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Inside *in* and *on*: Typological and psycholinguistic perspectives

Michele I. Feist

Although the use of a language's spatial relational terms appears trivially simple to native speakers, the marked variability in how spatial terms map onto relations in the world (see, e.g., Levinson et al., 2003) hints at a deeper complexity of meaning. One approach to probing the meanings of spatial relational terms is to ask what aspects of a spatial relation people pay attention to when talking about the location of one object with respect to another. In this chapter, I apply a two-pronged approach to understanding spatial meaning, surveying evidence regarding the meanings of *in*- and *on*-terms from a cross-linguistic elicitation study and from a set of experiments focused on English. Taken together, the results suggest that humans attend to a complex set of interacting factors related to geometry, function, and qualitative physics when choosing spatial terms to describe relations in the world.

Introduction

Spatial language offers us many windows onto the landscape of human spatial cognition. But how can we best understand the insights offered by spatial language? What do we pay attention to when we talk about space? Researchers investigating these questions have suggested a variety of factors, often individually. How then to make sense of this complex landscape?

In this chapter, I will sketch the view through two windows onto the landscape of spatial cognition: one being that of a semantic typologist; the other, that of a psycholinguist. The evidence gathered by looking through these two windows will suggest that despite surface differences in how we talk about space, all humans are attuned to the same three abstract families of factors - geometric, functional, and qualitative physical - which together influence the ways in which we talk about relations in space. I will examine each of these families of factors in turn, along with limitations on meanings based on a single type of factor.

The importance of geometry to the meanings of spatial relational terms has long been noted (Bennett, 1975; Feist, 2000; Feist & Gentner, 2003; Herskovits, 1986; Landau, 1996; Lindkvist, 1950; Miller & Johnson-Laird, 1976; Talmy, 1983; Tyler & Evans, 2003), and in fact geometry has been given a central role in many characterizations of the meanings of spatial prepositions. Geometry includes information such as the relative vertical and horizontal positions of the Figure and Ground,[1] their proximity to one another (with inclusion being the closest possibility and contact the next closest), their shapes, and their relative sizes. Such information forms the basis of many proposed meanings of topological spatial prepositions, exemplified by the following two researchers' proposed meanings for *in*:

(1) A[locative[interior of B]]

(Bennett, 1975, p.71)

(2) *in*: inclusion of a geometric construct in a one-, two-, or three-dimensional geometric construct

(Herskovits, 1986, p.48)

In support of geometric approaches to spatial meaning, it has been found that simply changing the geometrical relations in a spatial scene can shift speakers' intuitions regarding the most appropriate preposition to describe the scene (Coventry & Prat-Sala, 2001; Coventry, Prat-Sala, & Richards, 2001; Feist, 2000, 2002; Feist & Gentner, 1998, 2003, in preparation). For example, Coventry and Prat-Sala (2001) showed participants piles of objects placed in containers. They varied the heights of the piles, placing the Figure at the very top, then asked participants to rate the appropriateness of *in*, *over*, and *above* to the resultant scenes. They found that this manipulation resulted in higher ratings for *in* when the piles were low, and for *over* and *above* when the piles were high.

Although they are intuitively appealing, there are a variety of problems with representations of the semantics of spatial relational terms based solely on geometry. First, and most importantly, there are many static spatial uses that fall outside the purview of the proposed geometric meanings. A simple example will suffice. Consider the two proposed meanings for *in* cited above. In both cases, *in* is described as applicable to situations in which the Figure is located at the interior of, or included in, the Ground, as in the case of the pear in the bowl in Figure 1a. However, many spatial terms used to describe situations of full inclusion, like English *in*, can also be used for partial inclusion (Figure 1b) or, in some cases, situations in which the Figure is not geometrically included in the Ground at all (Figure 1c). It is difficult for a geometric approach to account for such uses.

[FIGURE 1 NEAR HERE]

A second problem faced by geometric accounts of spatial relational meaning is the existence of multiple possible descriptions for a single scene, as demonstrated in example (3). Although one can argue that there are distinct shades of meaning, or conceptualizations (Tyler & Evans, 2003), corresponding to the two sentences, the fact remains that there is but one geometric relation being described. In addition to failing to motivate alternate conceptualizations, geometric approaches are unable to provide a principled means of explaining why a speaker might choose one over the other for a particular situation.

(3) a) The players are *on* the field.
b) The players are *in* the field.

More recently, researchers have begun to argue that the meanings of spatial relational terms rely crucially on functional attributes of spatial scenes (Coventry, Carmichael, & Garrod, 1994; Coventry & Garrod, 2004; Coventry & Prat-Sala, 2001; Feist, 2000, 2005b; Feist & Gentner, 2003; Vandeloise, 1991, 1994), as in the proposed meanings in (4) and (5). Functional attributes include knowledge about the normal uses (if any) of the objects (particularly the Ground), particularly the purpose for which they were created (Coventry et al., 1994; Feist, 2000, 2002; Feist & Gentner, 1998, 2003, in preparation; Vandeloise, 1991), knowledge about whether or not the Figure and Ground normally interact (Coventry & Prat-Sala, 2001), and knowledge of the manner in which they are interacting in the current scene.

