

Semantics and Pragmatics of Locative Expressions*

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The paper examines locative expressions and shows that an adequate account of their meaning must be based on two essential understandings: First, the simple spatial relation, often given as the meaning of the spatial prepositions, is only an "ideal" from which there are deviations in context; second, a level of "geometric conceptualization" mediates between "the world as it is" and language. Pragmatic "near principles" are formulated to explain some deviations from the ideal and several other apparent irregularities of prepositional use. A set of "use types" of the ideal meaning is proposed to account for conventional aspects of locative meaning. The paper concludes with a discussion of the consequences of this description of locative expressions for artificial intelligence and linguistics.

1. INTRODUCTION

The problem of lexical meaning is the skeleton in the closet of both artificial intelligence and logical semantics. The lexical representations used in artificial intelligence rarely even approximate speakers' uses, and in a majority of cases it is impossible to provide—as logical semantics requires—necessary and sufficient conditions to define word meanings, yet the business of building theories and models goes on as if such failures could be overlooked.

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Often, pragmatics is called upon to explain the discrepancies between meaning as produced by the theory and actual use, but this pragmatics is mostly uncharted. And those semanticists who pay attention to the complexities of word meaning, and have made many subtle observations about word use, have failed to tie them all together into a theory that explains composition or entailment.

In this paper, I will propose an analysis of spatial prepositions that respects the intricacy and seeming capriciousness of their behavior, and yet accounts for the meaning of complex locative expressions, and for their use in context. This analysis will be based on a prototype—a better term would be “ideal”—meaning for the preposition. This ideal is only part of the information needed in the lexical entry and deviations from the ideal will be precisely described. Prototypicality makes possible an account of polysemy; it also underlies some pragmatic processes of “allowance,” or “tolerance.”

I will call “locative expression” any spatial expression involving a preposition, its object, and whatever the prepositional phrase modifies (noun, clause, etc.), such as:

the spider on the wall

Jenny is at the playground.

There is a green house on the left of the church.

He is washing the dishes in the sink.

Concern with the use of these expressions leads to two fundamental questions, “encoding” and “decoding.” The decoding question is: Given a locative expression used in a particular situation, can one predict what it conveys, how it will be interpreted—that is, provided it has been used appropriately? If not, can one explain the inappropriateness? And the encoding question is: Given a situation with two spatial objects, can one predict the locative expression(s) that can be used truly and appropriately to describe their spatial relation?

At first sight, the problem appears relatively straightforward. We picture the world as made up of objects, each with a well-defined shape and position in space at a given time. Nouns denote the objects. Prepositions are assumed to denote simple spatial relations between two objects (“containment,” “support,” “contiguity,” etc.), or sometimes among three objects (e.g., *between*). The meaning of a locative expression (say a copulative expression, such as *The mouse is in the hole*) is a proposition predicating the relation denoted by the preposition of the objects referred to by the noun-phrases.

So, for instance, the meaning of *in* might be:¹

$\text{In}(X,Y) \text{ iff } \text{Included}(\text{Part}(X),Y)$

(X is *in* Y if and only if a part of X is spatially included in Y)

¹ The representations that follow are adapted from Cooper (1968) and Miller and Johnson-Laird (1976).

For some prepositions, we have to allow for ambiguity. So for *on*, at least two meanings are needed, one for three-dimensional examples, like *the book on the desk*:

$\text{On}_1(X,Y) \text{ iff } \text{Contiguous}(X,Y) \text{ and } \text{Support}(Y,X)$

and one for two-dimensional examples like *the house on the lake*:

$\text{On}_2(X,Y) \text{ iff } \text{Contiguous}(X, \text{Boundary}(Y))$

Then, given *The mouse is in the hole*, one can apply a simple compositional rule: Insert symbols denoting the referents of the noun-phrases as arguments of the relation defining the meaning of *in* above. One then obtains the relation:

$\text{In}(\text{Mouse}, \text{Hole}) \text{ iff } \text{Included}(\text{Part}(\text{Mouse}), \text{Hole})$

which is the relation that holds true in the situation described by *The mouse is in the hole*. That formula is “the meaning” of the sentence.

But this “simple-relations model” is inadequate.² Such simple relations together with the compositional rule yield wrong or insufficient predictions about the set of situations (intensionally the situation type) described by the locative expression. Current pragmatics gives us no clues on how to bridge the gap; and to dispose of the problem by labeling the uses not predicted by the model “idiomatic” often sounds like obfuscation—it fails to account for speakers’ frequent intuitions that such uses are motivated.

This paper will have two main purposes: First, to present evidence of the rather unexpected unruliness of locatives; second, to propose a model of their meaning and use that accounts for the empirical data. Here is a first sketch of this model:

1. The prepositional category as a whole is organized around a focal relation, the **ideal meaning**. The whole set of uses of the preposition can then be subcategorized into **use types** (corresponding roughly to different senses), each such subclass manifesting the ideal meaning, but usually after some transformation.

² The simple-relations model underlies most work on locatives within the computational paradigm (Bogges, 1979; Cooper, 1968; Miller & Johnson-Laird, 1976; Waltz, 1980; Winograd, 1972). Bogges takes into account an additional level of complexity, namely the role that a few perceptual features of the objects play in determining the interpretation of locative expressions, but, as we will see, this is insufficient. In linguistics, early work on locatives came mostly from structuralists (Bennett, 1975; Leech, 1969). Although they do not require meaning to express the sentence truth-conditions, only to account for intralinguistic relationships, their representations resemble the propositions just described. Implicit in Fillmore (1971) and Talmy (1975) is a view of spatial prepositions as expressing simple relations between physical objects. Recent work, such as that of Talmy (1983), Lindner (1981), and Brugman (1981), is more concordant with the views expressed here, but it gives neither a precise account of the relation of locative expressions to the real world of physical objects, nor of the respective roles of motivation and convention.

2. A level of "geometric conceptualization" mediates between our naive representation of the physical world and the application of locative terms; prepositional meaning applies in effect to schematic images (**geometric descriptions**) matched onto the objects.
3. A number of contextual factors bear on the choice and interpretation of a locative expression: **relevance, salience, tolerance, and typicality**. There are pragmatic principles relating to these that explain many characteristics of the situation of use.

One question will recur as this model takes shape: Which aspects of the meaning of locative expressions are arbitrary, and which are motivated? A precise account of the respective scopes of arbitrariness and motivation will eventually emerge, and each will find its proper place in the model.

Decoding and encoding are, of course, relevant to the building of computer models of language. In fact, the artificial intelligence view of "comprehension" and "production" matches the above definitions of encoding and decoding. In comprehension, the hearer holds in mind a partial representation of the "contextual situation," and transforms or augments this representation according to the content of the utterance. In production, the speaker, having in mind a representation of a given situation, generates an utterance describing some aspect of that situation. Clearly, solving the decoding and encoding problems is a preliminary to devising such models of comprehension and production. Note that these views of comprehension and production are by no means perfectly clear or unquestionable (cf. Dreyfus, 1979; Searle, 1981; Winograd & Flores, in press). As it makes no reference to psychological processes, the decoding/encoding problem raises fewer difficulties.

But building computer models of language in the spatial domain will turn out to be a very difficult task indeed. Because they lack a sufficiently fine analysis of lexical meaning, procedural linguists have failed to understand precisely how their programs fall short of modeling human capacities. In logical semantics, the same lack has led to theories that cannot possibly accommodate the range of empirical data. The paper will conclude with a precise description of the difficulties involved in building computer models for spatial expressions and suggest some consequences of the analysis in this paper for semantic theory.

To begin, then, consider a simple locative expression:

James is near the lemon tree.

I will call *James* the **subject**, and *the lemon tree* the **object** of the locative expression. The sentence manifests several linguistic choices, but those relevant to understanding locatives are the syntactic choice—or which noun-phrase is to function as subject, and which as object—and the choice of preposition. We can approach the decoding/encoding problem by asking:

What are these choices correlated with? What characteristics of the objects, of their interaction, of the context, are these choices correlated with? In the next section, I will consider the syntactic choice, and two problems which the simple-relations model ignores: the contrast between converse expressions, and the existence of constraints on the syntactical choice. I will then turn to the choice of preposition, first describing the shortcomings of the simple-relations model, and follow with my own proposal for the semantics and pragmatics of locatives.

