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Parts and boundaries*

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Abstract

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Within the framework of Conceptual Semantics, a family of conceptual features and functions is developed that accounts for phenomena in the semantics of noun phrases such as the mass-count distinction, plurality, the partitive construction (a leg of the table), *the constitutive construction* (a house of wood), *the "Universal Packager"* (three coffees), *and boundary words such as* end, edge, *and* crust. *Using the strong formal parallelism between noun phrase semantics and event structure that is a hallmark of the Conceptual Semantics approach, the features and functions of the NP system are applied to a wide range of problems in event structure, for example the analysis of the Vendler classes, the meaning of the progressive, the "imperfective paradox", and "aktionsarten" such as the syntactically unexpressed sense of repetition in* The light flashed until dawn.

Crucial to the analysis is that these features and functions can be expressed in syntactic structure either by being part of lexical conceptual structure, or by use of a morphological affix, or by being associated with the meaning of a construction such as N of NP *or nominal compounding. Alternatively, they may remain unexpressed altogether, being introduced into the conceptual structure of a phrase by "rules of construal". This shows that lexical semantics and phrasal semantics interpenetrate deeply, and that there is no strict one-to-one correspondence between syntactic and semantic structures. In addition, the analysis provides further evidence that natural language semantics must be based on a psychological view of meaning – it must be concerned with how language users are constructed to understand and schematize the world.*

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1. The framework

Given the many different opinions on what semantics is supposed to be about, I had better begin by situating this study in the overall enterprise of which it forms a part. A convenient starting point is Chomsky's (1986) distinction between two broad views of language. One, *E-language* or "externalized language", sees language as an external artifact, existing independently of speakers. The other, *I-language* or "internalized language", sees language as a set of mental principles that account for linguistic understanding and use. From the standpoint of psychology, the latter view is of greater interest.

One can approach semantics, the theory of linguistic meaning, from either of these views. For the most part, standard versions of truth-conditional semantics are concerned with the relation of language to the world independent of speakers, that is, *E-semantics*. By contrast, this study (along with Jackendoff 1983, 1990) is an inquiry into the principles of mental representation that support thought – that is, it belongs to a theory of *I-semantics*, which in principle should be more compatible than an E-semantic theory with the concerns of both psychology and generative grammar.

The basic hypothesis underlying Conceptual Semantics, the particular version of I-semantics pursued here, is that there is a form of mental representation called *conceptual structure* that is common to all natural languages and that serves as the "syntax of thought".[1] Conceptual structure is envisioned as a computational form that encodes human understanding of the world.[2] Rules of inference, pragmatics, and heuristics can all be thought of as principles that license the formation of new conceptual structures on the basis of existing ones. Since conceptual structure serves as the form of linguistic meaning, there must also be a set of *correspondence rules* that relate it to syntactic representations, which permit the expression of meaning. In addition, since the conceptualization of the world must be related to perception and action, conceptual structure must be linked by further sets of correspondence rules to the mental representations proprietary to the perceptual systems and to the production of action. The overall layout of the theory is shown in Figure 1.

Accordingly, the goal of Conceptual Semantics is to articulate each of the

[1] I use this term to distinguish my notion of conceptual structure from Fodor's (1975) "Language of Thought"; the latter carries with it the property of intentionality, from which I wish to distance myself. See Jackendoff (1990, 1991) for discussion.

[2] However, conceptual structure is not the only form of representation available to encode one's understanding of the world. Aspects of the world that are understood spatially are encoded in another central representation whose properties resemble Marr's (1982) 3D model structure (see Jackendoff, 1987b; Jackendoff & Landau, 1991 for discussion, as well as section 5); there may well be other central representations as well, for instance a "body representation" that encodes the position and state of the body. What distinguishes conceptual structure from these others is its *algebraic* character – its being formalized in terms of features and functions – and its capacity to encode abstractions.

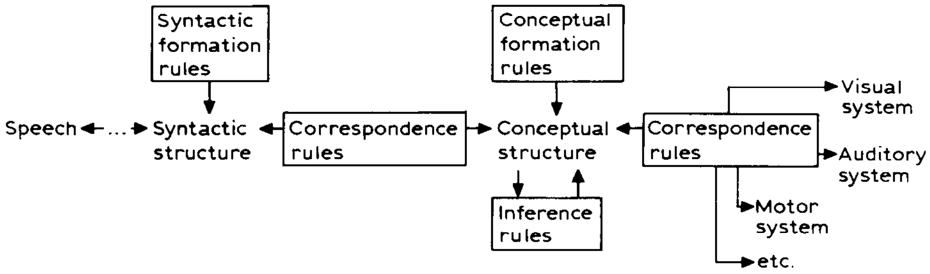

Fig. 1.

systems of principles in Figure 1: (a) the formation rules for conceptual structure, that is, the primitives and principles of combination that collectively generate the infinite class of possible concepts – both lexical concepts (word meanings) and phrasal concepts (including sentential concepts or *propositions*); (b) the rules of inference, pragmatics, and heuristics; (c) the correspondence rules between conceptual structure and the other representations with which it interacts. None of these goals, of course, can be pursued in isolation; they are intimately interdependent. The present study will touch on all of them to varying degrees.

The main issue, however, will be the primitives and principles of combination for a particular conceptual domain, that dealing with parts and boundaries. These are to be universal: they define what there is for language to express, and they do not depend on the vehicle of expression. We will also be concerned with the correspondence rules that determine the translation from conceptual structure into syntactic and morphological structure of English. Such rules are of the form "Such-and-such a configuration in conceptual structure corresponds to such-and-such a syntactic configuration." They thus must contain two structural descriptions, one for each of the levels being placed in correspondence. Since the syntactic side of the correspondence is in part language-particular, it is to be expected that the correspondence rules will also be language-particular, though undoubtedly constrained by principles of Universal Grammar that pertain to the correspondence rule component.

Within this framework, a lexical item can be seen as a correspondence between well-formed fragments of phonological, syntactic, and conceptual structure. Hence the lexicon is conceived of as part of the correspondence rule component. The leading questions of lexical semantics then come to be framed as: (a) What fragments of conceptual structure can be encoded in lexical items (of, say, English)? (b) When lexical items are combined syntactically, how are they correspondingly combined in conceptual structure, and what principles license these correspondences?

When one claims that conceptual structure can be described in terms of primitives and principles of combination, and in particular that lexical items can be conceptually decomposed into primitives,[3] the question arises of how one justifies primitives. This question in turn falls into two parts. The first is how to tell in general whether one putative primitive is better than another. In fact, an isolated primitive can never be justified; a primitive makes sense only in the context of the overall system of primitives in which it is embedded. With this proviso, however, I think a particular choice of primitives should be justified on the grounds of its capacity for expressing generalizations and explaining the distribution of the data. That is, a proposed system of primitives is subject to the usual scientific standards of evaluation.

The other part of the question concerning the justification of primitives is how to tell whether the primitives one has proposed are *really* primitive – with the insinuation that if one can't tell whether one is all the way at the bottom, the enterprise is hopeless. My answer is that one probably can't tell whether one is all the way at the bottom, but that this is not a matter for worry. Consider that the decomposition of all substances into 92 primitive elements was a major breakthrough 100 years ago, but that these primitives in turn have been further decomposed, first into electrons plus nucleus, then into electrons plus protons and neutrons, then all of these into quarks, which in turn are combinations of more primitive features such as spin, color, up/down, etc. Each level of decomposition explained more about the nature of matter and raised new questions of its own; and each step was cause for excitement, not discouragement. We will see parts of a similar progression here, when later in the paper some of the categories treated as primitive in Jackendoff (1983) undergo further decomposition in terms of a more explanatory set of primitives.[4]

A final general issue I must mention is that of the *reference* of linguistic expressions. Standard formal semantics seeks to explicate the relation of reference between language and the external world, usually modeling the world set-theoretically and often using the notion of possible worlds. In the present framework of I-semantics, the relation between language and the external world is taken to be mediated by the way the mind understands the world, as encoded in mental representations. Thus this theory contains no notion of reference in the standard sense. Rather, the corresponding construct is the mind's *construal* of the world, or how the speaker is at the moment inviting the hearer to *view* the world. This difference will play an important role in what is to follow, since the semantics

[3]Jerry Fodor, in an influential series of publications (Fodor, 1970, 1981; Fodor, Fodor, & Garrett, 1975; Fodor et al., 1980), has denied that lexical items have semantic decompositions. For replies, see Jackendoff (1983, Ch. 7; 1990, Ch. 1).

[4]Among other things, it will develop that there are probably no *words* that directly express conceptual primitives; all words are composite. This should not be cause for alarm. In chemistry/physics, after all, none of the quarks (not to mention quark-features) appear in isolation. Closer to home, no phonological primitives appear in isolation either; one of the major points of Prague School phonology, preserved in the generative tradition, is that the phoneme is always divisible into features which themselves never occur in isolation.

of parts and boundaries proves in many respects to depend crucially on what construals of objects and events are possible and salient.

2. The technology of conceptual semantics

Much of the theory of conceptual semantics (Jackendoff, 1976, 1983, 1987a, 1990) has been concerned with the encoding of verb-argument structure. To give the reader a feel for the notation and the claims it makes, consider a simple syntactic structure like (1):

(1) $[_{S}[_{NP}\ \text{Bill}][_{VP}[_{V}\ \text{went}][_{PP}[_{P}\ \text{into}][_{NP}\ \text{the house}]]]]$

This corresponds to the conceptual structure (2):

(2) $[_{\text{Event}}\ \text{GO}([_{\text{Thing}}\ \text{BILL}],[_{\text{Path}}\ \text{TO}([_{\text{Place}}\ \text{IN}([_{\text{Thing}}\ \text{HOUSE}])])])]$

Let me unpack this expression. Paralleling the notation for syntactic structure, the square brackets in (2) identify *conceptual constituents*. Each constituent is labeled as belonging to a *major conceptual category* or "semantic part of speech" – one of the kinds of entities the world is conceptualized as containing, for example Thing (or physical object), Event, State, Path (or trajectory), Place (or location), Property, Time, and Amount.

Within the brackets, the expressions in capital letters denote conceptual content. The expressions BILL and HOUSE are for present purposes undecomposed. The three other pieces of material are the functions IN, TO, and GO. IN is a one-place function that maps an object (its *reference object*) into a region or Place that encompasses the interior of the object. TO is a one-place function that maps a Thing or Place into a Path that terminates at that Thing or Place. Thus the Path constituent in (2) can be read roughly as "a trajectory that terminates at the interior of the house". GO is a two-place function that maps a Thing and a Path into an Event consisting of the Thing traversing the Path. Thus the entire Event in (2) can be read roughly as "Bill traverses a path that terminates at the interior of the house" ((2) does not encode tense or determiners, a gap in the theory at present).