(4) D/H: *a est* [=is] *dans/hors de b* if the landmark and the target are/are no longer the first and second elements in the container/contained relation.

(Vandeloise, 1991, p. 222)

(5) in: functional containment – *in* is appropriate if the [G]round is conceived of as fulfilling its containment function.

(Coventry et al., 1994)

In support of such analyses, Coventry and his colleagues (Coventry et al., 1994) found that the typical function of the Ground object influenced participants' judgments about the applicability of spatial relational terms: solid objects were judged more *in* bowls, which typically hold solids, than jugs, which more typically hold liquids. Similarly, Feist (2000; Feist & Gentner, 1998, 2003, in preparation; see below) found that participants were reliably more likely to use *in* than *on* if a pictured Ground was labeled as a *bowl* rather than a *plate*, despite the fact that all participants saw the same picture.

The functional approach provides a superior explanation for the range of pictures in Figure 1, as the bowl in each case is fulfilling its usual function as a container, motivating the use of *in*. The approach meets up with problems, however, when the Ground object does not have a normal function (as, for example, in the case of natural kinds), or when it is filling a qualitative physical role different from its normal function (see below). In such situations, it is unclear how a functional approach might predict speakers' uses of spatial relational terms.

Finally, it has been suggested that the meanings of spatial relational terms are influenced by the qualitative physics of the spatial scene (Bowerman & Choi, 2001; Bowerman & Pederson, 1992, 1996; Feist, 2000, 2005a, 2005b; Feist & Gentner, 2003; Forbus, 1983, 1984; Talmy, 1988; Vandeloise, 2003). Although considerably less attention has been paid to the independent role of qualitative physical attributes (such attributes, in fact, do not form the basis for any proposed spatial prepositional meanings), these may prove to be equal to geometry and function in their importance. By qualitative physics, I am referring to information about the physics of the configuration, including the presence or absence of a support relation and the ability of one entity to control the movement of itself or the other (cf. Coventry & Garrod's 2004 discussion of location control). Often, qualitative physical aspects of the scene result from functional features, as when a canonical container fulfills its typical function by constraining the location of another entity. However, this is not always the case. As a case in point, the typical function of an umbrella is to protect the bearer from falling rain. In the scene in Figure 2, however, the umbrella is constraining the location of the apple, motivating the appropriate use of *in*. As this example shows, it is important to carefully separate qualitative physical and functional features, despite their normal cooccurrence.

[FIGURE 2 NEAR HERE]

Although much theoretical work has suggested important roles for geometry, function, and qualitative physics in the semantics of spatial relational terms, there remain large gaps in our knowledge. First, most proposed meanings of spatial relational terms, such as those cited above, have their basis in a single feature, noting other aspects only as they support the prominent feature (as, for example, geometric inclusion is a characteristic of the functional containment relation (Vandeloise, 1991)). Such a view of spatial meaning, however, leaves many uses of spatial relational terms – even static spatial uses – unexplained (Feist, 2000), as outlined above. Second, the majority of the work to date has considered a single language (most commonly English). Yet because linguistic typology helps to separate out the motivated and explainable from the arbitrary (Croft, 1999), a deep understanding of the semantics of spatial terms may benefit from a crosslinguistic perspective. Third, while the roles of geometry, function, and qualitative physics have been suggested, their importance awaits detailed empirical verification (although there have been some efforts in this area, as noted above). To address these gaps, I will describe two studies. The first, a crosslinguistic survey, addresses the question of which, if any, of the identified factors recur in the spatial vocabularies of a variety of languages. The second, a psycholinguistic experiment, addresses the question of whether small changes in the geometric, functional, and qualitative physical attributes of a depicted spatial relationship will lead to concomitant changes in speakers' use of English spatial prepositions, thus providing empirical evidence for the importance of these factors to English prepositional meaning. As such, I will be presenting two complementary views onto the landscape of factors that combine to make up spatial relational meanings – one typological and one psycholinguistic. What we seek are the organizing principles around which spatial vocabularies are built.

A view through the window of typology

If there is any domain where we might expect universals, it is surely space, due in part to the universality of our early experience with space (Clark, 1973) and to the fact that the use of spatial relational terms appears simple and obvious to native speakers. It is perhaps this assumption that has led researchers to examine the semantics of spatial terms largely in single languages, as the simple topological notions into which spatial terms have been decomposed (Bennett, 1975; Herskovits, 1986; Miller & Johnson-Laird, 1976) are largely considered universal, with neurocognitive correlates (Landau & Jackendoff, 1993). In contrast to this intuition, however, the variation in spatial descriptions that has been uncovered in crosslinguistic studies is astonishing (Bowerman & Choi, 2001; Bowerman & Pederson, 1992, 1996; Brown, 1994; Feist, 2000, 2004; Gentner & Bowerman, 1996; Levinson, Meira, & Group, 2003; Majid, Bowerman, Kita, Haun, & Levinson, 2004; Pederson et al., 1998; Sinha & Thorseng, 1995; Sinha, Thorseng, Hayashi, & Plunkett, 1994). Careful examination of the extensional range of spatial terms in multiple languages further suggests that the very dimensions of variation may differ across languages, as in the oft-cited difference between English and Korean spatial terms (Bowerman & Choi, 2001). A simple example will illustrate this difference. Imagine two scenes: a cassette in its case, and an apple in a bowl. In English, the two scenes would be described using the same word, as both are instances of inclusion. In Korean, however, it would be inappropriate to describe them alike, as one (the cassette in its case) is an instance of tight fit, while the other (the apple in the bowl) is an instance of loose fit. In describing these two scenes, the dimensions of contrast that are important in English and Korean are in fact quite different (but see Vandeloise (2003, this volume) for an alternate view of this distinction).