2. FIGURE/GROUND AND PURPOSE

Although many prepositions have converses (*above/below*), and some are symmetric (*near*), the two possible assignments of the role of subject and object are not equivalent (Talmy, 1978a). The subject/object assignment is related to the purpose of the locative expression. In the prototypical case, that purpose is simply to inform the addressee of the location of an object (let us call this the **located object**, or **Figure**); this is accomplished by providing a constraint on that location, in the form of a spatial relation that holds between the Figure and a **reference object**, or **Ground**.¹ It is assumed the addressee either knows the location of the reference object or could easily discover it. The Figure is referred to in the subject position of the locative expression; the Ground is referred to in the object position. Compare:

The house is behind the church.
The church is in front of the house.

One can say that the first object is "conceptually movable" with respect to the second (Talmy, 1978a).

Suppose one wished to describe the location of an object A to a given addressee. Assume A is in the field of view and there is an object B near A that we know the addressee can see. Or, alternately, assume A is not visible, but we know the addressee knows the location of an object B near A. Even so, we may not be able to use a locative expression with A as Figure and B as Ground, though the relation expressed appears true. For instance, the sentences:

¹ The terms Figure and Ground are from Talmy (1978a). One should not look for too close a relation between this use of the terms and their use in Gestalt psychology. Given a figure seen against a background, the background acts as a fixed reference frame against which the figure could move. But Figure/Ground in the Gestalt sense is a perceptual relation, while in Talmy's sense, it is a conceptual relation. In *the chair to the left of the desk*, the chair does not act as perceptual background for the desk, although, in Talmy's sense, the desk is the Figure and the chair the Ground.

**Mary's house is near the bicycle.*⁴

**The gate is at Mary.*

are not acceptable, even if the addressee knows where I parked the bicycle; or if Mary is quite visible against a very long fence in the distance, while the gate does not stand out. In such contexts, one may use paraphrases:

Mary's house is near where the bicycle is.

The gate is where Mary is standing.

To explain this, we must look at the typical properties of pairs of objects, such that one is used as a reference for locating the other. I noted that a reference object should either be easy to see, or its location should be known to the addressee. In the former case, the chosen object would normally be visually salient, and the Figure would be less discernible than the Ground—otherwise the addressee could discover the Figure's location without locative information. In the latter case, the Ground object will often have a permanent location, since such objects are more likely to have their location known than objects which move freely.

In short, there is a tendency to use relatively large and fixed objects as references; and pairs of objects which greatly violate these conditions are unacceptable, even if the choice of reference object is perfectly rational in the current context. In the examples above, the need for a fixed Ground object is fulfilled by substituting *where the bicycle is* for *the bicycle*, or *where Mary stands* for *Mary*—by having a "place," that is, a fixed point of the earth's surface as reference object, instead of a typically very mobile object.

There are cases where the main purpose of the locative expression is not to inform the addressee of an object's location, but to identify an object, as in:

Give me the book next to the pencil!

In appropriate uses of this sentence, the particular book the speaker has in mind can be inferred from its location. Where identification is the main purpose, it would seem that the reference object need not be more salient than the located object; since the speaker wants the addressee to pick one out of several objects, the selected object need only be the only one to bear the relation expressed to the chosen Ground object. Yet, often the sort of Figure/Ground relationship that would be unacceptable with the prototypical use remains unacceptable here as well. So, as expected:

**The bottle is under the cap.*

sounds absurd; the addressee would be unlikely to see the cap but not the bottle. But:

⁴ The symbol "*" signifies syntactic, semantic, or pragmatic ill-formedness. This example is adapted from Talmy (1978a).

**The cognac bottle is the one under the cap.*

sounds no better, although such an expression should make sense if there were several similar bottles, and only the cognac bottle had a cap. Then one would say instead:

The cognac bottle is the one with the cap on it.

(*with* is not basically locative, and does not demand a fixed and/or salient reference object). In the same way:

**I painted the wall against the chair.*

is unacceptable. Our linguistic ear demands the same relative fixity and salience of Figure and Ground in the identification case as in the prototypical locative case.

It is difficult to state exactly the conditions that make a locative expression unacceptable because of inappropriate typical relative salience and fixity. The unacceptability depends on the preposition, and also seems to vary idiosyncratically with particular contexts. Thus, *at* and *against* strictly require a Ground that is fixed in relation to the Figure; *next to*, *by* and *behind* are less strict, as exemplified by:

The gate is just next to Mary.

I painted the wall by/behind the chair in blue.

One should probably consider such variable restrictions to be conventional properties of particular prepositions. When one tries to find the source of these restrictions in connotations of the preposition, the resulting explanations are very elusive. For instance, *against* suggests prototypically a movement of the Figure toward the Ground; in the static case, this might exclude situations with a movable Ground and a fixed Figure. Such connections may underlie speakers' intuitions, but that would be difficult to prove.

The following examples show that restrictions on Figure/Ground choices depend on more than the relative fixity and salience of the objects, and vary somewhat idiosyncratically with the context:

The mountain under the plane just now is Mount Shasta.

**The cognac bottle is the one under the cap.*

It seems that connotations of the preposition, the accumulation of experiences with the objects and with similar linguistic expressions, combine to make certain Figure/Ground assignments unacceptable in ways that are difficult to make explicit. In some cases, explanations suggest themselves—for example, human beings, though quite movable and often relatively unobtrusive, can be used as Grounds for much bigger, fixed objects, presumably because of the human tendency to picture oneself as the center of the universe:

The Empire State building is near us.

**The Empire State building is near the bicycle.*

In summary, there are typical patterns of conceptual movability: That is, for some pairs of object kinds, A and B, one will typically locate object of type A with respect to object of type B, and expressions that relate the objects in converse order are often unacceptable, however rational they might be in terms of the speaker's purposes. The acceptability of a certain Figure/Ground choice also varies with the preposition. Finally, with a given preposition, the unacceptability of a given locative expression cannot always be traced to a few properties of the objects involved; it varies in somewhat idiosyncratic fashion with the types of objects.

3. INSUFFICIENCIES OF THE "SIMPLE-RELATIONS MODEL"

Let us turn now to the meaning of the preposition proper. What does a preposition contribute to the description of a situation in which a locative expression is used truly and appropriately? I will show that the common answer to that question, which gives a simple spatial relation as the meaning of the preposition, is inadequate.

3.1 Geometric Conceptualization

One conspicuous shortcoming of the simple-relations model is that the simple relations would not, in any case, apply to the objects themselves, but rather to parts of space, to geometric images matched onto the objects, to what I call geometric descriptions of the objects. And even with the same preposition, different geometric descriptions may be applicable. For instance, in *the water in the vase*, the water is actually in the "volume of containment" of the vase, corresponding to the cross-hatched region in Figure 1(a). But in *the crack in the vase* (Figure 1(b)), the crack is in the "normal

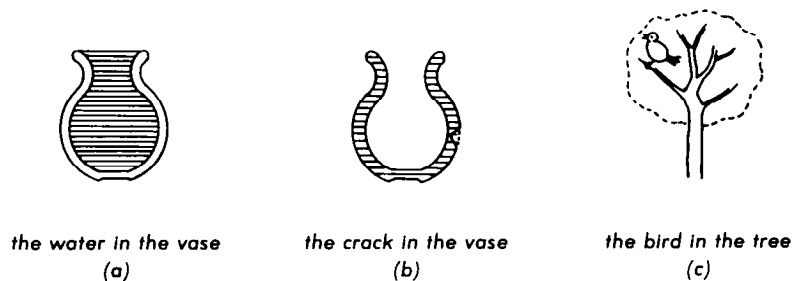


Figure 1

volume” of the vase, that is, the volume the vase would occupy if it were uncracked (to talk about a hole in something is implicitly to refer to a “normal” volume, the volume before the hole was there). Finally, in *the bird in the tree* (Figure 1 (c)), the bird is in the interior of the outline of a part of the tree.

In the simplest case, the applicable geometric description is the space occupied by the object, which I call the **place**, or **canonical description**, of the object. This is the case with the located object in all the examples above.

Another important type of geometric description involves viewing or conceptualizing an object as a point, a line, a surface, or a strip—in other words as some simple geometric figure. So in:

the village on the road to London

the village is viewed as a point, and the road as a line. Or in:

The top of the cloud cover is at 3000 feet.

the top of the cloud cover is viewed as a horizontal plane, by some process of approximation.