Notice that the standard thematic roles of Theme and Goal are encoded structurally in (2): Theme, the thing in motion, is the conceptual constituent that serves as the first argument of GO; Goal, the point at which motion terminates, is the conceptual constituent that serves as the argument of TO. Thus [BILL] is Theme of (2) and [IN([HOUSE])] is Goal of (2). This is an essential feature of Conceptual Semantics: thematic roles are treated as structural positions in conceptual structure, not as an independent system of diacritics (or case-markers).

Statement (2) is placed in correspondence with the syntactic structure (1) by virtue of the lexical entries in (3):

(3) a. $$\begin{bmatrix} \text{into} \\ \text{P} \\ [_{\text{Path}}\ \text{TO}([_{\text{Place}}\ \text{IN}([_{\text{Thing}}\ ]_{A})])] \end{bmatrix} \quad \begin{array}{l} \text{(phonological structure)} \\ \text{(syntactic structure)} \\ \text{(conceptual structure)} \end{array}$$

b. $$\begin{bmatrix} \text{go} \\ \text{V} \\ [_{\text{Event}}\ \text{GO}([_{\text{Thing}}\ ]_{A},[_{\text{Path}}\ ]_{A})] \end{bmatrix} \quad \begin{array}{l} \text{(phonological structure)} \\ \text{(syntactic structure)} \\ \text{(conceptual structure)} \end{array}$$

(3a) specifies that the phonological material *into* corresponds to a preposition in syntactic structure and to a certain expression in conceptual structure – the item's "lexical conceptual structure" or LCS. The LCS in (3a) is a function of one argument, a Thing; the argument is marked with the "linking subscript" A. An argument so marked must be expressed by a syntactic argument; by virtue of a general principle of linking, this syntactic argument will appear as the object of the preposition.[5] Thus the PP *into the house* in (1) is mapped into the full Path-constituent in (2).

Similarly, (3b) specifies that the phonological material *go* (ignoring the morphological alteration to *went*) corresponds to a verb in syntactic structure and to a two-place function in conceptual structure. The two arguments of the function are subscripted A, and therefore must be expressed in the syntax; by the linking principles, they are expressed as the subject and postverbal PP.

An alternative way of expressing conceptual structure (2) is as the English sentence (4a), whose verb has the lexical entry (4b):

(4) a. Bill entered the house.

b. $$\begin{bmatrix} \text{enter} \\ \text{V} \\ [_{\text{Event}}\ \text{GO}([_{\text{Thing}}\ ]_{A},[_{\text{Path}}\ \text{TO}([_{\text{Place}}\ \text{IN}([_{\text{Thing}}\ ]_{A})])])] \end{bmatrix}$$

The LCS of *enter* can be thought of as "incorporating" the LCS of *into* with that of *go*. By virtue of this incorporation, both arguments of *enter* are Things. The result is that the verb occurs with two NPs (subject and object) rather than with an NP and a PP. Thus it is possible for the same conceptual structure to correspond to more than one syntactic structure, depending in part on the argument structure of the lexical items involved.

We can see from these examples that Conceptual Semantics treats the "argument structure" or "θ-grid" of a lexical item not as a separate level of lexical

[5]This treatment of linking differs from treatments in Jackendoff (1983, 1987a), where linking was stipulated by coindexing between the LCS and the syntactic subcategorization feature. The present treatment, which is more general, is developed in Jackendoff (1990, Ch. 11).

representation (as in Grimshaw, 1990; Higginbotham, 1985; Rappaport & Levin, 1985, 1988; Stowell, 1981; Williams, 1984; and others), but simply as the collection of A-markings in the item's LCS. The structural positions of the A-marked constituents in turn determine the θ-roles of the syntactic arguments in the sentence; hence the process of "θ-marking" amounts essentially to linking syntax to conceptual structure.

More generally, this approach to conceptual decomposition bears a resemblance to other such theories, for example Schank's (1973) "conceptual dependency theory". It differs from Schank's approach in that (a) it takes seriously the contribution of syntactic structure to the form of a sentence, whereas Schank rejects an independent syntax; (b) it attempts to determine general primitives and principles of combination that explain facts of linguistic distribution, whereas Schank appears to be concerned primarily with covering the semantic facts with minimal concern for linguistic generalization.

All this said, we are finally ready to get to the problem at hand.

3. The puzzle and a preliminary solution

The problem that motivates the present study might be first illustrated with a sentence discussed by Talmy (1978):

(5) The light flashed until dawn.

Statement (5) conveys a sense of the light flashing repetitively. However, the "core" sentence *the light flashed* suggests not repetition but a single flash. Nor does the sense of repetition come from *until dawn*: *Bill slept until dawn*, for instance, does not express repeated acts of sleeping. Hence there is evidently no lexical item in the sentence that can be said to contribute to the sense of repetition; it must arise from combining the words into the sentence. Thus three questions must be answered: (a) How is repetition encoded in conceptual structure? (b) What principles of correspondence license its use in (5), despite the absence of a lexical item that contains it? (c) Why is it required in the interpretation of (5)?

To get a little more feel for the problem, let us explore some related examples:

(6) Until dawn,
- a. Bill slept.
- b. the light flashed. [*repetition only*]
- c. lights flashed. [*each may have flashed only once*]
- 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	[*each may have entered only once*]
j.	?some people ran into the house.	[*each person entered repeatedly*]
k.	Bill ran toward the house.	
l.	Bill ran into houses.	[*he may have entered each house once*]
m.	Bill ran into some houses.	[*he entered each house repeatedly*]
n.	Bill ran down the road.	
o.	*Bill ran 5 miles down the road.	[*OK only on the reading where 5 miles down the road is where Bill was, not on the reading where 5 miles down the road is how far he got*]

Some of the phrases in (6) combine with *until dawn* without changing sense; some add the sense of repetition; some are ungrammatical. Moreover, the possibilities are influenced by the choice of verb (6a vs. 6b vs. 6d); by the choice of singular versus bare plural versus *some* + plural in subject (6h, i, j), object (6d, e, f), or object of a preposition (6h, l, m); by the choice of aspect (6d vs. 6g); by the choice of preposition (6h vs. 6k vs. 6n); and by the choice of prepositional specifier (6n vs. 6o). We are thus dealing with a semantic system whose effects are felt in practically every part of the syntax. A properly general solution to the sense of repetition in (5) must therefore be an account of this entire system, and it must extend naturally to all the cases in (6).

With this in mind, let's sketch out the overall form of the solution, beginning with the sense of repetition. As has been pointed out many times (e.g., Gruber, 1967; Hinrichs, 1985; Langacker, 1987; Talmy, 1978; among others), the semantic value of repetition is identical to that of the plural, that is, it encodes the multiplicity of a number of entities belonging to the same category. In the case of objects, the plural maps an expression denoting an instance of a category (say *apple*) into an expression denoting a multiplicity of instances of the category (*apples*). In the case of repetition, an expression denoting a single instance of a particular category of events (*the light flashed*) is mapped into an expression denoting multiple instances of the same category. In English, the resulting expression does not differ in form; but there are languages such as Hungarian and Finnish that have an iterative verb aspect used for this purpose. Note also that if the event is expressed in English with a noun, for instance *a flash*, then its plural denotes repeated events, for instance *flashes*. Thus the identification of repetition with plurality is syntactically justified as well.

A consequence of this analysis is that the multiplicity of entities is a feature of conceptualization that is orthogonal to the distinction between objects and events. Such a result is consistent with the evidence from (6) that the system of conceptual encoding we are looking for cuts across this conceptual distinction.

Next consider the rule that permits (5) to be interpreted as repetitive despite the absence of any iterative morpheme. This rule appears to belong to a class of rules that might generally be called "rules of construal". Example (7), adapted from Nunberg (1979), is a standard case that invokes such a rule:

(7) [One waitress says to another:]
The ham sandwich in the corner wants another cup of coffee.

The lexical entry for *ham sandwich* certainly does not specify a potential reading "customer with a ham sandwich"; nor is there any other lexical item in the sentence that licenses such a reading. Rather, there is a general principle of construal that may be stated roughly as: "A constituent identifying an individual X may be used/understood to identify an individual contextually associated with X." This principle licenses the insertion of nonlexical material into the conceptual structure of a sentence, roughly "individual contextually associated with". In the process, the lexical material identifying X comes to be subordinated to the role of modifier of the new material, so that the subject of (7), for example, is understood as "individual contextually associated with a ham sandwich".[6]

Of course, if the rule used in (7) could operate freely, chaos would result. What renders its application appropriate in (7) is the fact that the literal interpretation of (7) is ill-formed: a ham sandwich can't want anything. This seems characteristic of this class of rules: the interpreter avails him/herself of them to understand otherwise ill-formed or pragmatically inappropriate utterances. (Jackendoff, 1990, suggests that rules of this sort fall into the same class as what Levin and Rapoport (1986) have called rules of "lexical subordination" and what Jackendoff (1990) calls "superordinate adjuncts".)

The rule of construal responsible for (5) has the effect of substituting "multiple events of category X" for "event of category X". What motivates its application? The basic insight is that the conceptual structure of *until dawn* places a temporal boundary on an otherwise temporally unbounded process. So, for instance, *Bill slept* expresses a process that is conceptualized as unbounded: the speaker's focus for the moment lies within the process, excluding the boundaries from view. The full sentence *Bill slept until dawn* then expresses the termination of this process. However, *the light flashed* expresses an inherently bounded occurrence: the light goes on, then goes off, and the event is over. Thus it cannot be subject to the extrinsic bounding imposed by *until dawn*. This is the ill-formedness, parallel to that of the literal interpretation of (7), that motivates applying a rule of construal. The effect of applying the rule is to map the "core" event into a sequence of flashes that can go on indefinitely; this sequence can then be bounded in time by the expression *until dawn*. By contrast, *Bill ate the hot dog* is inherently bounded and *cannot* be repeated (barring regurgitation), so applying the rule of construal

[6] This is how the rule looks from the point of view of syntax. From the point of view of semantics, a rule of construal licenses leaving material out of syntax, hence economizing the overt expression of thought.

to (6d) does not result in a well-formed reading; the sentence is therefore unacceptable.[7]

The basic formal shape of this solution appears in (8), a first approximation to the conceptual structure of (5):

(8)

$$\begin{bmatrix} \text{UNTIL}\left({}_{\text{Event}}\begin{bmatrix} \text{PLURAL}\left({}_{\text{Event}}\begin{bmatrix} \text{LIGHT FLASHED} \\ \text{BOUNDED} \end{bmatrix} \right) \\ \text{UNBOUNDED} \end{bmatrix}, [_{\text{Time}}\ \text{DAWN}] \right) \\ {}_{\text{Event}}\ \text{BOUNDED} \end{bmatrix}$$

Unpacking this, UNTIL is a function that bounds an unbounded event (its first argument) with a time (its second argument), producing a bounded event. PLURAL is a function that maps a bounded entity (its argument) into an unbounded multiplicity of entities of the same type; in the interpretation of (5) this function is contributed by the rule of construal.