Does this mean that the sets of attributes of spatial scenes that languages encode in their spatial relational vocabularies are incommensurable? Perhaps not. Consider again the English-Korean distinction. English *in* communicates inclusion, which is both geometric, and (due to our three-dimensional gravitational world) physical. Korean, on the other hand, distinguishes tight and loose fit – a qualitative physical (Vandeloise, 2003, this volume) and geometric distinction. Thus, despite surface differences in the ways in which words map to scenes, there are similarities at the abstract level of attention to geometry and qualitative physics. This explanation echoes the findings of Levinson and his colleagues (2003), who suggested that there may be universal "attractors", or abstract relations which languages will tend to recognize. This is also in line with Croft and Poole's (2004) suggestion that what is universal across languages may be the constraints on variation, rather than the specifics of how languages work.

In addition to uncovering abstract similarities in the semantics of spatial relational terms – and verifying them across a wide range of languages – there is yet another reason to examine the typology of spatial semantics. By including more languages in a sample, we increase the chances that potentially important factors will be identified, as in the identification of tight vs. loose fit as a result of studying Korean. In addition to shedding light on human spatial cognition in their own right, some of these factors may prove relevant even in languages where they were previously discounted. As a case in point, attributes of the Figure object have largely been considered unimportant to the uses of English spatial prepositions (Landau & Stecker, 1990; Talmy, 1983). Looking across languages, this is by no means a universal fact about spatial relational terms. Rather, in Mayan languages such as Tzeltal, the nature of the Figure seems to carry particular importance in the selection of a spatial relational term to describe a scene (Brown, 1994; Levinson, 1996). Upon reexamination of the role of the Figure in the use of the English prepositions *in* and *on*, Feist (2000; Feist & Gentner 2003, in preparation; see below) found a small but reliable effect, suggesting that the role of the Figure had been mistakenly discounted in previous accounts.

Although the field of semantic typology is still in its infancy, seminal work has already laid the foundations for important advances in our understanding of the ways in which languages categorize spatial relations (Bowerman & Choi, 2001; Bowerman & Pederson, 1992, 1996; Levinson et al., 2003). I will here describe one further contribution to this growing area (for complete details of this study, see Feist 2000, 2004), based on the pioneering work of Bowerman and Pederson (1992; 1996).

Bowerman and Pederson elicited descriptions of a range of topological spatial relations from speakers of thirty-four languages (see also Levinson et al., 2003), using a single set of pictures to elicit the terms from all of the languages in a uniform manner. Their findings illustrated a number of facts about the extensions of spatial terms across a range of languages. First, none of the languages in their sample used separate terms for each of the relations exemplified by pictures in their set. Rather, spatial terms in each of the languages grouped together multiple spatial relations for the purpose of communication. This finding is important, as it validates the study of the extensions of spatial relational terms as a means of examining those factors of spatial scenes that humans deem important. By examining the ways in which the elicited spatial terms grouped the pictures in their set, Bowerman and Pederson were able to infer the kinds of semantic distinctions that tend to appear in spatial language. They found that, along with prodigious cross-linguistic variation, there was a striking commonality. The pictures in their set could be arranged in a semantic map (Haspelmath, 2003), or "similarity gradient" (Bowerman & Choi, 2001), over which the range of application of each of the elicited terms could be mapped. Further, in keeping with Croft's Semantic Map Connectivity Hypothesis (Croft, 2001, 2003; Croft & Poole, 2004), Bowerman and Pederson found that none of the terms which they had elicited grouped together discontinuous portions of their similarity gradient. This systematicity suggests that significant variation co-exists with deep commonality.

By presenting a single set of pictures to speakers of a wide variety of languages, Bowerman and Pederson were able to directly compare the extensions of the languages' spatial terms. Inspired by this, my study borrows Bowerman and Pederson's methodology in order to elicit a data set from which the crosslinguistic importance of particular attributes to the semantics of spatial relational terms may be inferred. If geometry, function, and qualitative physics are important structuring elements for human spatial cognition, we can expect to see their influence in the spatial terms of a variety of unrelated languages.

