formal components:

(1) a set of formation rules that collectively describe in finite form the expressive power of the "language of thought," paralleling, for instance, the set of formation rules (the grammar) that delineate possible syntactic structures in a language;

(2) a set of inference rules that describe in finite form the allowable derivations from one conceptual expression to another (these may include rules of "invited inference" and "heuristics" as well as logical entailments);

(3) for each other form of information that conceptual information can be related to, a finite set of correspondence rules that define the mapping.

Under such a conception, much of semantic theory is not part of linguistics per se, since the conceptual structures with which the theory is concerned are not language-dependent. (Only the correspondence rule component has specifically to do with language.) I assume, on grounds of evolutionary conservatism, that nonlinguistic organisms--both higher animals and babies--also possess conceptual structures in their mental repertoire, perhaps not as rich as ours, but formally similar in many respects. The difference between us and the beasts is that we evolved a capacity to learn and process syntactic and phonological structures and the mappings from them to conceptual structures and to the auditory and motor peripheries. These mappings permit us a relatively overt realization of conceptual structure unavailable to other organisms.

However, this does not mean that linguists should not be concerned with semantic theory. Language provides the

best evidence we have for the constitution of conceptual structure, and linguistic methods are clearly applicable to the problem. If nonlinguistic evidence arises as well, say from the theory of vision, it should be welcomed as well. That is, semantic theory is the meeting ground of linguistics and other branches of psychology. (See Jackendoff 1987a,b for further discussion of this point and some concrete connections to visual theory.)

What do I mean by X-Bar Semantics? The term is obviously chosen in allusion to X-Bar Syntax, the aspect of the Extended Standard Theory and its descendants that concerns the nature of syntactic categories. Chomsky's original paper on the topic, "Remarks on Nominalization" (1970), was written in reaction to a series of arguments (e.g. Postal 1966, Ross 1969, Lakoff 1971) that since two syntactic categories (say Adj and V) share certain properties, one must be transformationally derived from the other. Chomsky argued that it is impossible to state a transformational derivation of any generality, and that the sharing of properties should instead be expressed by decomposing syntactic categories into a feature system--just as properties shared among phonological segments of a language are expressed in terms of distinctive features. While this program of research has not proven totally successful as a formal move, the points of similarity among syntactic categories that form the underpinnings of X-Bar theory are undeniable. Here are some of the major aspects of the theory:

(a) The category of a syntactic phrase is determined by the lexical category of its head (with marked exceptions such as gerundives).

(b) All major lexical categories (N, V, A, P) can subcategorize complements and impose selectional restrictions on them; the complements can range over most of the major phrasal categories.

(c) All phrasal categories permit, in addition to subcategorized arguments, other kinds of modification, in particular restrictive modifiers and appositives.

(d) Some categories (V and N in English) can support subjects, and others cannot.

(e) Some categories (V and P in English) can support direct objects (or, in some theories, case-marking), and others cannot.

In Semantics and Cognition (Jackendoff 1983) I proposed that much the same basic organization applies to major conceptual categories. Instead of a division of formal categories into such entities as constants, variables, predicates, and quantifiers, each of which has

nothing in common with the others, I argued that the major units of conceptual structure are conceptual constituents, each of which belongs to one of a small set of major categories such as Thing, Event, State, Place, Path, Property, and Amount. These are obviously all quite different in what kind of reference they pick out, but formally (algebraically) they have a great deal in common:

(a) Each contentful major syntactic constituent of a sentence (this excludes epenthetic it and there) maps into a conceptual constituent in the meaning of the sentence. For example, in John ran toward the house, John and the house correspond to Thing-constituents, the PP toward the house corresponds to a Path-constituent, and the entire sentence corresponds to an Event-constituent. (However, the converse of (a) is not the case: not every conceptual constituent in the meaning of a sentence corresponds to a syntactic constituent.)

(b) Each conceptual category supports the encoding of units not only on the basis of linguistic input, but also from the visual (or other sensory) environment. For example, That is a robin points out a Thing in the environment; There is your hat points out a Place; Can you do this? accompanies the demonstration of an Action; The fish was this long accompanies the demonstration of a Distance, independent of the object whose length it is.

(c) Many of the categories support a type-token distinction. For example, just as there are many individual tokens of the Thing-type expressed by a hat, there may be many tokens of the Event-type expressed by John ate his hat, and there may be many different individual Places of the Place-type expressed by over your head. (Properties and Amounts, however, do not so clearly differentiate tokens and types.)