The idea behind this solution appears in many sources (e.g., Declerck, 1979; Dowty, 1979; Hinrichs, 1985; Mourelatos, 1978; Platzack, 1979; Pustejovsky, 1991; Talmy, 1978; Vendler, 1957; Verkuyl 1972, 1989). In the course of subsequent sections, this solution will be refined and placed in the context of the larger system that is responsible for the facts in (6) and many other phenomena. In particular, my strategy is to make full use of the cross-categorial properties of this system, using the much richer grammatical resources of the noun system to elucidate the properties of the verbal system standardly called aktionsarten or event structure. (There is no space here to compare my proposals at any length with those in the extensive literature, only a small portion of which is cited above and later in the text. I hope to address the differences in future work.)

4. The features b(ounded) and i(nternal structure)

To begin approaching a more general solution, we introduce a pair of fundamental conceptual features. Consider first the feature of boundedness. It has frequently been noted (Bach, 1986; Fiengo, 1974; Gruber, 1967; Talmy, 1978; among many others) that the distinction between count and mass nouns strongly parallels that between temporally bounded events and temporally unbounded processes. For example, one hallmark of a count noun, say *apple*, is that one cannot divide its referent up and still get something named by the same count noun, i.e. another apple. By contrast, with a mass noun such as *water*, one can divide its referent up

[7] Notice that in a language like Chinese, which lacks a plural morpheme, this rule of construal will be responsible for the interpretation of plurality in noun phrases as well as sentences.

and still get something describable as water (as long as one does not divide it up so small as to break up the molecular structure). The same criterion applies to events versus processes. One cannot divide up the event *The light flashed* and get smaller events describable as *The light flashed*, but one can divide up a process described as *Bill slept* into smaller parts also describable as *Bill slept*.

Accordingly, we will introduce a feature $\pm$*bounded*, or $\pm$b, in both the object and the event system. Individual objects (usually described by count nouns) and completed events will be encoded as +b (replacing the notation BOUNDED in (8); unbounded substances (usually described by bare mass nouns) and unbounded processes will be encoded as −b (replacing UNBOUNDED in (8)).

Let me be slightly more specific about what is intended by −b. As suggested in the previous section, a speaker uses a −b constituent to refer to an entity whose boundaries are not in view or not of concern; one can think of the boundaries as outside the current field of view. This does not entail that the entity is absolutely unbounded in space or time; it is just that we can't see the boundaries from the present vantage point.

A second feature encodes plurality. As is well known, plurals and mass nouns pattern together in various respects, in particular admitting many of the same determiners, including *some*, *all*, *a lot of*, *no*, *any*, and, significantly, the zero determiner. Bare mass nouns and bare plurals, but not singulars, can occur in expressions of distributive location such as (9). When they serve as direct object of a verb such as *eat*, the resulting sentence is a process (10a, b) by contrast with singulars, which create closed events (10c):

(9) a. There was water all over the floor.

b. There were books all over the floor.

c. *There was a book all over the floor.[8]

(10) a. Bill ate custard until dawn.

b. Bill ate hot dogs until dawn.

c. *Bill ate a hot dog until dawn.

We will therefore group bare mass nouns and bare plurals together as unbounded (−b). Talmy suggests the term *medium* to encompass them both. The difference between the two kinds of media is that plurals entail a medium comprising a multiplicity of distinguishable individuals, whereas mass nouns carry no such entailment. We will encode this difference featurally; the difference in entailment

[8] A reader has observed that *There was a copy of the NY Times all over the floor* is grammatical. It appears that in this sentence the newspaper is being conceptualized as an unbounded aggregate of sheets of paper.

can then be a consequence of inference rules that refer to the feature in question. I will call the feature ±*internal structure*, or ±i. *Aggregates* – the entities normally expressed by plural nouns – will be +i. *Substances* – the entities normally expressed by mass nouns – will be −i. (Note: the value −i does not mean lack of internal structure, but rather lack of necessary entailment about internal structure.)

The +i distinction can be applied in the +b domain as well as the −b: it provides a way of encoding the difference between *individuals* and *groups*. (Here I begin to move away from standard proposals.) A group entity is bounded, but there is a necessary entailment that it is composed of members. An individual may have a decomposition into parts, but that is not a necessary part of its individuality. Thus the feature system, applied to objects and substance, comes out as (11):

(11) +b, −i: individuals (*a pig*)
+b, +i: groups (*a committee*)
−b, −i: substances (*water*)
−b, +i: aggregates (*buses, cattle*)

Individuals correspond to the conceptual category of Thing employed in section 2. We therefore need a larger supercategory that contains all of the entities in (11). Let us call it Material Entity (*Mat* for short). The term thing, previously regarded as primitive, now becomes composite: it is an abbreviation for [Mat, +b, −i]. Note, however, its privileged status: of the four subcategories of Mat, only Thing has an inherent shape. Therefore it is the only subcategory that has physical boundaries. (Groups are bounded in quantity but do not have an inherent shape.)

The features *b* and *i* can be applied in the event/process domain as well. A closed event such as *John ran to the store* is [+b, −i]; an unbounded homogeneous process such as *John slept* is [−b, −i]; an unbounded iterative process such as *The light flashed continually* is [−b, +i]; a bounded iterative event such as *The light flashed until dawn* is [+b, +i]. Thus the feature system cuts across major conceptual categories, expressing the generality of the phenomena of boundedness and plurality.

5. Functions that map between values of b and i

5.1 PL

How is the notion of plurality to be represented? There are two possibilities. Suppose (12a) is the conceptual structure of *a dog*, where the features [Mat, +b, −i] set the entity within the major category of individual objects, and DOG is a stand-in for the conceptual information that distinguishes dogs from other categories of individual objects. Then there are two possible ways to encode the term *dogs*, shown in (12b) and (12c)

(12) a. $\begin{bmatrix} +b, -i \\ _{Mat}\ DOG \end{bmatrix} = \text{a dog}$

b. $\begin{bmatrix} -b, +i \\ _{Mat}\ DOG \end{bmatrix} = \text{dogs}$

c. $\begin{bmatrix} -b, +i \\ _{Mat}\ PL\left(\begin{bmatrix} +b, -i \\ _{Mat}\ DOG \end{bmatrix}\right) \end{bmatrix} = \text{dogs}$

In (12b), the plural has been expressed by changing the b and i features of *a dog* from those for an individual to those for an aggregate. The plural morpheme is thus conceived of as expressing a feature-changing process. In (12c), by contrast, the lexical entry for *dog* has been left unchanged; it appears as the argument of a conceptual function PL that maps its argument into an aggregate. The plural morpheme is then taken to express this function.

I will adopt the latter solution, because it permits correspondence rules along lines known from the principles of verb argument structure illustrated in section 2. In particular, it gives the correspondence rules a property of "morphological transparency": for the most part, addition of syntactic information (including morphology) does not change features of the base element, but rather adds operators around the base. In the present case, the LCS of *dog* is found directly in (12c), embedded in the operator PL; by contrast, in (12b) the LCS of *dog* has disappeared.

One reason for adopting representation (12c) is what happens when we pluralize a group-noun such as *herd* or *committee*. Under the feature-changing treatment, the plural comes out as (13a), which is no longer distinct from the plural of an individual. Under the functional treatment, it comes out as (13b), in which one can still discern that the plurality is of groups rather than individuals:

(13) a. $\begin{bmatrix} -b, +i \\ _{Mat}\ COMMITTEE \end{bmatrix} = \text{committees}$

b. $\begin{bmatrix} -b, +i \\ _{Mat}\ PL\left(\begin{bmatrix} +b, +i \\ _{Mat}\ COMMITTEE \end{bmatrix}\right) \end{bmatrix} = \text{committees}$

The plural morpheme thus has the conceptual structure (14a); the LCS of the noun to which it applies fits into the A-marked argument slot. A lexical plural such as *people* or *cattle* has an LCS like (14b):

(14) a. $\text{N + plur} = \begin{bmatrix} -b, +i \\ PL([+b]_A) \end{bmatrix}$

b. $\text{people} = \begin{bmatrix} -b, +i \\ _{Mat}\ PL\left(\begin{bmatrix} +b, -i \\ _{Mat}\ PERSON \end{bmatrix}\right) \end{bmatrix}$

Note that the plural morpheme cares only that the noun to which it applies designates a bounded entity. It does not care whether that entity is Material or an Event (such as *earthquakes*), nor whether it is an individual or a group. On the other hand, the entity must be bounded, so that mass nouns, which are −b, cannot be pluralized. (We return to apparent counterexamples like *three coffees* in section 5.3.)

In the verbal system, PL is the function that iterates events. Thus a constituent of *The light flashed until dawn* is (15). This expression is the unbounded process that will eventually be bounded by *until dawn*; it replaces the notation for the first argument of UNTIL given in (8):

(15) $$\begin{bmatrix} -\mathrm{b}, +\mathrm{i} \\ \mathrm{PL}\left(\begin{bmatrix} +\mathrm{b}, -\mathrm{i} \\ \mathrm{LIGHT\ FLASHED} \end{bmatrix}_{\mathrm{Event}}\right) \end{bmatrix}_{\mathrm{Event/Process}}$$

In this case, PL is not introduced by a morpheme in the sentence. Rather, as argued in section 3, it is introduced by a rule of construal.

There are verbs that appear to lexically include PL, parallel to the lexically plural nouns. For example, *pound* and *hammer* normally describe not a single blow (as *hit* does), but a sequence of blows iterated into a process.

PL is one of a class of functions that map an entity with one value of b and i into another entity with different values. Having myself considered and rejected numerous hypotheses about the constitution of this class, I am not completely confident that the functions about to be proposed are properly characterized. (A different but related set is proposed by Winston, Chaffin, & Herrmann, 1987.) However, the discussion to follow shows the range of phenomena for which any competing analysis of this class of functions must be responsible.