Twenty-nine simple line drawings, each depicting two objects in a topological spatial relation, were used in this study. In each picture, one object (the Figure) was colored in yellow; the second object (the Ground) was left in black and white. Twenty-seven of the drawings were borrowed from Melissa Bowerman and Eric Pederson's Topological Picture Series (Bowerman & Pederson, 1992, 1996; Gentner & Bowerman, 1996; Levinson et al., 2003), one of the remaining two was modified from the Topological Picture Series, and the final one was borrowed from an example in Coventry (1998). Participants were asked to describe the locations of the yellow objects with respect to the other objects in the most natural manner. Twenty-seven speakers volunteered to describe the picture series, providing terms from sixteen languages and twelve language families. The languages are listed, along with their genetic affiliations[2] and the number of speakers participating, in Table 1.

[TABLE 1 NEAR HERE]

In order to understand the ways in which a small set of attributes may influence the use of spatial relational terms across the language sample, the pictures were first analyzed separately from the elicited terms. Afterwards, the analysis of the pictures was combined with an examination of the extensional maps of each of the elicited terms in order to isolate attributes which may influence the uses of the terms.

First, each of the pictures was coded for whether it matched each of a small set of geometric, functional, and qualitative physical attributes. The set of attributes was chosen largely from characterizations of spatial terms in the literature. The geometric attributes examined were:

i) *a difference in vertical position* – important to terms such as *above, below, over,* and *under* (O'Keefe, 1996; Tyler & Evans, 2003)

ii) *contact* – important to terms such as *on* (Cienki, 1989; Herskovits, 1986; Miller & Johnson-Laird, 1976)

iii) *inclusion*[3] – important to terms such as *in* (Cienki, 1989; Herskovits, 1986; Miller & Johnson-Laird, 1976; Tyler & Evans, 2003)

iv) *relative size* – not cited in the literature, but chosen because a larger Ground might facilitate other attributes, such as *inclusion* (above) and *support* (below).

One functional attribute – the presence of a functional relation based on the Ground's typical function (Coventry et al., 1994; Vandeloise, 1991, 1994) – was examined. To make this concrete, coffee and a coffee cup are functionally related, as the typical function of a cup is to contain a volume of liquid. As such, a functional relation would be coded as present for a picture of coffee in a coffee cup. On the other hand, a cloud and a mountain are not functionally related, and a functional relation would be coded as absent for a picture of a cloud over a mountain.

Finally, the following three qualitative physical attributes were examined:

i) *support* – important to terms such as *on* (Bowerman & Pederson, 1992, 1996; Herskovits, 1986; Miller & Johnson-Laird, 1976)

ii) *control by Ground* – important to terms such as *in* (Coventry et al., 1994; Coventry & Garrod, 2004)

iii) *animacy* – important to terms such as *in* (Feist, 2000; Feist & Gentner, 2003, in preparation)

Next, the range of application of each of the terms was examined as follows. For each term, all of the pictures described by the term were grouped together for further analysis. Each of the groups was then examined in order to isolate the attribute or attributes that were common to the pictures in the group, based on the picture codings just described.

Four of the coded attributes emerged as unifying factors in this analysis: *a difference in vertical position, contact, support,* and *inclusion*. The influence of these attributes is exemplified by the representative terms in Table 2. For each of the terms listed in Table 2, a plus under an attribute indicates that the attribute is present in all of the pictures described by the term; a minus indicates that the attribute is absent from all pictures described by the term.

[TABLE 2 NEAR HERE]

As further evidence of the unifying nature of these attributes, they together served to categorize fifty-six of the sixty-three collected terms into the following seven classes of meaning:

a) Figure higher than Ground
b) Figure higher than Ground, no contact
c) Figure lower than Ground, with contact
d) Ground supports Figure with contact
e) Contact
f) Inclusion of Figure by Ground
g) Absence of inclusion of Figure by Ground

These four attributes together provide evidence for the importance of geometry, function, and qualitative physics to the meanings of spatial terms across a variety of languages. The first two, *a difference in vertical position* and *contact*, provide information about the geometry of the Figure-Ground relationship. The third, *support*, provides qualitative physical information about the Figure-Ground interaction and the forces acting between the objects. Finally, *inclusion* provides information about geometry, function, and qualitative physics. In a three-dimensional world, geometric inclusion of one entity by another entails that the location of the included entity (the Figure) is constrained by the including entity (the Ground): in order to be geometrically included, the Figure must be located at the interior of the Ground. As such, the geometric attribute *inclusion* validates inferences about the presence of the qualitative physical attribute *location control*.[5] Similarly, as control of the location of an object is a common human goal, many artifacts have been created to fulfill this function, with the result that if the Ground is an artifact, *inclusion* of the Figure likely results from the fact that the Ground was created for this purpose.

The view through the window of semantic typology shows a landscape in which significant variation coexists with abstract similarities. Although spatial relations are grouped differently by the languages studied, attributes from all three families – geometric, functional, and qualitative physical – recurred in the meanings of the collected spatial terms. However, while typological studies such as the one presented here may suggest factors that are important to the meanings of spatial relational terms, controlled experimental investigation is necessary in order to test the roles of the factors in speakers' decisions to use specific terms. It is to this issue that we will now turn.