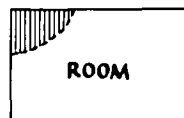
A few more examples of non-trivial geometric descriptions. In:

the crack in the surface

the surface is conceptualized as some very thin three-dimensional lamina, not as an actual two-dimensional surface without thickness. And in:

the chair in the corner of the room

the corner is conceptualized as some cylinder with a base about like the cross-hatched area in Figure 2, and a height equal to that of the walls.³



the chair in the corner

Figure 2

Finally, in:

to the right of the chair

a frame of reference is matched onto the chair, defining a front, back, right, and left. The frame of reference can be intrinsic to the chair, or it can be ascribed using the line of sight of some observer away from the chair. This frame of reference constitutes another kind of geometric description.

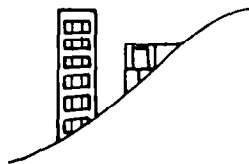
³ The base of a generalized cylinder can be any closed curve.

3.2 Synecdoche

The geometric descriptions considered so far correspond to a level of geometric conceptualization that mediates between language and perceptual representations or mental images of scenes. Linguistically, such geometric descriptions can be viewed as metonymies; that is, one could say that in *the village on the road*, we use *the village* to actually refer to a point on a kind of mental map. But other kinds of transfers to geometric descriptions arise from more classical types of metonymies, in particular synecdoche, where the whole stands for a part. Thus, in:

the child in the back of the car

the car stands for the interior that holds the passengers; the child is not in the trunk. In Figure 3, only the base of the house is above the base of the building; *house* and *building* are used as metonymic substitutes for their bases.



the house above the building

Figure 3

Or consider the use of *under*. In:

the key under the rug

the key is under the bottom surface of the rug. But in:

One could see shiny white carp under the water.

Ants dig burrows under the sand.

The Eskimo buried the animal under the snow.

carp, burrows, and animal are not under the bottom surface of respectively, water, sand, and snow, but under the top surface. In other words, *the water*, *the sand*, and *the snow* stand for their top surface. Such synecdoche may apply to all substances that constitute an extensive cover at ground level, when that surface stands out in the speaker's perceptual experience or mental image.

So one would have to extend the simple relations model at the very least to account for transfers to geometric descriptions, arising either through geometric conceptualization or through synecdoche.

3.3. Divergence from the Simple Relations

Another shortcoming of the simple-relations model is that the simple relations are often not true, not even of the geometric descriptions. So, for example, the pear in Figure 4(a) is *in* the bowl, although it is not in the interior of the bowl.

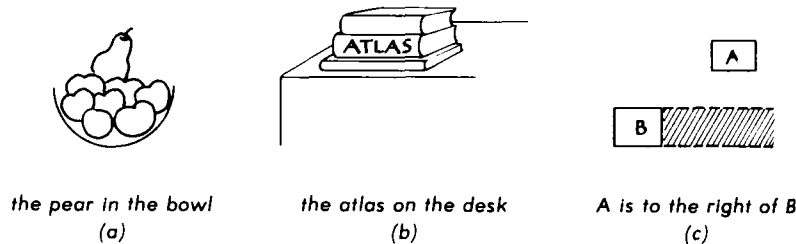


Figure 4

In Figure 4(b), the atlas is *on* the desk, although it is not contiguous with the desk, and is only indirectly supported by it. And in Figure 4(c), A is *to the right* of B, although it is not in the cross-hatched area where it should be according to the most plausible simple-relation meaning for *to the right* (if told *Put the chair to the right of the desk*, I would be expected to place the chair so).

Or take *at* to mean:

$At(X, Y)$ iff $Coincides(X, Y)$ (where X and Y are points)

as in:

The center of the circle is at the intersection of the axes.

But in:

Mary is at the gate.

Mary and the gate are not coincident; they are only very close together. So, there is an admissible tolerance for deviation from the simple relations.

In all these examples, the shift from the simple relation can be conceived of as gradual, measurable by some distance or angle, with perhaps a threshold beyond which it is inappropriate to use the preposition. But the shift cannot always be conceived of in this way. So, in:

the wrinkles on his forehead

a wrinkle is not an object contiguous with, and supported by, the forehead; but it appears to be, and this resemblance does motivate the use of *on*. Thus, one would not say:

**the ruts on the road*

because the depth of the surface accident here prevents one from seeing a resemblance with a situation of contiguity and support. Where the surface accident is deep, *in* is required, expressing the relation of a gap to the “interrupted” object:

the deep wrinkles in his forehead
the ruts in the road

Or consider:

the apple on the branch
the medal on a chain

The relation centrally expressed here is one of attachment. But, most often, attachment co-occurs with contiguity and support: The apple is contiguous with the branch through its stem, and ordinarily supported by the branch, though from above; and the same can be said of the medal and the chain. That attachment is implied, however, is shown by the fact that the first example would be appropriate if the branch were on the ground and the apple supported by the ground instead of the branch. We see that, although the meaning expressed is not the simple relation defining *on*, it is closely connected to that simple relation.

So, the simple-relation meaning is sometimes, one could say, “almost true,” and sometimes shifted to another, though closely related meaning. This suggests a prototypical meaning structure for the preposition.

3.4. Added Constraints

Sometimes there are added constraints; that is, the relation implied by a certain use is more specific than the simple relation. So, in:

the man at the desk

man and desk are very close to each other, but also we assume the man is working at his desk, or at least is in a position to do so. If he were doing somersaults on top of his desk, he would not be *at his desk*.

No doubt, in this example as in some that follow, the deviation from the simple-relations model could be described as exceptional and the expressions themselves as idiomatic, conventional ways to refer to a given situation. Yet, one needs an account of such expressions, idiomatic or not, and in particular an account of the choice of preposition which we perceive intuitively to be motivated, that is, to be related to other uses of the same preposition.

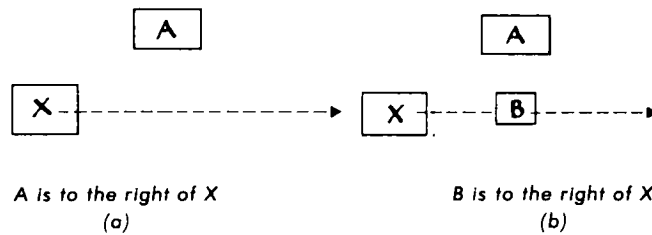
3.5. Unexplained Context Dependencies

There are also some unexplained context dependencies. In:

The gas station is at the freeway.

the gas station is at the intersection of the freeway with a crosspath to be determined by context. Ordinarily, speaker and addressee would be on that path.

In Figure 5(a), one could say that A is *to the right of* X.



But if an object B were introduced as in Figure 5(b), then, in many contexts, only B is *to the right of* X (in some contexts, one might say *A and B are to the right of* X, but *the building to the right of* X would be identified as B, and the school is *to the right of* X would not leave the addressee wondering whether the school is A or B). So the use of the expression *A is to the right of* X depends upon the presence of objects in the environment other than A and X.

Consider also:

Jim is at the supermarket.

The appropriateness of this sentence does not depend solely on Jim's position with respect to the supermarket, because if both speaker and addressee are in the supermarket the sentence is inappropriate—one would then be likely to say instead:

Jim is in the supermarket.

3.6. Unexplained Restrictions

Finally, there are restrictions that cannot be explained in terms of the simple-relations model. For example, one cannot say:

**Draw a line in the blackboard!*

**The table is in the lawn.*⁶

Although lawn and blackboard are areas *in* which something could, in principle, be included. But one can say:

Draw a line in the margin!

The table is in the garden.

⁶ This example is adapted from Fillmore (1971).

Or take the scenes of Figure 6.

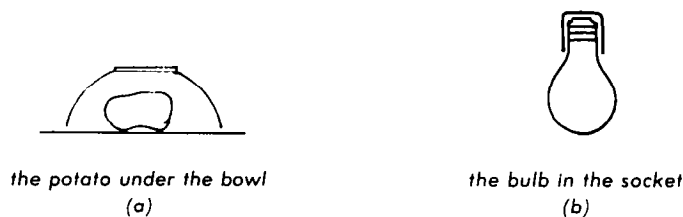


Figure 6

One would not ordinarily say:

- *the potato in the bowl*
- *the bulb under the socket*

to describe these scenes, although, according to the simple-relations meaning of the prepositions, both phrases should be true.

In conclusion, the simple relations together with the compositional rule do not constitute an adequate model in a variety of ways; they fail to predict the uses of a great many expressions.