5.2 ELT

A sort of inverse of PL is evoked in phrases like *a grain of rice*, *a stick of spaghetti*. In these phrases, the second noun is grammatically a mass noun, but it happens that it denotes an aggregate rather than a substance. The first noun picks out an individual of the aggregate. Hence, to express the meaning of the phrase, we need a function that maps an aggregate into a single element of the aggregate. I will call the function ELT (element of). *A grain of rice* then comes out as (16):

(16) $$\text{a grain of rice} = \begin{bmatrix} +\mathrm{b}, -\mathrm{i} \\ \mathrm{ELT}\left(\begin{bmatrix} -\mathrm{b}, +\mathrm{i} \\ \mathrm{RICE} \end{bmatrix}_{\mathrm{Mat}}\right) \end{bmatrix}_{\mathrm{Mat}}$$

A possible extension of ELT to another feature combination might be *a drop of* *water*, in which *a drop* is conceptualized as the natural unit into which the substance water divides itself:

(17)
$$\text{a drop of water} = \begin{bmatrix} +\text{b}, -\text{i} \\ \text{ELT}\left(\begin{bmatrix} -\text{b}, -\text{i} \\ \text{WATER} \end{bmatrix}_{\text{Mat}}\right) \end{bmatrix}_{\text{Mat}}$$

This extension is not, however, a natural inverse of the plural, since it conceptualizes a multiplicity of individuals (drops) combining into a substance rather than an aggregate. I will leave open whether this extension is correct.

PL and ELT thus form a pair that can be thought of as approximate inverses. I will call PL an *including function*: the function maps its argument into an entity that includes the argument as a subentity. By contrast, ELT is an *extracting function*: the function maps its argument into a subentity of the larger entity denoted by the argument. It is a characteristic of including functions that they transmit existential claims to their arguments. For instance, if there are dogs around, there is a dog around. By contrast, extracting functions do not transmit existential claims to their arguments. For instance, having a grain of rice around does not entail that there is a larger aggregate body of rice around – this single grain may be all we have.

The other functions to be introduced form pairs in the same way as PL and ELT: one member of the pair will be an including function and one an extracting function.

5.3 COMP

Consider an expression like *a house of wood*. The phrase *of wood* describes the substance of which the house is composed. To encode this relation, let us introduce a function COMP. Preserving the syntactic relations of subordination, this function will take a substance as its argument and map it into an individual:

(18)
$$\text{a house of wood} = \begin{bmatrix} +\text{b}, -\text{i} \\ \text{HOUSE} \\ \text{COMP}\left(\begin{bmatrix} -\text{b}, -\text{i} \\ \text{WOOD} \end{bmatrix}_{\text{Mat}}\right) \end{bmatrix}_{\text{Mat}}$$

("a house composed of wood")

Substituting an aggregate for the substance in (18), we can create expressions like *a house of bricks*:

(19)
$$\text{a house of bricks} = \begin{bmatrix} +\text{b}, -\text{i} \\ \text{HOUSE} \\ \text{COMP}\left(\begin{bmatrix} -\text{b}, +\text{i} \\ \text{PL}\left(\begin{bmatrix} +\text{b}, -\text{i} \\ \text{BRICK} \end{bmatrix}_{\text{Mat}}\right) \end{bmatrix}_{\text{Mat}}\right) \end{bmatrix}_{\text{Mat}}$$

In (18) and (19), the noun *house* contributes only the content [+b, −i, HOUSE]; it is presumably not part of the LCS of *house* that it *has* to be composed of something. In other words, the COMP function is contributed by the modifying construction *of wood* or *of bricks*. However, there are other nouns whose LCS contains COMP as an essential part. For instance, *a pile* or *a stack* is an inherently bounded collection of smaller elements, combined to create a particular form. Thus the LCS of these items is something like (20):

(20) a.
$$\text{pile} = \begin{bmatrix} +\text{b}, -\text{i} \\ \text{PILE} \\ _{\text{Mat}}\ \text{COMP}([-\text{b}]) \end{bmatrix}$$

b.
$$\text{stack} = \begin{bmatrix} +\text{b}, -\text{i} \\ \text{STACK} \\ _{\text{Mat}}\ \text{COMP}([-\text{b}, +\text{i}]) \end{bmatrix}$$

The difference between the two expresses the fact that one can have *a pile of bricks* (aggregate) or *a pile of sand* (substance), but only *a stack of bricks*, not **a stack of sand*.[9]

In the examples above, the COMP function maps its argument into an individual. But COMP can also provide an analysis for group-nouns such as *herd*, *flock*, and *group*:

(21)
$$\text{a flock of birds} = \begin{bmatrix} +\text{b}, +\text{i} \\ \text{COMP}\left(\begin{bmatrix} -\text{b}, +\text{i} \\ \text{PL}\left(\begin{bmatrix} +\text{b}, -\text{i} \\ _{\text{Mat}}\ \text{BIRD} \end{bmatrix}\right) \\ _{\text{Mat}} \end{bmatrix}\right) \\ _{\text{Mat}} \end{bmatrix}$$

Note the difference between *stack* and *flock*: a stack has an inherent shape, which makes it [+b, −i], while a flock has no shape of its own, which makes it [+b, +i].[10]

So far COMP has been introduced by a lexical item or by the *of*-construction. It can also be introduced by a rule of construal, in which case it serves as what has been called the "universal packager", attributed in the literature to David Lewis:[11]

[9]Notice that *a stack of wood* implies that the wood is in discrete largish pieces, that is, an aggregate rather than just a substance. However, one cannot have **a stack of wood chips*, even though *wood chips* is plural. That is, *stack* imposes further selectional restrictions that are not addressed here, probably having to do with orderly geometric arrangement of the elements of the stack.

[10]This extension does not appear to have full generality: an individual can be composed of either a substance or an aggregate, but a group may be composed only of an aggregate – the notion of a group composed of a substance seems anomalous or conceptually ill-formed. I leave open how this asymmetry in the COMP function is to be resolved.

[11]David Lewis has informed me (personal communication) that he has not used this term in print; he in turn attributes the notion to lectures or writings by Victor Yngve in the 1960s which he is now unable to trace. The same goes for the notion of the "Universal Grinder" in section 5.4.

(22) I'll have a coffee/three coffees.

Here *coffee* is construed as "bounded individual composed of coffee". The syntax of the construction is that of count nouns: it uses the indefinite article and the plural, which are conceptually incompatible with the LCS of *coffee*, a substance. Therefore a rule of construal, inserting the operator COMP, must apply to make the representation well formed:

(23) a. $$\text{a coffee} = \begin{bmatrix} +\text{b}, -\text{i} \\ \text{COMP}\left(\begin{bmatrix} -\text{b}, -\text{i} \\ \text{COFFEE} \end{bmatrix}_{\text{Mat}}\right) \end{bmatrix}_{\text{Mat}} \quad \text{“a portion of coffee”}$$

b. $$\text{coffees} = \begin{bmatrix} -\text{b}, +\text{i} \\ \text{PL}\left(\begin{bmatrix} +\text{b}, -\text{i} \\ \text{COMP}\left(\begin{bmatrix} -\text{b}, -\text{i} \\ \text{COFFEE} \end{bmatrix}_{\text{Mat}}\right) \end{bmatrix}_{\text{Mat}}\right) \end{bmatrix}_{\text{Mat}} \quad \text{“portions of coffee”}$$

(Note: this reading of *coffees* is distinct from the reading that means "varieties of coffee", as in *The store sells seventeen coffees, each from a different country*; the latter is due to a separate rule of construal.)

A more general situation in which a rule of construal makes use of COMP appears in examples like (24):

(24) a. Will you mop up *that water*, please?

b. They loaded *the sand* into the truck.

c. *The boys* were impressed.

In each of these, the italicized NP expresses a bounded entity composed of a substance or aggregate. One might think that the definite article is the source of COMP. But in fact in other contexts the very same phrases can be unbounded. *That water* in (25a), for instance, denotes a contextually identifiable medium, not a fixed amount:

(25) a. *That water* kept spurting out of the broken hose.

b. *The sand* stretched out as far as we could see.

c. *The boys* arrived for hours on end.

Apparently, then, definiteness contributes only the content "contextually identifiable"; the determination of boundedness depends on other constraints. The unbounded reading (26a) can be derived directly from the LCS of *that* and *water*; the bounded reading (26b) is the result of applying a rule of construal that inserts COMP (DEF is the conceptual structure associated with definiteness):

(26) a.

$$\text{that water (in (25a))} = \begin{bmatrix} -\text{b}, -\text{i} \\ \text{WATER} \\ \text{DEF} \end{bmatrix}$$

b.

$$\text{that water (in (24a))} = \begin{bmatrix} +\text{b}, -\text{i} \\ \text{DEF} \\ \text{COMP}\left(\begin{bmatrix} -\text{b}, -\text{i} \\ \text{WATER} \end{bmatrix}\right) \end{bmatrix}$$

5.4 GR

COMP, like PL, is an including function: it maps its argument into a larger entity that includes the argument. It therefore has the existential entailment characteristic of an including function: if there is a house of wood around, there is wood around. The inverse of COMP therefore ought to be an extracting function whose argument is an individual or group, and which maps its argument into a substance or aggregate of which the individual or group is composed.

Such a function is found in the so-called "universal grinder" (see footnote 11), illustrated in the grisly (27):

(27) There was dog all over the street.

Here the bare singular and the distributive location force the term *dog* to be interpreted as a substance. As usual, the relevant rule of construal does not simply change the lexical features of *dog* to make it into a substance. Rather, it preserves well-formedness by introducing a function GR, whose argument is the LCS of *dog*:

(28)

$$\text{dog (substance)} = \begin{bmatrix} -\text{b}, -\text{i} \\ \text{GR}\left(\begin{bmatrix} +\text{b}, -\text{i} \\ \text{DOG} \end{bmatrix}_{\text{Mat}}\right) \end{bmatrix}_{\text{Mat}}$$

Given this operator, we can also use it in the lexicon to express the relation between animals and their meat (29a), animal body parts and their meat (29b), and similar paired words like *rock/a rock* and *stone/a stone*:

(29) a.

$$\text{pork} = \begin{bmatrix} -\text{b}, -\text{i} \\ \text{MEAT} \\ \text{GR}\left(\begin{bmatrix} +\text{b}, -\text{i} \\ \text{PIG} \end{bmatrix}\right) \end{bmatrix}$$

b.

$$\text{liver} = \begin{bmatrix} -\text{b}, -\text{i} \\ \text{MEAT} \\ \text{GR}\left(\begin{bmatrix} +\text{b}, -\text{i} \\ \text{LIVER} \end{bmatrix}\right) \end{bmatrix}$$

GR applied to an individual yields a substance. For symmetry, it is useful to stipulate that GR applied to a group yields the aggregate of which the group is composed. This makes it not quite a true inverse of COMP, but it is close.