A view through the window of psycholinguistics

The view through the window of typology provided support for the theoretical import of geometry, function, and qualitative physics to the meanings of spatial relational terms. In language after language, it was found that geometric, functional, and qualitative physical properties united the disparate sets of scenes that could be described by a single term. Yet to be sure that these attributes truly influence speakers' choice of a word to describe a situation, we must seek corroborating evidence. Will a change in one of these factors lead to a concomitant change in a speaker's likelihood to employ a given term?

In order to closely examine the influence of any given attribute, it is desirable to hold as many other attributes constant as possible. This problem is nontrivial, as many of the attributes of spatial scenes that participate in spatial relational meaning cooccur in the real world. For example, support (a qualitative physical attribute) seldom occurs without contact (a geometric attribute) in everyday interactions (Feist, 2000). Similarly, as discussed above, many artifacts are created for the purpose of constraining the location of other objects, thus combining geometric, functional, and qualitative physical attributes in relations resulting from their normal use. In an attempt to tease apart a small set of attributes of scenes that influence the use of the English spatial prepositions *in* and *on*, Feist (2000; Feist & Gentner, 1998; 2003, in prep) adapted a method developed by Labov (1973) to study complex interacting factors in the use of English nouns. The details of the experimental study are reported in Feist (2000; see also Feist & Gentner, 2003, in prep). I present here an outline of the main experiment along with reasonably complete results.

Labov (1973) systematically varied the functional context and the relative height and width of a set of similarly shaped objects which he asked participants to name. He found that the variation in these factors led to changes in the nouns adults chose to name the objects. Similarly, I created a set of spatial scenes which were systematically varied with respect to geometric, functional, and qualitative physical factors in order to closely examine their influences on the use of the English prepositions *in* and *on*. The extent to which the differences in the pictures correlate with the changing rate of use of these English spatial prepositions is taken as indicative of the roles of these factors in their meanings.

In approaches to the meanings of *in* and *on* based on geometry, it is apparent that, while *in* requires that there be an interior of the Ground at which the Figure may be located, *on* requires merely a surface with which the Figure must be in contact (Bennett, 1975; Herskovits, 1986; Miller & Johnson-Laird, 1976). Consider a Figure in contact with the upper surface of a Ground. By manipulating the concavity of the Ground, without further change in the position of either object, it is possible to shift the relative applicability of the prepositions *in* and *on* (Figure 3). The influence of geometry was thus examined via changes in the curvature of the Ground. If geometry influences preposition choice, greater curvature (and concomitantly deeper concavity) of the Ground should correspond to a higher proportion of *in* responses.

[FIGURE 3 NEAR HERE]

To vary the perceived function of the Ground, we took advantage of Labov's (1973) finding that the choice of a noun to label an object is influenced by the functional context within which the object is presented. Thus, we introduced the inanimate Ground with one of five labels, each communicating different information about the typical function of the Ground. The labels chosen were *dish, plate, bowl, rock,* and *slab.* If function influences preposition choice, we should see the greatest use of *in* when the inanimate Ground is labeled as a *bowl,* which is a prototypical container. Use of *in* should be lower for *plate,* which typically names objects that function as a supporting surface, and intermediate for *dish,* which is a superordinate term for *plate* and *bowl.* Finally, use of *in* should be low for *rock*, which is an afunctional solid, and for *slab*, which is an afunctional surface.

As information about qualitative physics is difficult to directly manipulate in static scenes, we indirectly manipulated qualitative physical properties by varying the animacy of the Figure and the Ground. An animate Figure, by virtue of its ability to enter and exit a configuration under its own power, may be conceived of as being less under the control of the Ground than would be an inanimate Figure. Conversely, an animate Ground is able to exert volitional control over the location of the Figure, while an inanimate Ground is not. If indirect effects of animacy on qualitative physical attributes related to location control influence preposition use, we might expect to see the greatest use of *in* for those situations that are physically most stable – situations where the Ground is animate and situations where the Figure is not. Similarly, we might expect to see the least use of *in* for those situations which are least stable – situations in which the Figure is animate and situations where the Ground is not. Thus, we should see greater use of *in* when the Ground is animate than when it is not. Likewise, we should see that the use of *in* is more prevalent when the Figure is inanimate than when it is animate.

In all, there were a total of twelve pictures. The set included two Figure objects – one animate and one inanimate. The Figures were each placed with respect to two Ground objects – one animate and one inanimate – and the Grounds were depicted at three levels of concavity; with the concavity of the two Grounds being equal at each level. The complete design is sketched in Figure 4.

[FIGURE 4 NEAR HERE]

The twelve pictures were presented individually on a computer screen in random order, and participants were given answer sheets with sentences of the following form:

The *Figure* is IN/ON the *Ground.*

with *Figure* filled in with the noun referring to the pictured Figure (*firefly* or *coin*) and *Ground* filled in with *hand* when the pictured Ground was the animate, and the noun corresponding to the participant's labeling condition (*dish, plate, bowl, rock,* or *slab*) when the inanimate Ground was shown. The participant's task was to circle *in* or *on* to make each sentence describe the corresponding picture on the computer screen.