(d) Many of the categories support quantification. With Things: Every dinosaur had a brain. With Actions: Everything you can do, I can do better. With Places: Anyplace you can go, I can go too.

(e) Each conceptual category has some realizations in which it is decomposed into a function-argument structure; each argument is in turn a conceptual constituent of some major category. The standard notion of "predicate" is a special case of this, where the matrix category is a State or Event, as in John is tall (arguments are John (Thing) and tall (Property)), John loves Mary (arguments are both Things), and John tried to leave (arguments are John (Thing) and <PRU> to leave (Event or Action)). But a Thing also may have such a decomposition, as in father of the bride or president of the LSA; a Path may have a Thing

as argument, as in to the house, or a Place, as in from under the table; a Property like afraid of Harry has a Thing as argument.

(f) The conceptual structure of a lexical item is an entity with zero or more open argument places. The meanings of the syntactic complements of the lexical item fill in the values of the item's argument places in the meaning of the sentence. So, in the examples above, be is a State-function whose arguments are found in the subject and predicate adjective positions; love is a State-function whose arguments are found in subject and object position; try is an Event-function whose arguments are the subject and the complement clause; father and president are Thing-functions whose arguments are in the NP complement; from is a Path-function whose argument is a complement PP or NP; afraid is a Property-function whose argument is the complement NP.

These observations, though slightly tedious, should convey the general notion behind X-Bar Semantics: none of the major conceptual categories can be insightfully reduced to the others, but they share important formal properties. Thus, parallel to the basic formation rules of X-Bar Syntax in (1), we might propose the basic formation rule for conceptual categories in (2).

- (1) XP --> Spec - X'
 X' --> X - Comp
 X --> [+N, +V]

- (2) Entity --> [Event/Thing/Place/...
 Token/Type
 F (<Entity₁, <Entity₂, <Entity₃>>)]

In addition, observation (a) above can be formalized as a general correspondence rule of the form (3), and observation (f) can be formalized as a general correspondence rule of the form (4).

- (3) XP corresponds to Entity

- (4) [X⁰ <YP <ZP>>] corresponds to [Entity
 F (<E_i>, <E_j, <E_k>>)]
 where YP corresponds to E_j, ZP corresponds to E_k,
 and the subject (if there is one) corresponds to E_i.

The examples in (a)-(f) above show that the values of +N, +V, and the conceptual n-ary feature Thing/Event/Place...

are irrelevant to the general form of these rules. The algebra of conceptual structure and its relation to syntax is best stated cross-categorially.

These phenomena, explored in more detail in Semantics and Cognition, chapters 3, 4, and 9, concern areas where the syntactic category system and the conceptual category system match up fairly well. In a way, the relation between the two systems serves as a partial explication of the X-Bar properties of syntax: syntax presumably evolved as a means to express conceptual structure, so it is natural to expect that some of the structural properties of concepts would be mirrored in the organization of syntax.

On the other hand, there are other aspects of conceptual structure that display a strong X-Bar character but which are not expressed in so regular a fashion in syntax (at least in English). One such aspect has been discussed steadily but not centrally in the literature over the last 20 years. The best known line of descent in these investigations starts with Vendler 1967 and continues through such works as Verkuyl 1972, Dowty 1979, Hinrichs 1985, and Bach 1986; other independent lines that have come to my attention but not to that of the "main line" include Talmy 1978, Platzack 1979, and Declerck 1979. A representative range of facts appears in (5).

(5) { For hours, }
 { Until noon, }

- a. Bill slept.
- b. The light flashed. [repetition only]
- c. Lights flashed.
- d. *Bill ate the hot dog.
- e. Bill ate hot dogs.
- f. *Bill ate some hot dogs.
- g. Bill was eating the hot dog.
- h. ?Bill ran into the house. [repetition only]
- i. People ran into the house.
- j. ?Some people ran into the house. [repetition only]
- k. Bill ran toward the house.
- l. Bill ran into houses.
- m. Bill ran into some houses. [repetition only]
- n. Bill ran down the road.
- o. *Bill ran 5 miles down the road.

[ok only on reading where 5 miles down the road is where Bill was, not where 5 miles down the road is how far he got.]