As required, GR is an extracting function: its output is a subentity of its argument. Like our other extracting function ELT, it does not transmit existential claims to its argument: if there is dog all over the place, it does not follow that there is a dog around.

In the verbal system, GR appears to be (one of) the reading(s) of the progressive aspect in English. For example, *Bill is running to the store* can be construed as "the process out of which the event *Bill runs to the store* is composed". This analysis allows us to incorporate Bach's (1986) solution to the "imperfective paradox" – the fact that even if it is true that *Bill is writing a novel*, there need not yet (or ever) be a novel such that Bill is writing it. Bach, drawing on Link's (1983) treatment of the semantics of the mass/count distinction, points out that the existence of a part of an object does not entail the existence of the whole object. For instance, one may find (or make) a part of a violin without there being (now or ever) a violin of which this is a part. Similarly, Bach argues, the progressive is extracting a part of an event, and hence carries no entailment that the event is ever carried to completion. Since the existence of the (complete) novel depends on the completion of the event, the novel too carries no existential claim. In the present analysis the same conclusion follows from the claim that the progressive involves applying the extracting function GR to the event, which does not transmit existential claims (or in the case of events, truth claims) to its argument.

Before going on to the next function, notice that all the functions discussed so far can be introduced by rules of construal, and that at least two, ELT and COMP, show up in the *N of NP* construction. This is one of the difficulties of separating these functions clearly – their great degree of syntactic overlap, when they are expressed at all.

5.5 PART

Another *N of NP* construction occurs in (30):

(30) a. a leg of the table

b. the roof of the porch

c. a part of the group

This *partitive* construction takes as its argument a bounded entity and addresses its internal articulation, picking out an identifiable bounded part. It is thus an extracting function like ELT and GR; as noted by Bach, it shares the characteristic entailment of extracting functions. Unlike GR, it extracts a bounded part, not an unarticulated substance. Unlike ELT, it presumes that the entity extracted from is nonhomogeneous: a house can have different kinds of parts, but rice has only one kind of internal element, a grain. Thus it appears that the partitive is a distinct function from the other two. I will encode (30a), for example, as (31)

(31) $$\begin{bmatrix} +\text{b}, -\text{i} \\ \text{LEG} \\ \text{PART}\left(\begin{bmatrix} +\text{b}, -\text{i} \\ \text{TABLE} \end{bmatrix}\right) \end{bmatrix}$$

Note that words like *leg* and *roof* are lexically partitive – a leg has to be a leg *of something*. Statement (30c) shows the same operator applied to a group noun, yielding a smaller group:

(32) $$\text{part of the group} = \begin{bmatrix} +\text{b}, +\text{i} \\ \text{PART}\left(\begin{bmatrix} +\text{b}, +\text{i} \\ \text{GROUP} \end{bmatrix}\right) \end{bmatrix}$$

A word like *subcommittee* lexically incorporates the whole complex in (32).

PART also appears to be able to map its argument into a substance. An example is *(the) blood of a pig*, which seems altogether parallel to *a/the heart of a pig* in its structure. A possibly more controversial extension would be to cases with an unbounded argument, as in *an ingredient of stew*, whose proper analysis I leave open.

Another frequent syntactic realization of the PART function is as a nominal compound. So, for example, parallel to the examples above we have *table leg*, *porch roof*, *pig blood*, *pig heart*, and *stew ingredients* (though not **group part*).

5.6 CONT

Each of the other functions has an approximate inverse. This suggests that PART should too. What would be its properties? It would have to be an including function that mapped its argument into an entity containing the argument as a part.

One possible instance of such a function is in compounds like *drop-leaf table* ("a table whose identifying part is a drop-leaf") and *beef stew* ("stew whose identifying ingredient is beef"). By extension, it would also be invoked by a rule of construal in synecdoche and exocentric compounds, where a distinguishing part is used to identify the whole (*Hey, Big-Nose!*). Another possible case is NPs containing a *with*-modifier, such as *table with a drop-leaf* and *house with an orange roof*. It is clear that this relation is distinct from the other including functions, PL and COMP; let's call it CONT ("containing"). Then *beef stew*, for instance, would have the structure (33):

(33)
$$\text{beef stew} = \begin{bmatrix} -\text{b}, -\text{i} \\ \text{STEW} \\ \text{CONT}\left(\begin{bmatrix} -\text{b}, -\text{i} \\ \text{BEEF} \end{bmatrix}\right) \end{bmatrix}$$

Thus we have found six functions that map one combination of the features *b* and *i* into another, expressing different relations of parts to wholes. (34) summarizes:

(34)

Including functions:	PL	COMP	CONT
Extracting functions:	ELT	GR	PART

6. Dimensionality and directionality

We next have to look briefly at the dimensionality and directionality of entities and how they are encoded in conceptual structure.

The basic observation about dimensionality is that a point is conceptualized as 0-dimensional, a line or curve as 1-dimensional, a surface as 2-dimensional, and a volume as 3-dimensional. (The notion of dimensionality here is essentially the number of orthogonal degrees of freedom within the object.) However, following and extending Marr's (1982) theory of encoding of object shapes, we can decompose an object's dimensionality into a hierarchical arrangement of dimensions.

Consider for example a road, a river, or a ribbon. These can be schematized as a line (the primary dimension) elaborated by a linear cross-section (the secondary dimension), yielding a surface. The primary dimension of these objects may be bounded or unbounded; the secondary dimension is bounded. In order to encode dimensionality in conceptual structure, we will introduce a 4-valued feature *DIM nD*, where *n* varies from 0 to 3. Statement (35) illustrates the use of this feature; the secondary dimension appears in the inner brackets:

(35)
$$\text{road, river, ribbon} = \begin{bmatrix} \pm\text{b}, -\text{i} \\ \text{DIM 1D} \\ \begin{bmatrix} +\text{b}, -\text{i} \\ \text{DIM 1D} \end{bmatrix} \end{bmatrix}$$

Contrast these items to a layer or a slab, which are basically thickened surfaces. Here the primary dimension is a bounded or unbounded surface, and the secondary dimension is an orthogonal dimension that is bounded and linear, giving a volume. Statement (36a) shows this representation. A different case arises with a tube or a beam, whose primary dimension is linear, and whose cross-section is a 2-dimensional shape (36b):

(36) a.

$$\text{layer, slab} = \begin{bmatrix} \pm\text{b}, -\text{i} \\ \text{DIM 2D} \\ \begin{bmatrix} +\text{b}, -\text{i} \\ \text{DIM 1D} \end{bmatrix} \end{bmatrix}$$

b.

$$\text{tube, beam} = \begin{bmatrix} \pm\text{b}, -\text{i} \\ \text{DIM 1D} \\ \begin{bmatrix} +\text{b}, -\text{i} \\ \text{DIM 2D} \end{bmatrix} \end{bmatrix}$$

On the other hand, a sphere has no salient decomposition into axes, so its dimensionality is just [DIM 3D].

The dimensionality feature can easily be extended to time and to states and events. Points in time, states at a point in time, and point-events are [DIM 0D], while periods of time and states and events with duration are [DIM 1D]. This of course does not leave much room for distinctions of primary versus secondary dimensionality, but we will see shortly that such possibilities arise nevertheless.

The dimensionality feature is subject to a principle of reconstrual that I will call the *zero rule*: a bounded object can always be idealized as a point. Under this idealization, the object's intrinsic dimensionality becomes secondary and the primary dimensionality is 0d. (This is the principle that allows cities to be represented by points on maps.)

(37) (Zero rule – idealizing object as point)

$$\begin{bmatrix} \text{X} \\ +\text{b} \\ \text{DIM nd} \end{bmatrix} \Leftrightarrow \begin{bmatrix} \text{X} \\ +\text{b} \\ \text{DIM 0d} \\ [\text{DIM nd}] \end{bmatrix}$$

The use of this principle will become evident in the subsequent sections.

A further wrinkle in the dimensionality feature is that any 1-dimensional axis can have a *direction* or *orientation*. So, for example, a line has no intrinsic direction, but a vector and an arrow do. We can encode this by adding a further distinction to the dimensionality feature, marking vectors and arrows as [DIM 1d DIR] and ordinary lines as just [DIM 1d].[12]

[12] I am treating DIR as a "privative" feature, that is, one that is either present or absent. Alternatively it could be treated as a binary feature ±DIR. However, the only descriptions in the present paper where the feature −DIR is necessary are Place and State (see (38)), which may not prove to need independent definitions – they may be just the residue of Spaces and Situations when Paths and Events are removed.

A surface or volume can acquire directionality only by being decomposed into linear axes. For instance, the human body has a primary directed up–down dimension, a secondary directed front-to-back dimension, and a tertiary side-to-side dimension that is symmetric rather than directed. However, a sphere and a layer have no inherent directionality.

I would like to use the directionality feature to resolve a problem in the set of major conceptual categories in Jackendoff (1983, 1990). This class includes Thing (now expanded to Material), State, Event (now including processes), Place, Path, Time, and others. When these categories were proposed, there was clearly a close relation between States and Events and between Places and Paths, but this relationship found no formal expression.

So let us consider the relation between Places and Paths. Places can be regions of any dimensionality: *at this point* is 0-dimensional, *along the line* is 1-dimensional, *in the circle* is 2-dimensional, and *in the cup* is 3-dimensional. Thus Places share the dimensionality features of objects. But Paths can be only 1-dimensional and must moreover be directed: there is an intrinsic direction in which they are viewed – in the standard case, from Source to Goal. This suggests that Places and Paths can be combined into a supercategory that may be called Space. Paths are the subset of spaces whose dimensionality feature is [DIM 1d DIR] and places are the rest. In other words, the relation of Places and Paths can be formally expressed by a feature distinction.

I would like to extend this, a little speculatively, to the relation between Events and States. States like *X is red* or *X is tall* are conceptualized as "just sitting there" – they have no inherent temporal structure. (The "state" of being in continuous motion, however, is now encoded as a process, or unbounded Event.) Events, by contrast, do have an inherent temporal structure which proceeds in a definite direction. I would like to suggest therefore that the two categories be combined into a supercategory called Situation, with States as the undirected case and Events as the directed case. (Bach, 1986, uses the term *eventuality* in the same sense.)