As predicted, participants' choices between *in* and *on* were found to be influenced by geometric, functional, and qualitative physical factors, as confirmed by a 2 (Ground: hand or inanimate) x 2 (Figure: firefly or coin) x 3 (concavity) x 5 (labeling condition) repeated measures analysis of variance. I will discuss each of these factors in turn.

That geometry plays a role in the meanings of *in* and *on* can be seen from the effect of changing the concavity of the Ground. As the concavity of the Ground increased, so did the use of *in*, with the average proportion of *in* responses for scenes depicting low concavity at .38, the average proportion for scenes depicting medium concavity at .45, and the average proportion for scenes depicting high concavity at .54, $F(2,172) = 28.34$, $p < .0001$ (Figure 5).

[FIGURE 5 NEAR HERE]

That functional information plays a role in the meanings of *in* and *on* can be seen from the effect of varying the label provided for the inanimate Ground ($F(4,86) = 10.77$, $p < .0001$). As expected from the fact that the label was only changed for the inanimate Ground, there was also an interaction between the labeling condition and the animacy of the Ground ($F(4,86) = 5.43$, $p = .001$) (Figure 6). When the inanimate Ground was labeled as a *bowl*, a label normally applied to prototypical containers, the use of *in* was most prevalent (mean proportion *in* responses = .65). When the inanimate was labeled with *plate*, a noun normally used to label a functional surface, the proportion *in* responses was much lower (mean proportion *in* responses = .09). When the superordinate term *dish* was used, the proportion *in* responses was in between (mean proportion *in* responses = .50). Finally, the use of *in* was quite rare when the Ground was presented along with a label which suggested that it was not a functional artifact (mean proportion *in* responses for *rock* = .07; mean proportion *in* responses for *slab* = .08).

[FIGURE 6 NEAR HERE]

Finally, the influence of qualitative physics on the meanings of *in* and *on* can be inferred from the effects of the animacy of the Ground and the animacy of the Figure. When the depicted Ground was a hand, which is able to exert volitional control over another entity, the use of *in* was more prevalent than when the depicted Ground was inanimate (mean proportion *in* responses, hand as Ground = .63; mean proportion *in* responses, inanimate Ground = .28, $F(1,86) = 65.59$, $p < .0001$). Further, I found an interaction between the animacy of the Ground and its concavity whereby the increase in the proportion *in* responses as concavity increased was sharper for the hand than for the inanimate ($F(2,172) = 5.50$, $p = .005$) (Figure 7). This difference makes sense in qualitative physical terms: because it can continue to close, a hand may be thought of as having more control over the location of its contents as it becomes more concave (more closed), while an inanimate object's degree of control, like its ability to continue closing, would remain constant across concavities.

[FIGURE 7 NEAR HERE]

In support of this explanation of the effect of the animacy of the Ground, when the depicted Figure was animate (a firefly), and thereby able to exert control over its own location, the use of *in* was *less* prevalent than when the depicted Figure was inanimate (mean proportion *in* responses, firefly as Figure = .43; mean proportion *in* responses, coin as Figure = .49, $F(1,86) = 9.69$, $p < .005$). Further, the influence of the animacy of the

Figure interacted with the influence of functional information about the Ground: the extent to which *firefly* received a lower proportion *in* responses than did *coin* was greatest when the label for the inanimate Ground suggested a containment function (*bowl* and *dish*), $F(4,86) = 2.73$, $p < .05$ (Figure 8). The function of a container is, at its most basic, to fulfill the qualitative physical role of constraining the location of another object. This function can best be fulfilled if the object is more constrainable. As such, qualitative physics and function reinforce one another in scenes depicting an inanimate Figure and a Ground labeled as a container, hence raising the applicability of *in*.

[FIGURE 8 NEAR HERE]

Taken together, this set of results demonstrates that geometric, functional, and qualitative physical properties all influence speakers' uses of the English spatial prepositions *in* and *on*. Furthermore, although each exerts an independent influence on English prepositional usage, these three families of factors are not completely independent. Rather, they influence one another in complex ways, often providing reinforcing information that can raise the applicability of a preposition to a scene. Thus, the view through the window of psycholinguistics reinforces the view through the window of typology, providing evidence that those factors which recur in the uses of spatial terms across languages also individually influence speakers' choices in a controlled communicative environment.

Conclusions

Multiple times each day, speakers choose from among a relatively small set of spatial relational terms (Landau & Jackendoff, 1993) to describe one of infinitely many possible spatial configurations between two objects in the environment. Their decisions are quick and sure, reflecting the automaticity of spatial relational terms. What attributes of spatial configurations must speakers attend to in order to fluently use the set of spatial relational terms available in their language?

While the semantics of spatial relational terms have received extensive attention, the picture of spatial relational meaning that emerges from an examination of theoretical treatments of spatial semantics is difficult to interpret. First, most characterizations of the meanings of spatial relational terms rely on a single type of feature. As a result, many common uses of spatial relational terms are left unexplained by the proposed meaning. Further, there is disagreement about whether geometric or functional features are criterial for spatial relational meaning. Second, the majority of the studies to date have involved single languages. Although these studies have catalogued the uses of the terms in the language under consideration, they are unable to provide a sense of spatial language more generally. Such a sense can only be gotten by considering the spatial vocabularies of many languages. It is precisely this sense of spatial language more generally that may provide the insights necessary to arrive at a descriptively adequate account of the meanings of individual spatial relational terms. Third, while theoretical treatments of spatial relational terms have proposed hypotheses about the factors that participate in the meanings of the terms, very few controlled experimental tests of the hypotheses have appeared.