4. MEANING AND USE OF SPATIAL PREPOSITIONS

In the introduction, I outlined a description of the semantics and pragmatics of locatives. One can examine the elements of this description in terms of the contrast between systematicity and idiosyncrasy. Locative expressions show systematicity in two respects:

1. Each preposition has an ideal meaning, a kind of prototype, manifested in every use of the preposition; such an ideal meaning, or some transformation of it, applies to schematizations (geometric descriptions) of the objects.
2. There are a number of pragmatic "near-principles" involving salience, relevance, tolerance, and typicality that explain certain prepositional choices and metonymies.

Outside these patterns of motivation, one finds idiosyncratic aspects of meaning which must somehow be specified in the lexicon as properties of the preposition. The set of use types will collect the necessary information. Detailed descriptions of these various elements follow.

4.1. Ideal Meanings

It is no coincidence that most linguists have proposed the same simple spatial relations as meanings of the prepositions. Indeed, these simple relations

play an important role, but as something akin to prototypes, not as truth-conditional meanings. I prefer the term “ideal meaning” to “prototype,” first because there is little agreement about the nature of prototypes; second, at least for natural kinds, prototypes appear to be rather concrete: They correspond to some “best” instance and function as a central model to shape the category. But in the case of prepositions, what seems to shape the category is a very abstract geometric relation, while the best example of use is more concrete. For instance, if one asks informants for the best instance of use of *in*, the answer is usually something like “containment in a medium-size box”; we clearly do not want to describe the whole category of uses of *in* in terms of such a concept, but instead, in terms of the topological relation of inclusion, whatever the dimensionality, size, or kind of the reference object.

The idea of an ideal meaning is that (a) it is manifested in all uses of the preposition, although shifted or distorted in various ways, and (b) it does not apply to the referents of the noun-phrases, but to geometric descriptions associated with these referents. The whole prepositional category is structured by resemblance to an ideal relation; the spatial relation fulfilled in any given use of the preposition is distinctly derived from that ideal relation (it may be identical to it). So, given a locative expression:

“NP₁ Preposition NP₂”

if NP₁ refers to O₁ and NP₂ refers to O₂, then a relation like the following may hold:

$$\text{IM}(G_1(O_1), G_2(O_2))$$

where G₁ and G₂ are the geometric descriptions applying respectively to O₁ and O₂, and “IM” is the ideal meaning of the preposition. But often, the ideal meaning is transferred to another relation, say “[T(IM)]”; it is this transformed ideal meaning that applies to the geometric descriptions. The relation that holds is then:

$$[T(\text{IM})](G_1(O_1), G_2(O_2))$$

When the ideal meaning is a three-place relation, we get:

$$[T(\text{IM})](G_1(O_1), G_2(O_2), G_3(O_3))$$

I call such a formula the **geometric scene representation**. Below, I will give several specific examples of such representations; they appropriately capture the meaning of an expression, evaluated in terms of truth in the world, but one should be aware that the “T(IM)” and the “G” functions are frequently fuzzy.

As the examples of divergence from the simple relations in the last section (see 3.3) suggest, transformations applying to the ideal meaning are of two kinds: (a) shifts to another relation—let us call these “sense shifts” (these will give rise to different “use types”); (b) gradual shifts such that the ideal meaning, or sometimes the ideal meaning transformed by a sense shift,

is "almost true"; these will be called "tolerance shifts," and will be the topic of a later section.

No general principle regulates sense shifts, but here are some of the possibilities:

1. When the ideal meaning is a conjunction of conditions, the transformed meaning may be derived by dropping one of the defining conditions. For instance, in three dimensions, the ideal meaning of *on* involves contiguity and support, but there is a set of cases where only contiguity is required, as with:

The chest of drawers is on the left wall.

2. The transformed ideal meaning may involve an added condition as exemplified by *the man at the desk*.
3. The transformed ideal meaning may be related to the ideal meaning by a process involving resemblance, as in *the wrinkles on his forehead*.
4. The conditions of the ideal meaning may hold in the majority of situations where the transformed meaning is true—in other words the two relations generally co-occur in the everyday world. Thus, *on* is used to mean attachment, but attachment most often co-occurs with contiguity and support, as in *the pear on the tree*.
5. I have suggested "coincidence of two points" as the ideal meaning of *at*. Yet, there are uses with one- and two-dimensional reference objects:⁷

The temperature is highest at the equator.

There is a film of oil at the surface of the water.

But those uses are clearly not prototypical. It seems reasonable to describe them as generalizations to higher dimensions of an ideal meaning with punctual (zero-dimensional) arguments.

In the literature on prototypes for object categories (e.g., Rosch & Mervis, 1975) and one study of a verb (the study of *lie* by Coleman and Kay, 1981), "family" resemblance has generally been accounted for by means of attributes or features: The prototype of a category—which may or may not match an actual member of the category—shares some features with any member in the category, but there is no criterial set of features for category membership. In the case of the prototypical structure of prepositional categories, resemblance with the prototype involves more complex processes than the sharing of features (only the transformations in 1 and 2 previously cited fall under that description).⁸

⁷ These examples are from a lecture given by Roger Shephard.

⁸ In effect, it is unlikely that features are generally adequate for expressing resemblance. Goldmeier (1972) shows that it is not the case in perception; it would be unlikely to be the case with conceptual structure.

As an example of geometric scene representation, take *The chest of drawers is on the left wall*. It can be represented as:

$\text{Contiguous}_A(\text{Place}(\text{Chest}), \text{OuterSurface}(\text{Place}(\text{LeftWall})))$

where Contiguous_A is a predicate derived from the ideal meaning of *on* in two steps. First, we get the predicate *Contiguous* by dropping the support condition from the conjunction of contiguity and support that defines *on*. Second, we allow some tolerance; the subscript "*A*" in Contiguous_A indicates that contiguity need be only approximately true—if, for instance, a tapestry were hanging between the wall and the chest, the chest would still be *on the left wall*. The composite predicates applying to the two objects *Chest* and *LeftWall* yield the geometric descriptions relevant to this example. (In this and other examples, I use variable and predicate names that are full words or even phrases; this is for perspicuity, but these are just names—as far as the structure of the formula is concerned, one could just as well use *X* or *Y*.)

In summary, the category denoted by a preposition is shaped by an ideal meaning, which is subjected to transformations: Some represent conventional extensions of the range of use of the ideal meaning; others represent allowances for graded deviations from either the ideal meaning or from those conventional extensions. But the arguments of such shifted ideal meanings are not simply the referents of the subject and object noun-phrases; they are the geometric descriptions, which are examined next.

4.2. Geometric Descriptions

The ideal meaning or transformed ideal meaning applies to parts of space associated with the objects by ordinary synecdoche, or by processes of geometric conceptualization. The functions that relate an object to the relevant geometric descriptions are **geometric description functions**. Here, I will survey the range of such functions.

In some cases, the applicable geometric description is the space occupied by the object, its "place." By "object," I mean anything that could be referred to in a locative expression; this will include more than ordinary solid objects, since one can refer to a whole range of spatial entities. A classification of the entities one might encounter is in Table I.

TABLE I
Basic Kinds of Spatial Entities

Ordinary solid objects	Geometric objects
Liquid or gaseous "bodies"	Parts of space
Geographical entities	Holes
Parts	Unbounded "entities"
Groups	Substances

In order to define a canonical geometric description for each kind of entity, one needs a way to represent vagueness. One wants, for instance, to be able to speak of the "place" of a wrist, although the end boundaries of such an object are vaguely defined, to interpret the expression:

the bracelet around his wrist

Other examples requiring the representation of vague boundaries are:

He stopped at the curve in the road.

The child hid in the folds of her skirt.

the bump on his forehead

One will also need to represent "unboundedness." With vagueness, one can define a zone of uncertainty such that every point on one side of that zone is definitely part of the object, and every point on the other side is definitely not part of the object. But with:

He walked through the water.

as noted by Talmy (1978b), focus is on the water immediately surrounding the walker; the extent and boundaries of that body of water are irrelevant to the speaker. There would be no sense in defining such a zone of uncertainty.

Beyond the canonical geometric description function, I have come upon 21 elementary geometric description functions occurring in the uses of the various prepositions. These are listed in Table II, divided into six groups described in detail below.