Statement (38) summarizes this further analysis of the *S&C* primitives:

(38)
$$[\text{PLACE}] = \begin{bmatrix}\text{SPACE}\\ -\text{DIR}\end{bmatrix}$$
$$[\text{PATH}] = \begin{bmatrix}\text{SPACE}\\ \text{DIM 1d DIR}\end{bmatrix}$$
$$[\text{STATE}] = \begin{bmatrix}\text{SITUATION}\\ -\text{DIR}\end{bmatrix}$$
$$[\text{EVENT}] = \begin{bmatrix}\text{SITUATION}\\ \text{DIR}\end{bmatrix}$$

There is a slight asymmetry in this reanalysis, forced by the existence of point-events such as *The light turned on* or *The clock ticked once*. According to our treatment of dimensionality, these should be 0-dimensional; but as Events, they are directional. Thus we have to admit the possibility of 0-dimensional directed Situations, whereas the original intuitions motivating directionality pertained only to 1-dimensional entities. One can think of a number of solutions for this asymmetry, but nothing much hangs on it for now, so I will leave it unresolved.

The main point, however, is that the dimensionality and directionality features, developed to account for conceptual properties of objects, turn out to permit an insightful unification of completely independent conceptual categories.

7. Boundaries

What sort of entity is a boundary? It follows from the definition of the feature system that only a [+b, −i] category – an individual – can have a boundary. If an entity is conceptualized as [−b], this means it is conceptualized without a boundary; in order to discuss its boundary, we have to first reconceptualize it by applying the COMP function. A [+b, +i] entity, a group, is bounded in quantity, but it has no inherent shape – it is just a collection of individuals. Hence it has no discernible entity serving as a boundary.

A basic condition on boundaries is that a boundary has one dimension fewer than what it bounds: a line can be bounded by a point, a region by a line, and a volume by a surface. However, this basic condition is an idealization of the actual situation. Consider a stripe that bounds a circle: it is locally 2-dimensional, not 1-dimensional. What makes the stripe a boundary for the circle is its schematization as a line (its primary dimension) elaborated by a cross-section (its secondary dimension). At the schematic level of primary dimensionality it *is* 1-dimensional, as the basic condition stipulates. From this we can see that the actual condition on dimensionality of boundaries is that the *schematization* of a boundary has one dimension fewer than the *schematization* of what it bounds.

This enables us to make an important generalization in the conceptual structure of words like *end* and *edge*. Consider what kinds of things can have ends, and their dimensionality. A line (1d) has a 0d end; a ribbon (2d) has a 1d end; a beam (3d) has a 2d end. This is not very enlightening. However, the proper analysis emerges if we observe that each of these objects has a 1d primary dimensionality, that is, they are all schematized as lines. By descending to the level of the 1d schematization, we can treat the end in each case as a point bounding the line.

How then does the end acquire its actual dimensionality? Consider again the beam, whose dimensionality is given in (36b). The 2d secondary dimensionality here represents the cross-section of the beam, say an H shape. The end of the beam inherits its shape from this cross-section. More generally, an end can be schematized as having a 0d primary dimension, elaborated by the same secondary dimension as the object it bounds:

(39) a. line $= [\text{DIM 1d}]$ end of line $= [\text{DIM 0d}]$

b. ribbon $= \begin{bmatrix} \text{DIM 1d} \\ [\text{DIM 1d}] \end{bmatrix}$ end of ribbon $= \begin{bmatrix} \text{DIM 0d} \\ [\text{DIM 1d}] \end{bmatrix}$

c. beam $= \begin{bmatrix} \text{DIM 1d} \\ [\text{DIM 2d}] \end{bmatrix}$ end of beam $= \begin{bmatrix} \text{DIM 0d} \\ [\text{DIM 2d}] \end{bmatrix}$

Using the zero rule (37) from right to left, the end of the ribbon and the end of the beam can be reanalyzed as entities in their own right, with one and two dimensions respectively.

An end is therefore fundamentally a point that bounds a line. An *edge*, by contrast, is fundamentally a line that bounds a surface. For instance, the edge of a ribbon (2d) is 1-dimensional. A table-top can be conceptualized as a surface (2d) elaborated by a thickness (1d). The edge of a table-top is the boundary of the surface (1d) elaborated by the same thickness, hence a ribbon-like surface:

(40) a. ribbon $= [\text{DIM 2d}]$ edge of ribbon $= [\text{DIM 1d}]$

b. table-top $= \begin{bmatrix} \text{DIM 2d} \\ [\text{DIM 1d}] \end{bmatrix}$ edge of table-top $= \begin{bmatrix} \text{DIM 1d} \\ [\text{DIM 1d}] \end{bmatrix}$

Notice that a ribbon is conceptualized under different schematizations depending on whether one is identifying its end or its edge.

One further very important wrinkle – what do you do when you *cut off the end of a ribbon*? It would be absurd to think of just cutting off the geometric boundary, as the analysis so far would suggest. Rather, in this context, the end of the ribbon includes the geometric boundary plus some pragmatically determined but relatively small part of the body of the ribbon – similarly for *putting the cup on the end of the table*, in which the end includes some part of the top surface. These examples show that the primary dimension of an end, the one that bounds the linear axis of the object, need not be just 0d, but can be expanded a small amount along the axis. I will encode this expansion by the notation $0 + \varepsilon\text{d}$, as in (41). This notation may be thought of as designating a dimensionality that is something more than a point but something less than a line:

(41) object $= \begin{bmatrix} \text{DIM 1d} \\ [\text{DIM nd}] \end{bmatrix}$ end of object $= \begin{bmatrix} \text{DIM 0}(+\varepsilon)\text{d} \\ [\text{DIM nd}] \end{bmatrix}$

The expansion of the boundary is optional in the case of *end*, and one might want to attribute this possibility to a general rule of construal. However, there are other boundary words for which the expansion is obligatory. Consider a *crust*.

This is a surface bounding a volume, plus an expansion of the surface some small pragmatic distance into the volume; it is hard to tell where the crust of a loaf of bread breaks off and the body of the bread begins. We can express the dimensionality of a crust therefore as [DIM 2 + εd]. Similarly, the *border* of a rug is liable to extend further into the rug from the geometric boundary than does the *edge*. Thus, to distinguish *surface* from *crust* and *border* from *edge*, something like the epsilon notation is necessary in lexical conceptual structure. In turn, the optional expansion of *end* may be either lexical or supplied by a rule of construal; in either case, though, the formal effect is encoded by the epsilon notation.

This treatment of the dimensionality of ends gives us an immediate solution for a well-known puzzle in event structure. If the end of a talk is located at its temporal boundary, it must take place at a *point* in time. However, it is perfectly acceptable to say *Fred is ending/finishing his talk*, where the use of progressive implies a process taking place over a *period* of time. What is going on? The solution lies in the optional expansion of the end some small pragmatically determined distance back into the body of the talk, so that the end has dimensionality [DIM 0 + εd]. The expanded end takes up a period of time, and the activity within this period can therefore be described as *ending the talk*. In short, the analysis of *end* developed to account for obvious geometric intuitions generalizes to the less transparent temporal case, providing a natural explanation.

We complete this section by offering a formalism for the functions that relate boundaries to what they bound. As in the case of the functions introduced in section 5, there is a pair of boundary functions that are approximate inverses of each other. Statement (42) gives a first pass:

(42) a. $$\begin{bmatrix} \mathrm{X} \\ +\mathrm{b}, -\mathrm{i} \\ \mathrm{DIM\ n-1d} \\ \mathrm{BD}\left(\begin{bmatrix} \mathrm{Y} \\ +\mathrm{b}, -\mathrm{i} \\ \mathrm{DIM\ nd} \end{bmatrix}\right) \end{bmatrix} = \text{“an X that bounds Y”}$$

b. $$\begin{bmatrix} \mathrm{Y} \\ +\mathrm{b}, -\mathrm{i} \\ \mathrm{DIM\ nd} \\ \mathrm{BDBY}\left(\begin{bmatrix} \mathrm{X} \\ +\mathrm{b}, -\mathrm{i} \\ \mathrm{DIM\ n-1d} \end{bmatrix}\right) \end{bmatrix} = \text{“a Y that is bounded by X”}$$

For our purposes here, one refinement is necessary in these functions.[13] Just in

[13]The definitions in (42) and (43) stipulate that the entity being bounded and its boundary both be [+b, −i]. This pertains, of course, only to the dimension whose boundary is being determined. A river, for instance, has boundaries for its secondary dimension (its edges), while its primary dimension may be regarded as unbounded.

case the entity being bounded (Y in (42)) is directed, the two boundaries must be distinguished as *top* and *bottom*, *front* and *back*, or *beginning* and *end*. Accordingly, we introduce the notation in (43) as a subcase of (42):

(43) a. $$\begin{bmatrix} \mathrm{X} \\ +\mathrm{b}, -\mathrm{i} \\ \mathrm{DIM}\ 0(+\varepsilon)\mathrm{d} \\ \mathrm{BD}^{\pm}\left(\begin{bmatrix} \mathrm{X} \\ +\mathrm{b}, -\mathrm{i} \\ \mathrm{DIM}\ 1\mathrm{d}\ \mathrm{DIR} \end{bmatrix}\right) \end{bmatrix} = \text{“an X that terminates (+) or originates (−) Y”}$$

b. $$\begin{bmatrix} \mathrm{Y} \\ +\mathrm{b}, -\mathrm{i} \\ \mathrm{DIM}\ 1\mathrm{d}\ \mathrm{DIR} \\ \mathrm{BDBY}^{\pm}\left(\begin{bmatrix} \mathrm{X} \\ \mathrm{DIM}\ 0(+\varepsilon)\mathrm{d} \\ +\mathrm{b}, -\mathrm{i} \end{bmatrix}\right) \end{bmatrix} = \text{“a Y that has X as a terminus (+) or origin (−)”}$$

Thus, assuming an axis directed from back to front, the front of an object will be its BD^{+} and the back its BD^{-}; the beginning of an event will be its BD^{-} and the end its BD^{+}.

Another refinement is necessary to specify that a boundary inherits its secondary dimensionality from the object it bounds, as shown in the cases of *end* and *edge* in the previous section. However, this plays no formal role in what is to follow, so I will leave it for another occasion.

8. Using the formalism

I have introduced a fair amount of new machinery here, but each piece was motivated by its ability to capture aspects of the conceptualization of objects and substances as well as their linguistic reflexes. We now apply the machinery to a variety of analyses in path and event structure.