In recent years, all three of these open issues have begun to be addressed, leading to a clearing picture of the factors participating in the semantics of spatial relational terms. With regard to the first issue, meanings incorporating more than one type of factor have been proposed (Coventry & Garrod, 2004; Feist, 2000; Herskovits, 1986), expanding the range of uses that can easily be accounted for within the proposed meaning. On the second count, researchers have begun to examine the spatial relational terms of multiple languages within a single project (Bowerman & Choi, 2001; Bowerman & Pederson, 1992, 1996; Feist, 2000, 2004; Levinson et al., 2003), concomitantly expanding the range of distinctions of which they are aware. Finally, with regard to the third open issue, researchers have begun to test the validity of the proposed factors in controlled psycholinguistic experiments (Coventry et al., 1994; Coventry & Prat-Sala, 2001; Coventry et al., 2001; Feist, 2000, 2002, 2005b; Feist & Gentner, 1998, 2003, in preparation), allowing them to verify the role that each one plays in the meanings of individual spatial relational terms.

In this chapter, I have provided an overview of two studies designed to address the second and third of the identified gaps in our understanding of the semantics of space. In doing so, these studies provide valuable data which can be used to further efforts to address the first gap.

The first of the studies discussed compared the extensional ranges of sixty-three spatial relational terms collected from sixteen languages, representing data from twelve language families. In order to be made maximally comparable, the terms were elicited by having all of the participants describe the same set of simple line drawings. The results showed that four attributes of spatial scenes, *a difference in vertical position*, *contact*, *support*, and *inclusion*, together provided unifying explanations for the individual extensional ranges of the fifty-six specific spatial terms collected (those encoding relatively detailed information about the Figure's location; see Feist (2004, in prep) for details). At a more abstract level, these four attributes impart information about geometric, functional, and qualitative physical aspects of the spatial scenes, providing evidence that these three families of factors influence the uses of spatial relational terms across a range of languages.

The second of the studies discussed in this chapter examined English speakers' uses of the prepositions *in* and *on* to describe a small set of scenes designed to vary along geometric, functional, and qualitative physical parameters. The results suggest roles for all three kinds of factors in the meanings of these two prepositions. The influence of geometry was demonstrated by the rise in *in* responses as concavity of the Ground increased (Figure 5). The influence of function was demonstrated by the observed effect of labeling condition: the use of *in* was most prevalent when the noun labeling the inanimate Ground typically names a container (*bowl*), with concomitantly low rates of use when the noun labeling the Ground typically names a functional surface (*plate*) or a nonfunctional entity (*rock* or *slab*) (Figure 6). Finally, the influence of qualitative physics was indirectly demonstrated via the effects of animacy of the Figure and Ground: use of *in* was most prevalent when the Ground was animate, enabling it to exert control over the location of the Figure, and when the Figure was inanimate, preventing it from exerting control over its own location.

Taken together, these two studies sketch two complementary views onto the landscape of human spatial cognition. The first view, that of the semantic typologist, considers both the unity and diversity of spatial language in order to arrive at a comprehensive picture of the set of factors involved in spatial relational meaning. The second view, that of the psycholinguist, considers the separable effects of a complex set of interacting factors on the uses of spatial relational terms. Both views suggest roles for three families of attributes of spatial scenes: geometric, functional, and qualitative physical. In combination, these three types of attributes can form the basis for a new representation of spatial relational meaning which, with one eye on typology and one on psycholinguistics, may better account for the uses of spatial relational terms than any one type of factor alone.

Notes

[1] Following Talmy (1983), I will be referring to the located object, alternately called the trajector, or TR (Langacker, 1987), as *Figure*, and the reference object, alternately called the landmark, or LM, as *Ground*.

[2] Data on genetic affiliations from Ethnologue, produced by the Summer Institute of Linguistics: http://www.ethnologue.com.

[3] Although *inclusion* is listed here as a geometric attribute, its presence bears on both functional and qualitative physical inferences, as will be discussed below.

[4] The remaining seven terms fall into an eighth class, general spatial terms, which do not encode any specific attribute values. For details, see Feist (2000; 2004; in prep).

[5] Note that this is not the case for the other geometric attributes. For example, although *contact* tends to co-occur with *support* across a variety of situations, the two attributes can easily be dissociated (as, for example, in the case of two boxes side-by-side on the floor – they are in contact, but neither supports the other (Feist, 2000)).