TABLE II
Elementary Geometric Description Functions

(1) Parts:
Three-dimensional part
Edge
Base
Oriented total outer surface
Oriented free top surface
Top surface
Lowest surface
Underside
(2) Idealizations:
Approximation to a point
Approximation to a line
Approximation to a surface
Approximation to a strip
(3) Good Forms:
Normal shape
Outline

TABLE II (continued)

- (4) Adjacent Volumes:
 - Interior
 - Volume/area associated with vertex
 - Lamina associated with a surface
 - (5) Axes:
 - Main axis
 - Associated frame of reference
 - (6) Projections:
 - Projection on plane at infinity
 - Projection on ground
-

The list should cover all the more common occurrences. These functions map a certain part of space (a geometric construct) onto another; the canonical function, say *Place*, applies first to the spatial entity, mapping it onto the space it occupies at the time at which the locative expression applies. Several "elementary" functions can then apply in succession, their composition yielding the relevant geometric description, as shown below.

Elementary geometric description functions fall into six categories:

1. Functions that map a geometric construct onto one of its parts (either a three-dimensional part, or a surface, edge, etc.). Take, for instance:

the path along the ocean

Assume the ideal meaning of *along* to be: for two lines to be parallel and "very" close to each other or coincident. Note that the path could vary in height following the edge of a cliff. So the phrase indicates that the projection onto a horizontal plane at sea level of a line approximating the path is parallel and close to a line approximating the edge of the ocean:⁹

*Along_A(HProj(LineApprox(Place(Path))),
LineApprox(Edge(Place(Ocean))))*

The subscript "A" on the ideal meaning indicates that the relation denoted need be only approximately true. *HProj* is the function projecting onto sea level.

⁹ In all such representations, I will use the name of the preposition itself as the ideal meaning of the preposition, except for *at*, *on*, and *in*, for which the following ideal meanings are proposed:

- in*: spatial inclusion
- on*: contiguity and support (for three dimensional objects)
contiguity (for one- or two-dimensional reference objects)
- at*: coincidence of two points.

2. Functions that map a geometric construct onto some idealization of it, such as a point, line, plane, or strip. In:

the village on the road to London

the village is idealized to a point and the road to a line:

*Contiguous_A(PtApprox(Place(Village)),
LineApprox(Place(Road)))*

3. Functions that map a geometric construct onto some associated "good form," obtained by filling out irregularities ("normal shape" and "outline"); such functions implement the Gestalt principle of "closure" or "good form."

The bird is in the bush.

can be represented as follows:

*Included(Part(Place(Bird)),
Interior(Outline(VisiblePart(Place(Bush)))))*

4. Functions that map a geometric construct onto some associated volume that the construct partially bounds ("interior," "volume associated with a vertex," and "lamina associated with a surface"). With:

the crack in the surface

an imaginary very thin lamina is matched onto the surface.

Included(Place(Crack), Lamina(Place(Surface)))

5. Functions that map a geometric construct onto an axis, or a frame of reference (consisting of six orthogonal axes).

She rewound the vine along an horizontal lath.

The location of the vine after it has been rewound is such that the axis of its spiral shape is coincident with the main axis of the lath.

Along_A(Axis(Outline(Place(Vine))), Axis(Place(Lath)))

The example below will involve mapping of an object onto a frame of reference.

6. Functions that map a geometric construct onto a projection.

The North Star is to the left of the mountain peak.

In this use of *to the left*, there is an implicit observer, referred to as "Observer" in the geometric scene representation. A frame of reference is mapped onto that observer. *To the left* could not be true of the mountain peak and the North Star themselves: One must consider the apparent relative position of the star and the peak in the plane of view; in other words, the relative positions of their projections on the plane at infinity. More precisely, from the

observer's point of view, the projection on the horizon of the image of the star is to the left of a point approximating the image of the mountain peak (the horizon being a line in the plane of view).

*ToTheLeft_s(HorizonProj(InfinProj(Place(NorthStar))),
PtApprox(InfinProj(Place(Peak)),RefFrame(Place(Observer)))*

All the formal representations of the meaning of locative expressions given in this section include elements which are not explicitly coded in the linguistic expression. Must we take these as conventionally introduced, or does the context bring them in in systematic ways? This question is taken up next.

4.3. Pragmatic Near Principles

Are there principles that can be used to predict the applicable geometric descriptions and the acceptable shifts from the ideal meaning? Or are these a matter of convention? One can ask a similar question about the other apparent irregularities described—unexplained context dependencies and restrictions. Can all or any of these phenomena be explained by inferences from world knowledge, conversational principles, or other pragmatic principles yet to be formulated?

I believe that the place to look for principles, for regular behavior, is at some fundamental properties, principally salience, relevance, typicality, and tolerance, and I have formulated some sort of pragmatic principles relating to these properties. But, although one can discern some systematicity, it is actually very hard to formulate rigorous principles and find rigorous inferential paths from them; I will, thus, speak of “quasi” or “near” principles. These near-principles are not predictive; they embody necessary but not sufficient conditions for the appropriateness of a certain use, and are formulated in terms of factors for which we lack a formal account. Note that similar problems arise with the application of Grice's cooperative principle and maxims (Grice, 1974), which appeal to entities like “amount of information,” “relevance,” “clarity,” and provide no clue on how those should be evaluated. Yet these maxims, like the near-principles I will describe, reveal some of the forces that shape language use.

Salience. Salience explains the direction of metonymic shifts. Here is a near-principle that motivates certain synecdoche:

“One can use a noun which basically denotes a whole object to refer to a part of it that is typically salient.”

To illustrate, in:

a waiting line at the counter

a functionally salient part of the line, its head, should be substituted for the line itself; the phrase is appropriate only if the head of the line, and not any other part, is very close to the counter. A salient interior is substituted for the whole reference object in:

the child in the back of the car

In:

the cat under the table

the cat is probably not under the legs of the table; *table* here stands for the table top, a functionally salient part of the table.

The word "typically" in the formulation of this principle is important. There must be a common experience, shared by all speakers, in which the relevant part is salient. One cannot use a noun-phrase denoting a whole object to refer to a part simply because that part is in focus in the particular context. For instance, one cannot say:

**He held the cup by putting two fingers through it.*

using *cup* to refer to its handle, since the most important part of a cup is typically the containing part, not the handle.

This near-principle has a corollary:

"One can use a noun-phrase denoting an object to refer to a part of it that is typically visible."

So, in:

There is a rabbit under the bush.

the rabbit is not under the whole bush, which would be under the roots.

And in:

the house on top of the hill

only the visible part of the house, not the cellar or the foundations, is *on top of the hill*.

A second corollary is:

"The geometric description applicable may be the base of the object (i.e., its area of contact with the ground plane)."

This would account for:

the house above the building

in Figure 3.

Also, whenever we describe an object as being "in an area," only the base of the object is in the area. For instance, one would describe Figure 7 by:

The block is in the circle.

although, in fact, only the lowest surface of the block is within the area of the circle.

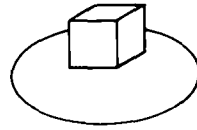


Figure 7

This has come to be so natural to us that it is hard to think that it involves any special process such as metonymy. Yet, if we consider the analogous situation in two dimensions, a similar metonymy does not pertain. One could not say, in Figure 8:

**The rectangle is in the line.*



Figure 8

One cannot say:

**Mary was standing in the edge of the cliff.*

**The town is in the border.*

although one can express inclusion in a line, as in:

a notch in the edge

an opening in the boundary

Typically, knowing where an object is located involves knowing on which part of the earth's surface that object sits; the location of the base is what matters.

Two other near-principles authorize metonymies on the basis of salience:

The geometric description applicable may be the projection of the object on the plane at infinity.

In other words, one can locate according to appearance rather than fact. Thus, in:

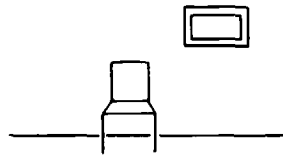
The North Star is to the left of the mountain peak.

to the left could be strictly true only of the appearances of the North Star and the peak in the plane of view. This near-principle relates to salience, since appearance is a salient aspect of one's experience of objects.

Another near-principle is:

The geometric description applicable may be the projection of the object on the ground plane.

The caption attached to Figure 9 is appropriate, although the painting is actually higher than the chair.



The painting is to the right of the chair.

Figure 9

Horizontal coordinates stand out in our experience of objects because we are normally bound to the ground and we move on it to approach objects. So one often ignores altitude when using prepositions like *to the right*, *in front of*, etc.