8.1 Paths

The first case is the Path-function TO, whose argument position defines the thematic role Goal, and which is treated as a conceptual primitive in Jackendoff (1983, 1990) (and most other sources as well). This function is most directly expressed by *to* in English but is also incorporated in a wide range of other prepositions and verbs, as seen in section 2.

We can now decompose TO. It defines a Path that terminates at the Thing or Place that serves as its argument. This is easily encoded in terms of the features and functions introduced here:

$$\text{(44)}\quad \text{TO X} = \begin{bmatrix} +\text{b}, -\text{i} \\ \text{DIM 1d DIR} \\ {}_{\text{Space}}\ \text{BDBY}^{+}([_{\text{Thing/Space}}\text{X}]) \end{bmatrix}$$

That is, TO specifies a 1-dimensional bounded directed Space (i.e., a bounded Path), bounded on its positive end by the Goal. FROM, the function whose argument defines Source, differs from TO only in that BDBY^{+} is replaced by BDBY^{-}. That's all there is to it.

VIA is a path-function that defines routes, again primitive in Jackendoff (1983). It forms part of the LCS of prepositions like *through* ("via the interior of") and *past* ("via near"). In the present notation it can be analyzed as (45):

$$\text{(45)}\quad \text{VIA}[_{\text{Place}}\text{X}] = \begin{bmatrix} -\text{b}, -\text{i} \\ \text{DIM 1d DIR} \\ {}_{\text{Space}}\ \text{CONT}([_{\text{Space}}\text{X}]) \end{bmatrix}$$

This is a directed 1-dimensional Space (a Path) that is unbounded – if you tell me you went *past* my house I have no idea where you started or ended. The only thing I know about your path is that it includes the region near my house as a significant part. That is precisely what CONT was designed to encode in expressions like *beef stew* (section 5.6).

The other two major Path-functions in Jackendoff (1983) are TOWARD and AWAY-FROM, which are like TO and FROM except that they do not include the Goal and Source respectively. In the mass-count test they behave like substances: any part of a Path *toward the house* is also describable as *toward the house*, whereas this is not true of *to the house*. We therefore want to describe TOWARD as unbounded. Statement (46) gives two possible analyses:

$$\text{(46)}\ \text{a.}\quad \text{TOWARD X} = \begin{bmatrix} -\text{b}, -\text{i} \\ \text{DIM 1d DIR} \\ \text{GR}\left(\begin{bmatrix} +\text{b}, -\text{i} \\ \text{DIM 1d DIR} \\ \text{BDBY}^{+}([\text{X}]) \end{bmatrix}\right) \\ {}_{\text{Space}} \end{bmatrix}$$

$$\text{b.}\quad \text{TOWARD X} = \begin{bmatrix} -\text{b}, -\text{i} \\ \text{DIM 1d DIR} \\ {}_{\text{Space}}\ \text{BDBY}^{+}([\text{X}]) \end{bmatrix}$$

Statement (46a) treats TOWARD X as a "ground-up" version of TO X, that is, roughly as the "Path-substance" of which TO X is made. Statement (46b) treats it by analogy with the notion of an "open interval" in mathematics – a space that is bounded by but does not include the Goal. In this treatment, we have to admit the possibility of [−b] entities that have boundaries. In either case, AWAY-FROM is identical except that $BDBY^-$ replaces $BDBY^+$. At present I do not know how to decide between these alternatives.

The inverse of TO is a function called AT-END-OF in Jackendoff (1990). This appears as part of the reading of a number of prepositions, for instance *across* in *Bill is across the road from here.* In this example, *across the field* expresses a Place that is at the terminus of a Path that begins here and extends across the field. (47) analyzes this function:

$$\text{(47)}\quad [_{\text{Place}}\text{AT-END-OF}([_{\text{Path}}\text{X}])] = \left[\begin{array}{l} +\text{b}, -\text{i} \\ \text{DIM 0d} \\ _{\text{Space}}\ \text{BD}^{+}\ ([\text{X}]) \end{array}\right]$$

8.2 Aspectual functions

INCH (inchoative) is a function that maps a state into an event culminating in that state. It is an optional element in the conceptual structure of such verbs as *stand*, *sit*, *point*, *cover*, *extend*, and *surround*. In Jackendoff (1990) (and many other sources) INCH is treated as primitive, but again the present analysis permits a decomposition:

$$\text{(48)}\quad \text{INCH}([_{\text{State}}\text{X}])(\text{“State X comes about”}) = \left[\begin{array}{l} +\text{b}, -\text{i} \\ \text{DIM 1d DIR} \\ _{\text{Sit}}\ \text{BDBY}^{+}([_{\text{Sit}}\text{X}]) \end{array}\right]$$

Notice that this is identical to the analysis of TO, except that the major category feature *Situation* replaces *Space*! That is, the present analysis formally captures a deep parallelism between the end of a Path and the state at the end of an Event.

The last section spoke of beginning and finishing as Events that serve as boundaries of other Events. Here is a formal treatment of *finish*; *begin* replaces BD^+ with BD^-:

$$\text{(49)}\quad \text{Situation X finishes/ends} = \left[\begin{array}{l} +\text{b}, -\text{i} \\ \text{DIM 0}(+\varepsilon)\text{d DIR} \\ _{\text{Sit}}\ \text{BD}^{+}[_{\text{Sit}}\text{X}] \end{array}\right]$$

Section 5.4 analyzed the progressive aspect as "grinding up" an action into a process, showing how this solves the "imperfective paradox". This analysis can be extended to express the difference between *stop doing X* and *finish doing X*. Both are termini of an action; but you can stop doing something without finishing it. Here is a possible analysis for *stop running to the store*:

$$(50)\quad \left[\begin{array}{l} +\mathrm{b}, -\mathrm{i} \\ \mathrm{DIM}\ 0(+\varepsilon)\mathrm{d}\ \mathrm{DIR} \\ \mathrm{BD}^{+}\left(\left[\begin{array}{l} +\mathrm{b} \\ \mathrm{COMP}\left(\left[\begin{array}{l} -\mathrm{b} \\ \mathrm{GR}\left(\left[\begin{array}{l} +\mathrm{b} \\ \mathrm{RUN\ TO\ STORE} \end{array}\right]\right) \end{array}\right]\right) \end{array}\right]\right) \end{array}\right]_{\mathrm{Sit}}$$

This unpacks as follows: the bounded event *run to the store* is ground up by GR into a process; some of this process is gathered up into a unit by COMP; the end of this unit is picked out by BD^{+}. It is this boundary event that is expressed by *stop running to the store*. In turn, since *run to the store* has been ground up, there is no inference of completion.

Statement (50) has a lot of functions in it. Which ones are lexical? My guess is that BD^{+} and COMP are due to the verb *stop*, which can also apply to States and Processes such as *Paul stopped being sick* and *Paul stopped sleeping*. GR in (50) is likely inserted by a rule of construal that converts a closed Event into an unbounded entity so that it can be bounded again internally.

An alternative rule of construal available in this context inserts our old friend PL, which creates a different kind of unbounded entity. This is the most likely reading of *The light stopped flashing*, and a secondary reading of *Bill stopped running to the store* (*all the time*), namely the termination of a sequence of iterations:

$$(51)\quad \left[\begin{array}{l} +\mathrm{b}, -\mathrm{i} \\ \mathrm{DIM}\ 0(+\varepsilon)\mathrm{d}\ \mathrm{DIR} \\ \mathrm{BD}^{+}\left(\left[\begin{array}{l} +\mathrm{b}, +\mathrm{i} \\ \mathrm{COMP}\left(\left[\begin{array}{l} -\mathrm{b}, +\mathrm{i} \\ \mathrm{PL}\left(\left[\begin{array}{l} +\mathrm{b} \\ \mathrm{RUN\ TO\ STORE} \end{array}\right]\right) \end{array}\right]\right) \end{array}\right]\right) \end{array}\right]_{\mathrm{Sit}}$$

Notice that in (51) there is no extracting function in the chain, so this time we can infer that Bill did run to the store.

8.3 The "Vendler classes"

Much of the discussion of event structure has taken as a starting point the so-called Vendler classes of states, activities, accomplishments, and achievements. It is by now well known that these classifications pertain to entire sentences rather than to verbs as Vendler (1957) thought. There is not space here to discuss the extensive literature. However, I have become convinced, especially by the work of Declerck (1979), that the distinctions have to do with temporal structure, and have nothing to do with causation or volition, as implied by Dowty's (1979) influential analysis. The present formalism provides a straightforward encoding of the Vendler classes and permits us to set up a couple of other cases that Vendler and many later investigators have missed.

States are simply undirected situations, of 0 or 1 dimension. They may be bounded or unbounded; but I don't think they can be intermittent, hence they are [−i]. The formal specification is (52):

(52) $\text{State} = \begin{bmatrix} & -\mathrm{i} \\ _{\mathrm{Sit}} & [-\mathrm{DIR}] \end{bmatrix}$

Activities correspond to what have been called here processes: unbounded directed situations. These can be produced either intrinsically (*swim*), by grinding bounded events (*be running to the store*), or by iterating bounded events (*flash repeatedly*). But these latter two cases are just elaborations of the basic case shown in (53), in which the "core" (*run to the store*, *flash*) is embedded as the argument of a GR or PL function (in other words, the "conversion" of an accomplishment (event) into an activity (process) is produced by a rule of construal that adds an operator):

(53) $\text{Activity} = \begin{bmatrix} & -\mathrm{b} \\ _{\mathrm{Sit}} & [\mathrm{DIR}] \end{bmatrix}$

Accomplishments (e.g., *run to the store*, *eat an apple*) are directed situations with a final boundary. They intrinsically take place over a period of time, so they have to be 1-dimensional:

(54) $\text{Accomplishment} = \begin{bmatrix} & +\mathrm{b} \\ & [\mathrm{DIM\ 1d\ DIR}] \\ _{\mathrm{Sit}} & \mathrm{BDBY}^{+}([\ ]) \end{bmatrix}$

However, an accomplishment can be subjected to the zero rule (37), which idealizes it as a point. This is what allows us to attribute an accomplishment to a point in time, as in *Bill ate an apple at 6:00.*

The trickiest case is the *achievements* such as *reach the top*, *arrive*, *die*, and, notably, *finish*. Our analysis of this last verb in the previous section provides the key: they are all events that mark the culmination of some larger event. Although they are fundamentally 0-dimensional, the optional expansion with epsilon provides a little temporal window into which we can sneak a progressive:

(55) $\text{Achievement} = \begin{bmatrix} & +\mathrm{b}, -\mathrm{i} \\ & [\mathrm{DIM\ 0(+\varepsilon)d\ DIR}] \\ _{\mathrm{Sit}} & \mathrm{BD}^{+}([\ ]) \end{bmatrix}$

Related to the class of achievements but not distinguished by Vendler are the *inceptions* such as *leave*, *commence*, and *start*. These are just like achievement except that BD^+ is changed to BD^-:

$$\text{(56) Inception} = \begin{bmatrix} +\text{b}, -\text{i} \\ [\text{DIM } 0(+\varepsilon)\text{d DIR}] \\ {}_{\text{Sit}}\quad \text{BD}^-([\ ]) \end{bmatrix}$$

Another class includes *point-events* like *flash* and *click*. These are not regarded as having appreciable duration. Statement (57a) gives their schema. A final class is *duratives* like *stay*, *keep*, and *persist*, which like activities are not inherently bounded, but unlike activities cannot be asserted at a point in time. Statement (57b) gives their schema:

$$\text{(57) a. Point-event} = \begin{bmatrix} +\text{b} \\ {}_{\text{Sit}}\ [\text{DIM 0d DIR}] \end{bmatrix}$$

$$\text{b. Durative} = \begin{bmatrix} -\text{b} \\ {}_{\text{Sit}}\ [\text{DIM 1d DIR}] \end{bmatrix}$$

The upshot of this analysis is a general agreement with such writers as Verkuyl (1989) and Pustejovsky (1991), who regard the Vendler classes not as a basic division of the aspectual system, but rather as various realizations of a set of more fundamental parameters. Here the parameters available are those of dimensionality and bounding, motivated independently for the conceptualization of objects; and therein lies their novelty.

8.4 *Until and since*

We finally return to our initial example, *The light flashed until dawn*, which we can now formalize. Recall the informal analysis of section 3: *until* places a boundary on an otherwise unbounded event. This comes out as (58):

$$\text{(58) X until Y} = \begin{bmatrix} +\text{b} \\ [\text{DIM 1d DIR}] \\ \text{COMP}\left(\begin{bmatrix} \text{X} \\ {}_{\text{Sit}}\ -\text{b} \end{bmatrix}\right) \\ {}_{\text{Sit}}\quad \text{BDBY}^+([_{\text{Sit/Time}}\ \text{Y}]) \end{bmatrix}$$

This is a bounded event, composed of the state or process X (*until* doesn't care which), and ended by the situation or time Y.[14]

The fact that X must be unbounded in order to be the argument of COMP explains why *The light flashed*, which has event structure (57a), cannot appear unmolested before *until*. The day is saved by the rule of construal that inserts iteration, to give (59), a more complete version of our original attempt in (8):

(59) The light flashed until dawn =

$$\begin{bmatrix} +\mathrm{b} \\ [\mathrm{DIM\ 1d\ DIR}] \\ \mathrm{COMP}\left(\begin{bmatrix} -\mathrm{b}, +\mathrm{i} \\ \mathrm{PL}\left(\begin{bmatrix} +\mathrm{b} \\ [\mathrm{DIM\ 0d\ DIR}] \\ \mathrm{LIGHT\ FLASH}\end{bmatrix}\right)\end{bmatrix}\right) \\ \mathrm{BDBY}^{+}([_{\mathrm{Time}}\ \mathrm{DAWN}]) \end{bmatrix}_{\mathrm{Sit}}$$

For some reason, the rule of construal that inserts GR instead of PL cannot apply with *until*, so that *Bill ran into the room until we stopped him* can only mean repeated running into the room, not our stopping him before he had a chance to get all the way in. I don't know why. (Using the progressive, *Bill was running into the room until we stopped him*, is cheating – it grinds the event into a process before submitting it to *until*.) However, another variation is available, seen in *Bill went away until Tuesday*. Here the state that results from or is the culmination of Bill going away persists until Tuesday. I am not sure how to formalize this case.

Since is approximately the reverse of *until*. *Bill has liked Sue since 1948* expresses a state beginning with (BDBY^{-}) 1948, containing (CONT) the discourse reference time (in this sentence, NOW), and composed of (COMP) Bill liking Sue. In *The light has flashed since dawn*, the most prominent reading iterates *the light flashed* into a process so that it can be unbounded, as required for it to be the argument of COMP. Another reading, more prominent in *The light has flashed just once since dawn*, appears to substitute CONT for COMP, so that a single flashing can constitute a significant part of the period since dawn. Note that *ever since* can be used only in the first reading:

(60) a. Ever since dawn, the light has flashed. (iterative)

b. *Ever since dawn, the light has flashed just once.

[14]For simplicity, I have treated *until* as a function of two arguments: the Event to be bounded and the Time. This actually does not accord too well with the syntactic pattern of the sentence, in which *until Y* is a modifier of the sentence expressing the event to be bounded. Improving this analysis would take us deeply into the theory of arguments, adjuncts, and modifiers, a topic beyond the scope of this paper.

Some of these complications seem to be tied up with the strongly preferred use of perfective aspect with *since*, a problem beyond the scope of this paper.

We have not dealt with the conceptual structure of measurement and quantity, so we cannot formalize phrases like *for 3 hours*, *in 3 hours*, and *3 times*, which have been crucial in the study of event structure at least since Vendler (1957). However, the present approach suggests that *for 3 hours* should be constructed so as to be compatible with expressions in the noun system such as *3 inches of rope*, which measures out a quantity of an unbounded substance; by parallelism, *X took place for 3 hours* measures out a quantity of an unbounded Situation (i.e., State or Process). *X took place in 3 hours* ought to be parallel to *Object X is located within 3 miles of Place Y*; both of them require bounded entities for X. *Three times* ought to just put a count on iterations of bounded events, just as *three cows* puts a count on iterations of *cow*. That is, when counting and measuring can be formalized in the noun and preposition system, the treatment should generalize naturally to the aspectual system along the lines seen here in the formalization of parts, composition, and boundaries.

9. Final remarks

I want to make four points in closing. First is that I have proposed what may seem like a substantial amount of machinery, including the features ±b and ±i, the six extracting and including functions (PL, ELT, COMP, GR, PART, and CONT), the dimensionality feature (including the epsilon dimensionality), the directionality feature, and the two boundary functions BD and BDBY. All of these parts have been necessary to get at the proper analysis of our initial puzzle, *The light flashed until dawn*. This may seem like excessive use of force. However, with this machinery we have been able to address along the way a wide range of phenomena, including the plural, collective nouns like *group* and *pile*, *N-of-NP* constructions and *N-N* compounds, boundary nouns like *end* and *crust* and prepositions like *to* and *from*, the Vendler classes, progressive aspect, and the "imperfective paradox". Thus we see that the true scope of the solution has proven to be an extremely broad one. A cornerstone of the solution has been the "X-Bar" character of the major conceptual categories – the possibility of features and functions that apply equally to Things, Places, and Events. To the extent that the description here has been successful, this vindicates and deepens this aspect of the theory of Conceptual Semantics.

Second, despite the fact that this paper is ostensibly about lexical semantics, the distinction between lexical semantics and phrasal semantics has played only an incidental role. The very same features and functions can appear in conceptual structure by virtue of either lexical entries, morphological affixes, constructional meanings (*N of NP* and *N-N* compounds), or rules of construal. In a sense, this supports an even more fundamental tenet of Conceptual Semantics: that conceptual structure is autonomous from language and that there is no intervening level of "purely linguistic semantics" intervening between it and syntax. The conceptual features and functions proposed here are indifferent to how they are expressed syntactically; it just so happens that four different kinds of correspondence rules – lexical entries, morphological affixes, constructional meanings, and rules of construal – are all capable of licensing relations between syntactic and conceptual structure in this domain.

Third, let us return to the issue of semantic primitives raised in section 1: when we propose a conceptual analysis of a word or phrase, how do we know we have got it all the way down to primitives? The answer is that we don't know, but this shouldn't stop us. For instance, the identification in Jackendoff (1983) of a conceptual category Path spelled out by a repertoire of five Path-functions was, I believe, an advance that permitted an insightful description of many phenomena. The fact that these putative primitives have now been subjected to further decomposition in order to bring them into a still larger orbit does not negate the earlier treatment. Similarly, the functions proposed here – PL, ELT, COMP, GR, PART, CONT, BD, and BDBY – will no doubt themselves submit to further analysis, as well may the ontological supercategories Material, Situation, Space, and Time.

I am not disturbed by this state of affairs. Rather, I am cheered by the analogy to our favorite high-prestige model, physics, where, as pointed out in section 1, the decomposition of matter into ever smaller and more general primitives has been one of the major scientific successes of our century, and where the prospect of not yet having hit bottom is an exciting spur to further research. For those who *are* disturbed by semantic decomposition, the phenomena analyzed here present a major challenge for a nondecompositional theory (be it a theory of monads connected by meaning postulates, as in Fodor, Garrett, Walker and Parkes (1980) or a connectionist theory of meaning).

Finally, I return to the issue of I-semantics versus E-semantics, raised at the outset. There has been considerable philosophical dispute (e.g., Fodor, 1987; Putnam, 1988; Schiffer, 1987) over whether a theory of meaning is even possible. Closer examination reveals that the sort of theory in dispute is always a theory of E-semantics, that is, one that asks for a direct connection between language and the real world; it may or may not in addition contain a psychological component. Schiffer concludes that there is no such theory, and that philosophy of language must find a new set of presuppositions under which to pose questions about meaning. I would like to suggest that the proper questions to ask are those of I-semantics, namely the characteristics in terms of which speakers *construe* the reality they experience. These are the presuppositions under which the present study and the others in this volume have been conducted, and under which some progress has apparently been made.

Let me illustrate with one example. As long as one sticks with unanalyzed sentences like *snow is white* and *tigers have stripes*, one can happily remain under the presumption that sentences are connected to the world pure and simple. But consider the word *end*. What do the end of a table, the end of a trajectory, and the end of a speech have in common, such that we use the word *end* for them all? Nothing, unless we admit the possibility of schematizing objects, trajectories, and events in terms of a common abstract notion of bounded 1-dimensionality. It is hard to regard this schematization as an inherent property of *reality*; but it makes a great deal of sense in terms of the psychological organization with which one construes reality. What we have seen here is that such psychological organization lies a very short distance below the surface of everyday lexical items – and that progress can be made in exploring it. This suggests to me that the issue for philosophers of language ought not to be whether it is possible to do E-semantics, but rather how one can make sense of the explanations offered by I-semantics within a broader psychological, social, and biological context.

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