The question raised by these examples is why prefixing for hours or until noon should have such effects on such a disparate range of examples. The essential insight is that for hours places a measure on an otherwise temporally unbounded process, and that until noon places a temporal boundary on an otherwise temporally unbounded process. Bill slept is such a process, so it can be prefixed with these expressions. On the other hand, Bill ate the hot dog is a temporally bounded event, so it cannot be further measured or bounded.

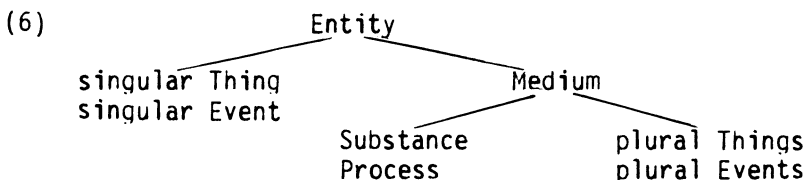
There are two ways in which a sentence can be interpreted as a temporally unbounded process. One is for the sentence to directly express a temporally unbounded process, as is the case in (5a, c, e, q, i, k, l, n). We will return to these cases shortly. The other is for the sentence to be interpreted as an indefinite repetition of an inherently bounded process, as in (5b, h, j, m). (Bill ate the hot dog, like Bill died, is bounded but unrepeatable, so it cannot be interpreted in this fashion.) This sense of repetition has no syntactic reflex in English, though some languages have an iterative aspect that does express it.

How should this sense of iteration be encoded in conceptual structure? It would appear most natural to conceive of it as an operator that maps a single event into a repeated sequence of individual events of the same type. Brief consideration suggests that in fact this operator has exactly the same semantic value as the plural marker, which maps individual Things into collections of Things of the same type. That is, this operator is not formulated specifically in terms of Events, but should be applicable in X-Bar fashion to any conceptual entity that admits of individuation. The fact that this operator does not receive consistent expression across syntactic categories should not obscure the essential semantic generalization. However, it is a place in the grammar (at least in most languages) where the syntax and semantics are not parallel in structure.

Returning to the inherently unbounded cases, it has often been observed that the bounded/unbounded (event/process, telic/atelic) distinction is strongly parallel to the count/mass distinction in NPs. For instance, a part of an apple (count) cannot not itself be described as an apple, and a part of John ate the sandwich (event) cannot itself be described as John ate the sandwich. By contrast, any part of a body of water (mass) can itself be described as water (unless the part gets too small with respect to its molecular structure); any part

of John ran toward the house can itself be described as John ran toward the house (unless the part gets smaller than a single stride). These similarities suggest that conceptual structure should encode this distinction cross-categorially too, so that the relevant inference rules do not care whether they are dealing with Things vs. Substances or Events vs. Processes.

It has also been often observed that plurals behave in many respects like mass nouns, and that repeated events behave like processes. (Talmy suggests the term "medium" to encompass them both.) The difference is only that in plural nouns and repeated events the "grain size" is fixed by the singular individuals making up the unbounded medium, so that decomposition of the medium into parts is not as arbitrary. Thus the structure of the desired feature system is organized as in (6).



That is, the features that distinguish Things from Events are orthogonal to the features differentiating individuals from media, and within media, homogeneous media from aggregates of individuals.

The examples in (5) also demonstrate that Paths participate in the system shown in (6). For instance, to the house is a bounded Path; toward the house and down the road are unbounded Paths, any part of which can also be described as toward the house or down the road, and into houses describes multiple bounded Paths, one per house.

What factors are involved in determining whether a sentence expresses an Event or a Process? The examples in (5) illustrate a wider range of such factors than are generally cited in any single piece of work in the literature I am familiar with. These factors include the following:

- (a) choice of verb (5a vs. 5b)
- (b) choice of aspect (5d vs. 5q)
- (c) choice of singular or bare plural in the subject (5h vs. 5i), in the object (5d vs. 5e), and in object of a preposition (5h vs. 5l)
- (d) choice of determiner in the subject (5i vs. 5j), in the object (5e vs. 5f), and in the object of a preposition (5l vs. 5m)
- (e) choice of preposition (5h vs. 5k)
- (f) choice of prepositional specifier (5m vs. 5n)

How all these factors enter into the choice of boundedness or unboundedness for a sentence is not altogether clear. The general shape of the solution would seem to take the form of an algebraic system that combines the values of the features for any conceptual function and its arguments to derive a value for the entity as a whole. This system, operating recursively up through the conceptual embeddings, will eventually take into account the values for each of the parts of the sentence. (Many of the authors cited above propose fragments of such a system, but none develops it in the full generality required by the range of examples in (5).) It is tempting to speculate that such a system is at the root of a deeper account of the scope of quantification--an explanation of why an operator on a single NP in a sentence can extend its effects over the entire sentence.