Relevance. Relevance bears on prepositional choice in ways that are not immediately obvious; among the necessary “near-principles,” I thus propose to include some offshoot of Grice’s maxim: “Be relevant.” I distinguish relevance and salience thus: Salience refers to the kind of foregrounding of objects or object parts that arises in our interactions with and perception of our environment, while relevance has to do with communicative goals, with what the speaker wishes to express or imply in the present context.

Take, for instance, something in a container, like milk in a bowl.



the milk in the bowl

Figure 10

The body of milk is contiguous with, and supported by the bowl; yet one cannot use *on*, one must use *in* to describe its relation to the bowl. One cannot say:

**the milk on the bowl*

To account for this restriction, one could posit a hierarchy among prepositions, such that when both *in* and *on* apply, the expression of containment—therefore *in*—has priority. This would reflect the perceptual salience of containment. But in Figure 11, *on* is appropriate, although there is containment.



the oil in/on the pan



the dust in/on the bowl

Figure 11

Relevance helps explain these examples. One uses *in* or *on* according to whether containment or contact is most relevant. If one is most concerned with contact and its consequences, such as whether the surface of the pan is oiled, or the surface of the bowl is soiled, then one will use *on*. If one is more concerned with containment and its consequences—such as, the milk can be carried around, etc.—then one will use *in*. Usually, with milk in a bowl, there is no reason to focus on contact, which is why the use of *on* sounds very odd.

Another example of the role of relevance is provided by the bulb and socket in Figure 6(b). Both *in* and *under* are, strictly speaking, true in this case. But generally, concern is with the objects' function—one wants to know if the bulb will work, and this can be inferred from *in*, but not from *under*, as *in* is associated with the bulb functioning. Therefore, *under* sounds odd, though not impossible—precisely in contexts where bulb function is not the topic, for instance: *Place bulb and socket assembly in such a way that the bulb is under the socket.*

Similarly, the potato in Figure 6(a) is *under*, not *in* the bowl, because *in* is typically associated with the bowl functioning as a container. If it is important for the addressee to know that the bowl is not in a position to function as a container (if function is most relevant), then one must not use a preposition that will mislead the addressee into assuming that it does. Note that two facts condition the choice of *under*: First, function is important to the addressee; second, *in* is closely associated with the bowl's normal function, where the bowl faces upwards.

As another example of relevance, consider the space under a desk; it is frequently four-sided, and constitutes as good an enclosure as, say, a gutter. Yet, one says:

the water in the gutter

but not:

**I stretched my legs in the desk.*

Instead, one will say *under the desk*. This surrounding is irrelevant, because it has no functional significance; an alternative to *in*, namely *under*, is preferred.

Finally, consider Figure 12.



Figure 12

Whether the finger is *in* or *on* the glass depends on whether one is most concerned with the consequences of contact or containment. Two legends could be used to illustrate this picture:

*If you put your finger on the glass, the sound will stop.
Never put your finger in the jelly glass!*

Tolerance. There is a certain tolerance for deviation from truth of the ideal meaning (or from the truth of the shifted ideal meaning, when a sense shift has taken place). I am concerned here with gradual deviations measurable in terms of an angle or a distance. For example, I want to ask: How far apart can two objects be so that one can still say that one is *at* the other) How close to the gate must Mary be, for the sentence:

Mary is at the gate.

to be true? I ask an analogous question of:

The runners are at the starting line.

Or, consider Figure 13. How close to the right axis must an object A be, for:

A is directly to the right of X.

to be true?

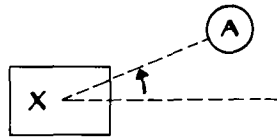


Figure 13

How does the required accuracy vary with different kinds of objects, say houses on a block, chess pieces on a board, or silverware on the table?

First, there is a basic indeterminacy stemming from the nature of the objects. Consider:

Put the napkin directly to the right of the plate!

How precisely can one define the right axis of a plate? That axis would normally be parallel to the edge of the table, and that edge cannot be defined with more than a certain accuracy, given the surface texture of any physical object (there always are surface irregularities, which can be made apparent by increasing the visual acuity, if necessary by artificial means).

Another source of indeterminacy is perception, and the degree to which two positions can be distinguished. For instance, the truth of:

The white horse is at the finish line.

depends on the means available to tell how close a horse is to a finish line, which changed once high-speed cameras became available.

But primarily, tolerance depends on what the speaker deems to matter, on relevance. So, for instance, with chess-pieces on a board, if the game is what matters, then the grid of the board defines the relevant precision. If I say:

The Knight is directly to the right of the Queen.

the allowed distance from the right axis that preserves truth is defined by the size of the squares. Or, with a horse *at the finish line*, the tolerance depends on what matters in the context; it is not the same when racing with a friend as it is at the race track.

So, tolerance depends on the nature of the objects, on perception, and also on what is relevant. Possibly, given (a) some physical description of the objects, (b) some account of perceivable differences in location, (c) a theory of relevance, and (d) a representation of the speaker's purposes in discourse, one could, at least in some cases, predict what distance or angular deviation is tolerable in various contexts. But often, the tolerance reflects an accumulation of practices, of interactions with the objects, making prediction impossible. In our constant intercourse with the objects in our world, we have integrated into our knowledge strategies that allow us to count or discount some fact according to context; what those strategies are is still very much a mystery. Yet tolerance is one direction in which the search for systematicity could proceed.

One phenomenon related to tolerance does show some clear systematicity. If two objects, A and B, are placed in relation to a reference object in such a way that the ideal meaning of a preposition is truer of A than of B, then one can use that preposition to discriminate A from B—so that the locative phrase will be assumed true of A, but not of B. I will give two examples of this “shifting contrast” near-principle (so named because the contrast expressed by the preposition “shifts”).

Consider, again, the use of *to the right* in Figures 5(a) and 5(b). One would say that A is *to the right* of X in 5(a), but if B is placed as in 5(b), then the ideal meaning applies better to B than to A, and, in many contexts, only B is *to the right* of X; *to the right* can be used to discriminate A from B.

Consider also the pear and bowl of Figure 4(a). One would ordinarily say:

The pear is in the bowl.

but a photographer might say:

Move the pear so that it is in the bowl!

The ideal meaning of *in* applies better to the apples than to the pear; one can use *in* to contrast their location, although most often that contrast will be ignored.

Typicality. Finally, let us consider typicality. It is quite difficult to enunciate even near-principles in this area, but it is easy to see how pervasive the influence of typicality is. Its role in motivating pragmatic inferences has been widely studied in artificial intelligence, but it has rarely been observed that typicality also motivates metonymies and certain linguistic choices.

As an example of a pragmatic inference, consider the following. If I say:

The fountain is behind the city hall.

you will assume that the fountain is close to the city hall, in fact that it is *next to* the city hall, meaning that no other salient architectural object is between the city hall and the fountain. This “nextness condition” is not part of the meaning of *behind*, because in:

The treasure is buried 600 feet in a straight line behind you.

no such proximity should be assumed. Still, we find it most useful to relate objects by means of *behind* when they are close together for several reasons: The direction defined by *behind* is otherwise difficult to evaluate, and it is generally more rational to choose a reference object close to the object one wishes to locate. So, most typically, objects will be close together. As a consequence, “nextness” is the unmarked case, the default, the inference one should draw, unless one has evidence to the contrary.

As for metonymies, the first salience near-principle made an explicit reference to typicality: Metonymies are allowed on the basis of typical properties of the objects—which part is typically salient, typically visible, etc. If one referred to a part by means of a phrase denoting a whole object, choosing any part in focus in the particular context, one would risk failure in communication.

The corollary stating that one can use a term referring to a whole object while, strictly speaking, locating its base also depends on typicality. Typically, in our world, objects sit somewhere on the ground, and we generally focus on the location of that base.

We have also seen how typicality restricts the assignments of the roles of Figure and Ground. When two kinds of objects get typically involved in a locative relation with a certain Figure/Ground assignment, it is sometimes impossible to use a converse assignment, even when it would be rational to do so in the particular current situation. So, one does not say:

**the bottle under the cap*

because, typically, caps are conceptually movable with respect to bottles.

Note that the characteristics whose typical value we need to consider are not only the physical characteristics of the objects. Thus, the typical use of, or intercourse with, an object plays a role in allowing for metonymies. In fact, one must even consider typical characteristics of the act of locating as well: The fact that reference objects are usually close to the located object (which allows some pragmatic inferences), the fact that the location of the base of an object is generally what matters (which allows certain metonymies), and the fact that certain kinds of objects are not normally used as references for other kinds (which restricts role assignment).

4.4. Use Types

I have considered a number of pragmatic near-principles. These could be part of a pragmatics that complements the simple-relations model. But this would still leave many phenomena unaccounted for.

For instance, there is no way to predict that one cannot say:

**the cat in the lawn*

or that it is possible to use *in* with the following kinds of geometric descriptions: the volume of containment, the normal volume, and the outline. There is no explanation for the fact that *at* can be used indexically, as in *The gas station is at the freeway*. After all, in French, where *à* takes on many of the functions of *at*, one cannot say:

**La station-service est à la route.*

As another type of use that has to be taken in part as conventional, consider:

Jim is at his desk.

The implication that Jim is using his desk might seem obtainable as a pragmatic inference: If Jim is *at* his desk, then he is very close to his desk, and he is very probably using it. But then, one could draw such an inference by similar processes from:

Jim is by his desk.

Jim is just next to his desk.

Since these do not give rise to the same implication, there is an element of conventionality involved in this use of *at*.

Similarly, the use of *on* to refer to attachment (*the pear on the tree*) and other kinds of divergence from the ideal meaning that I have called sense-shifts are not deducible from the ideal meaning and pragmatic information about the objects.

So, all such conventional facts of use—facts that are neither determined by the ideal meaning of the preposition, and the meanings of the subject and object of the expression, nor pragmatically inferable—will have to be somehow specified in the lexicon, as characteristics of additional senses of the preposition or of idiomatic forms. The kind of lexical representation I suggest, the use type, will preserve the relation of the various uses of the preposition to its ideal meaning. It will also be a uniform representation, one that does not distinguish between senses and idioms. I want to show that the distinction between regular uses and idiomatic uses does not justify two distinct kinds of lexical entities.

Consider:

the book on the desk

the man on the bus

Speakers have an intuition that the first is regular—i.e., generated by the core grammar together with perfectly straightforward rules of semantic interpretation—but the second is idiomatic. Let us compare the two phrases.

1. Both phrases imply contiguity and support—the man is normally contiguous with, and supported by, the floor of the bus. But in the second phrase, there is an additional implication that the man is travelling on the bus, since:

? *The family is living on a converted bus.*

is odd to most speakers. Note that in both cases, contiguity can be relaxed; the book may be on top of a pile of books, and the man sitting on a suitcase.

2. The oddity with *the man on the bus* is that when an object is *in* another, one would more typically use *in*, unless the relation of support acquired a special relevance; since there is no reason for this here, the use of *on* suggests an element of conventionality. In other words, the geometric description applicable to the Ground, that is the surface offering support, is not the most typical one, namely the top surface.
3. Each phrase corresponds to a productive pattern—that is, one can substitute an indefinite number of noun-phrases for *book*, *man*, *desk*, and *bus*, while preserving the relation between Figure and Ground—but the selection restrictions for the second pattern are tighter than for the first. In the first, any physical object could take the place of *desk*, but in the second, the reference object must be some “large” vehicle.

The differences can be summarized as follows: In the idiomatic pattern, the meaning of *on* is further from the ideal meaning, the selection restrictions are tighter, and the geometric description applying to the Ground is not the one expected. But such differences do not amount to a difference of nature; idiomaticity is a matter of degree determined by factors such as the distance from the ideal meaning, the scope of the selectional restrictions, and the geometric descriptions normally expected. I will suggest a uniform representation for both patterns, by assuming that each phrase is generated by a use type.

A use type is, thus, a phrase pattern centered around a preposition, together with the interpretation, or meaning, associated with the pattern. Most often, the phrase pattern is simply a preposition with selection restrictions for the subject and object of the preposition, but sometimes it involves a specific word as object of the preposition. So, there will be a use type:

“Person ‘at’ Artifact”

with the interpretation that the person is using the artifact. From this use type one can generate examples such as:

Jim is at his desk.
the man at the stove

But, there will also be a use type:

“Spatial Entity ‘at sea’”

where the very word *sea* must occur as object of the preposition, and this will yield examples such as:

The Titanic will never be at sea again.
We had a ball at sea.

Here are some other examples of use types:

“Object viewed as Point ‘at’ Object viewed as Line”

with the interpretation that the first object is at the intersection of the second with a crosspath, for phrases like:

The gas station is at the freeway.
The turn in the road is at the river.

Or again:

“Physical Object ‘on’ Physical Object”,

with the interpretation that the first object is attached to the second (the subscript “2” is illustrative; such subscripts are needed to distinguish use types with the same pattern; the above, very general pattern would obviously be the first constituent of more than one use type). From this use type, one can generate:

a pear on a tree
a dog on a leash

I see use types as complex entities, more elaborate than senses as linguists usually conceive of them. One might specify in a use type a whole range of elements of meaning, anything that holds true for any phrase generated by the use type pattern, for instance:

1. The spatial constraints on the objects related, consisting of: (a) one central constraint, which is either the ideal meaning, or derived from the ideal meaning; (b) the allowed deviation from that central constraint, when it cannot be inferred from general considerations involving tolerance (e.g., a specification of the precise conditions under which one can say that an object is *in* a container when not in its interior, or of the conditions under which an object can be said to be *on* another when they are not touching).
2. Selection restrictions, or just which words with which senses can occur as subject and object of the preposition. For instance, there is a use type:

“Object ‘on’ Area”,

with the interpretation that the object is contiguous with the edge of the area as in:

the house on the lake

But in such phrases, the Figure-object must have a fixed position, and be relatively large. One cannot say:

**the truck on the lake*

**the bush on the lake*

3. Constraints on the applicable geometric descriptions.
4. The way context-dependent parameters, or indexicals, should be computed—in other words, a specification of the functions of context that will yield the appropriate referents. This is necessary, for instance, for *The gas station is at the freeway*, where the corresponding use type should make explicit how a crosspath is to be obtained from context.
5. Any contextual condition that must hold for all expressions in the use type. For instance, compare:

Jean is at the park.

Jean is in the park.

Although they may denote situations with Jean in identical positions with respect to the park, they would not be used in the same context. The preposition *at* is: (a) preferred if the speaker's knowledge is indirect, that is, if he or she cannot see Jean in the park; (b) unacceptable if speaker and hearer are in the park; (c) unacceptable if the speaker wishes to contrast inside and outside of the park. These conditions follow (loosely speaking) from taking a remote viewpoint on the situation. This viewpoint condition should be included in the use type:

"Object 'at' Place",

The idea that one's linguistic competence consists of a repertory of syntactic patterns, each associated with its own partially idiosyncratic semantic interpretation and pragmatic information, with "regular" case just patterns among others, runs counter to traditional linguistic theory. Naturally, this would not be limited to locative expressions, but should be the case throughout language. Recent work by Fillmore, Kay, and O'Conno (1983) on "minor" grammatical constructions (e.g., expressions involving *let alone*, as in *He never made first lieutenant, let alone general*) support this view. They find that a large part of a speaker's competence consists of such "peripheral" constructions; given that the machinery required to handle these would be powerful enough to handle the regular structure, they suggest a uniform treatment for both.

5. DISCUSSION

Let me summarize this analysis of the spatial uses of the prepositions:

First, I have proposed that the lexical information attached to a preposition should consist of: (a) an ideal, prototypical meaning, which is an abstract geometric relation; and (b) a collection of use types, which are complex bundles of information corresponding roughly to various senses and idioms.

Then, I have pointed to a level of geometric conceptualization that mediates between the perception or mental images of scenes and language. Geometric descriptions are the result of these processes of geometric conceptualization and of metonymy.

The meaning of a locative expression can then be represented by a relational formula involving a shifted ideal meaning applying to the geometric descriptions. These shifts and transfers to geometric descriptions are in part a matter of convention, in part pragmatically controlled.

Finally, I have proposed pragmatic near-principles relating to salience, relevance, tolerance, and typicality, principles that explain certain metonymies, deviations from the ideal meaning, inferences, prepositional choices, and role assignments.

The discussion which follows focuses on the consequences of this analysis for artificial intelligence models, but most of the points raised are relevant to the problem of formalizing and integrating the semantics and pragmatics of locatives in a more traditional linguistic framework. I will briefly point to some more specifically linguistic consequences at the end.

Assume that the regularities made explicit in the model proposed take the form of propositional knowledge in the speaker's mind, and that comprehension and production consist in linguistic and reasoning processes exploiting such knowledge. Such assumptions generally form the basis of artificial intelligence models. Building such models in the domain of locatives will clearly be extremely difficult.