To sum up the discussion of (5): these examples show that (a) there is a common feature system that deals with boundedness and individuation, cutting across Things, Events, and Paths; (b) the system is expressed by a heterogeneous collection of syntactic factors, including lexical choice, aspect, determiner, and perhaps case (e.g. the use of partitive in some languages to express unboundedness); (c) there is a set of algebraic principles over conceptual structure that correlates the values of the features in all parts of the sentence with the features of the sentence as a whole.

Here is an example that illustrates some of the explanatory power achieved through such a system: the meaning of the word end. For a first approximation, an end is a zero-dimensional boundary of an entity conceived of as 1-dimensional. So, for the simplest case, the end of a line is a point. A beam is conceived of (as in Marr (1982)) as a long axis elaborated by a cross-section. The end of a beam is a point bounding the long axis, elaborated by the same cross-section; this makes it 2-dimensional. A table can be said to have an end just in case it can be seen as having a long axis (e.g. it is rectangular or oval but not square or circular); the end is then just the boundary of the long axis elaborated by the short axis. However, in standard X-Bar fashion, we can speak of the end of a week (a point bounding a 1-dimensional period of time) and the end of a talk (a zero-dimensional State bounding an Event that extends over time).

However, there is an apparent difficulty in this account of end. If the end of a talk is a point in time, how can one felicitously say, "I am now doing the end of

my talk," or "I am now finishing my talk"? The progressive implies the existence of a process taking place over time, and therefore seems to attribute a temporal extent to the end.

An answer is provided by looking at the Thing system. Consider what is meant by Bill cut off the end of the ribbon. Bill cannot have cut off the geometrical boundary of the ribbon. Rather, the sense of this sentence shows that the notion of end permits an optional elaboration: the end may consist of a part of the object it bounds, extending from the actual boundary into the object some small distance epsilon.

There are other boundary words that obligatorily include this sort of elaboration. For instance, a crust is a 2-dimensional boundary of a 3-dimensional volume, elaborated by extending it some distance epsilon into the volume. Border carries a stronger implication of such elaboration than does edge: consider that the border of the rug is liable to include a pattern in the body of the rug, while the edge of the rug is more liable to include only the binding.

The claim, then, is that end includes such an elaboration as an optional part of its meaning. Going back to the case of Events, I can therefore felicitously say "I am doing the end of my talk" or "I am finishing my talk" if I am within the region that extends backward the permissible distance epsilon from the actual cessation of speech. In other words, the featural machinery of dimensionality and boundaries, with which we characterize Things and the regions of space they occupy, extends over to Events as well. That's why the word end is so natural in either context. The main difference in the systems is that Things have a maximum dimensionality of 3, while Events have a maximum dimensionality of only 1, so that certain distinctions in the Thing system are leveled out or unavailable in the Event system. Only in a theory of conceptual structure that permits this sort of cross-categorical generalization can even the existence of a word like end be explained, much less the peculiarities of its use in so many different contexts.

A general conclusion seems to emerge from the considerations I have raised here. It is legion among people studying semantics that the natural categories we speak of, such as horses and chairs and cups and games and running and believing, are full of complex phenomena, possibly invoking fuzzy categories and/or stereotypes and/or other formally intimidating notions. However, the present discussion has suggested that beneath this surface

welter is a highly abstract formal algebraic system that lays out the major parameters of thought. The distinctions in this system, by contrast with the factors that distinguish categories within the major parameters, are not at all fuzzy or nondiscrete. Nor are they based on experience: rather, they are the machinery the human mind has to channel the ways in which all experience can be mentally encoded.

Some aspects of this system are reflected rather directly in the grammar of natural language, but others are much less so. Moreover, the primitives of this system, like phonological features, do not appear in isolation as individual morphemes such as cause or do. Rather, they are more like the quarks of particle physics: they can only be observed in combination, and their existence must be inferred from their effects on the language as a whole. This does not impugn their status as discrete elements forming strict families of distinctions. However, it makes it more difficult to discover the underpinnings of semantic structure without first attaining a fairly thorough understanding of the grammar of natural language.

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Acknowledgment

The research reported here was supported in part by NSF Grant IST 84-20073 to Brandeis University.