Implicit in most computational approaches to the problem of locatives is the following belief: Given a description of a scene, or an environment, in terms of the shape and location of the objects it contains (the canonical description), one could generate appropriate locative expressions, using more or less complex spatial relations as meanings of the prepositions. But in fact, the spatial objects we relate are mental constructions, geometric conceptualizations. These geometric images are neither contained in, nor directly inferable from, the canonical description. Certainly, the selections, approximations and idealizations that give rise to the geometric descriptions are not strictly linguistic: they are inherent in our spatial knowledge, implicit in the way we move in the world among and toward objects, in the way we interact with the objects; they may also play a role in perception.

Geometric conceptualization introduces ambiguity (with the same preposition, several geometric descriptions are frequently possible), vagueness (e.g., in *Mary is at the gate*, the points in the conceptualized space corresponding to Mary and the gate are very imprecisely defined), and occasional context dependency (e.g., for what size of box and what locative purpose is it appropriate to "see" the box as a point, as required by *The box is six feet from the wall*), into the process of defining the proposition corresponding to a given situation.

Then, various contextual factors play a role in determining an appropriate locative expression, requiring the representation and use of knowledge beyond that contained in the canonical description. For instance, salience interacts with typicality to determine the direction of metonymic shifts; to predict such shifts, one needs to know which part of an object is foregrounded for someone who uses the object, and more generally interacts with it, in a typical manner. But the corresponding metonymies do not apply in all contexts; for instance, it is not always the case that the top surface of a large body of water is salient, so that one can say *It is under the water* of an object that is in the water. Most people do not accept **Fish swim under the water*, because in the associated mental image, the surface of the water is completely out of focus. In *One could see shiny white carp under the water* however, the phrase *One could see* brings that surface into focus. It is, of course, difficult to characterize formally the kind of context in which a given metonymy is appropriate.

Typicality also allows for some pragmatic inferences. Drawing inferences based on typical, rather than necessary conditions, is one central problem of artificial intelligence. Research on this problem proceeds in two main directions: the development of default logics (e.g., Reiter, 1980); and the search for models of memory such that appropriate inferences fall out of general processes of manipulation of memory structures (e.g., Minsky, 1980; Quillian, 1968; Schank, 1980). Neither approach has so far yielded results approximating human performance.

Note that it is not enough to represent the typical properties of object categories, even including information about how we normally interact with the objects. We found several cases where typical characteristics of the act of locating played a role in determining certain metonymies, inferences, and linguistic choices.

Relevance explains certain prepositional choices and, in conjunction with tolerance, allows certain relational approximations. Relevance requires us to take into account what matters, to whom, and in what circumstances. Underlying any communication, there is a network of concerns shared by speaker and addressee, which they need not make explicit. This becomes apparent when one imagines contexts in which concerns are changed. This dependence on underlying concerns is generally overlooked in artificial in-

telligence work; only situations based on the most typical concerns are considered, and we are left in the dark as to whether the proposed treatment is generalizeable or not. It is, in fact, not clear how it is possible to make an explicit representation of all relevant concerns.

The relational approximations allowed by the interplay of tolerance and relevance require a spatial knowledge beyond the canonical description of a scene (and one which is not explicit in the meaning of the prepositions). For example, with *Mary is at the gate*, defining the space within which Mary must be for the sentence to be true requires specific knowledge about the positions and distances involved in arriving and waiting at a gate. As with the geometric conceptualizations of objects, such relational approximations are implicit, grounded in our physical involvement in the world.

Although I have offered a general description of the information use types should contain, their actual representation presents many difficult problems. For instance, I have said that a use type should specify the way context-dependent parameters are computed, but such specification is, in fact, no simple matter. Take *The Knight is to the right of the Queen*: the relevant right axis would not normally be that of the Queen herself (except in *Alice in Wonderland*), but an axis defined by the chess board and one of the two normal players' positions; this follows from the fact that the important facts in that context are those which have to do with the game. Here again, relevance plays an important role, and one must appeal to the shared concerns of speaker and addressee. No simple predetermined function of the context can be used to assign a value to the variable right axis. Another source of difficulty is the representation of vagueness. What counts as a large vehicle in expressions of the type *John is on the bus/boat/subway/...* Note that, in effect, more than size is involved. For instance, most speakers accept:

I came on the jitney.

though jitneys may be no bigger than a taxi; but the fact that the jitney is public transport like a bus reduces the size threshold. Vagueness often involves not simply a zone of uncertainty on a single scale, but it depends on many interacting parameters.

Finally, comprehension and production would involve respectively matching a situation with a given use type, and the converse, matching a use type with a given situation. The necessary matching processes would actually be very complex, beyond our present expertise.

In summary, language is very thoroughly context-dependent. We rely on implicit shared beliefs and concerns for communication to a degree which has not been sufficiently recognized in artificial intelligence. Pronouns and other indexicals represent only the most conspicuous cases; a closer look reveals a wealth of hidden context dependencies. To characterize precisely the

functions of context involved is most difficult. In fact, it is not even certain that this can be done. It may be impossible to define a fixed set of parameters upon which the literal meaning of a given utterance must depend. Possibly, for any such set of parameters, one can come up with a context such that a parameter outside the set matters. This is the kind of argument that Searle makes in "Literal meaning" (1979). Another way to express the same thing is to say that every utterance takes its meaning from a background of assumptions and beliefs that cannot all be made explicit. Winograd and Flores (in press) express a similar idea. Naturally, such a claim cannot be proved, but the context dependency found to permeate such an apparently concrete and objective domain as that of locatives gives it some credibility.

Another difficulty is vagueness. No satisfactory formal solution exists for this problem. Zadeh's fuzzy logic (1974) is not the answer; the problem is not simply that of allowing degrees of truth, but of understanding how we integrate the interplay of many vaguely defined parameters and resolve it into some definite utterance. It is not clear that this can be solved by making explicit the set of relevant parameters and attaching an appropriate weight to each because, in effect, it is not clear that a list of such parameters and weights can be specified once and for all in every case.

Naturally, such problems spell trouble for logical semantics as well. From a linguistic point of view, the central question is that of deriving the truth conditions of a locative sentence, given lexical representations of the component morphemes, a syntactic description of the sentence, and the context. I have shown that a specification of those truth-conditions would consist of a relational formula, with a shifted ideal meaning applying to geometric descriptions—not to the referents of the subject and object of the preposition themselves. Conventional facts of use (captured by the use types), as well as pragmatic principles, determine these shifts and reference transfers. Clearly, if the principle of compositionality (i.e., the meaning of an expression is a function of the meaning of its parts and of their mode of combination) applies here, it will not do so in a direct and simple way, as it does with the simple-relations model. A first problem is the fact that two elements, the ideal meaning and a use type, are candidates for entering into the combination process; but clearly, only the use type fully defines the contribution of the preposition to the truth-conditions. Plausibly then, a theory could be devised that maintained compositionality and accounted formally for the way a use type combines with the meanings of the other lexical items in the sentence so as to produce those truth-conditions. Such a theory would have to cope with: (a) pragmatically controlled shifts of relational meaning and reference transfers—concealed indexicality is surprisingly widespread, and, moreover, it is difficult, maybe even fundamentally impossible, to fully specify the parameters controlling the values that the indexical variables take in particular contexts; (b) the complex interplay of motivation and

convention—in other words, the lack of a clear division of spatial expressions into idiomatic and regular ones; (c) vagueness. No present theory deals with these basic facts of language.

A somewhat impressionistic, but revealing view of language would be as follows:

Word meanings are defined in an ideal world—a world of lines, points, surfaces, definite relations of inclusion, contact, intersection, etc. But our need to describe, to communicate facts efficiently about a complex and imperfect world, which never matches our ideal concepts, forces us to bend and stretch the concepts. This bending and stretching, however, is not to be done at the speaker's whim; while it may not be all the result of "linguistic rules" proper, it is certainly constrained to preserve mutual comprehension, so our references to objects and facts are, usually, successful. There is evidence that a similar claim can be made in cognitive domains other than space (see Sweetser's analysis of *lie*, 1981). Only with such a view of language can we make sense of all the apparent irregularities a careful look at any semantic domain reveals. We can then proceed to rigorously describe the ways in which ideal conceptual objects are distorted by their immersion in a linguistic and situational context.

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