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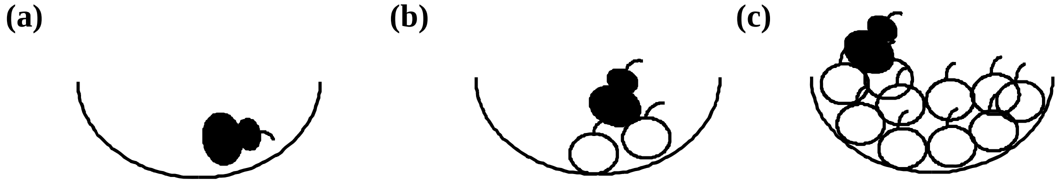

Figure 1 Three pears in three bowls

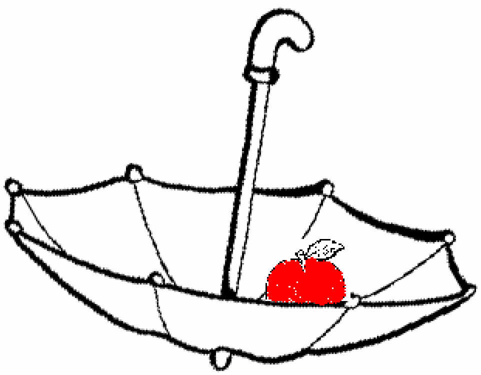

Figure 2 An apple in an umbrella

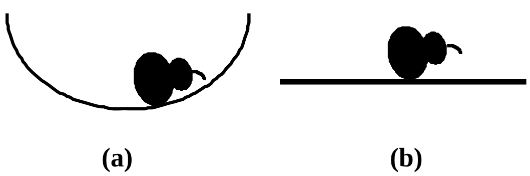

Figure 3 Two scenes differing only with respect to the concavity of the Ground

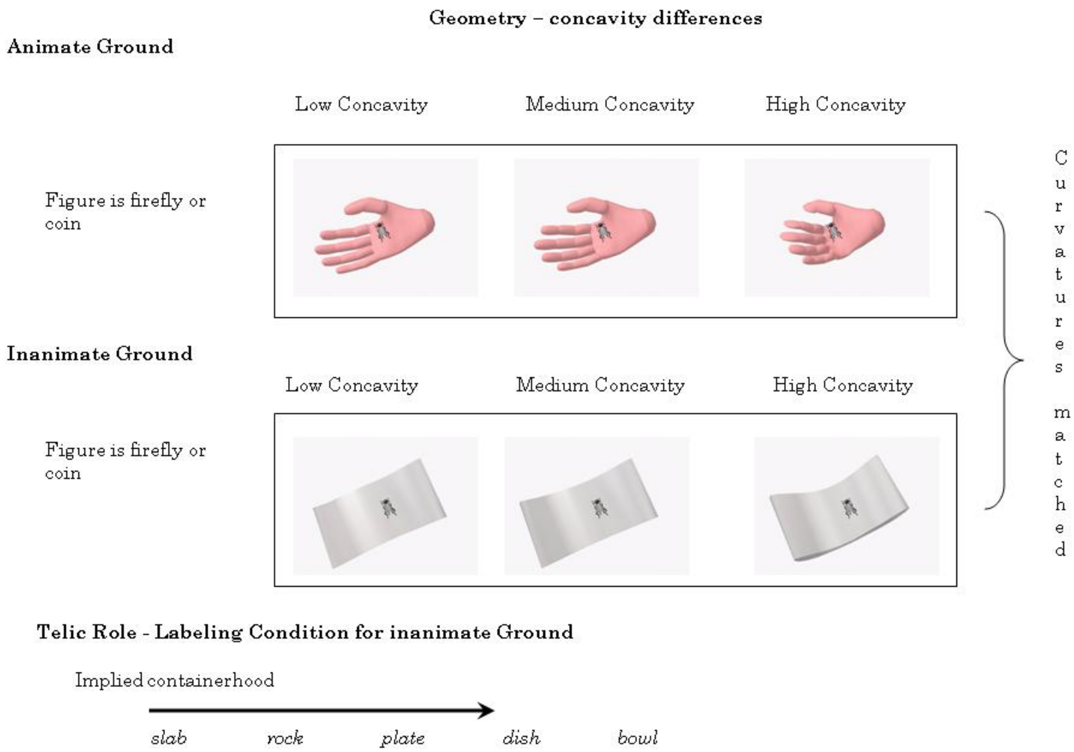

Figure 4 Design of the psycholinguistic study

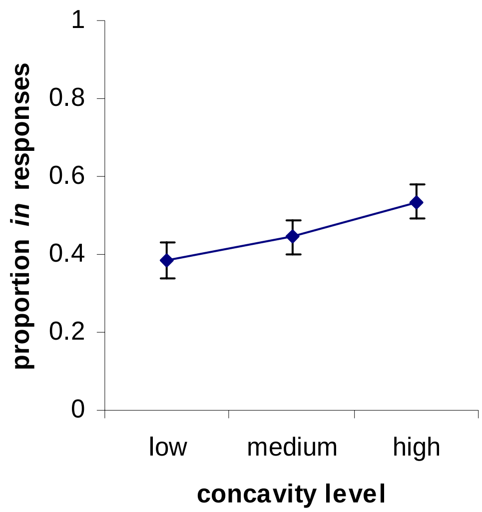

Figure 5 Effect of concavity, averaged across both Figures, both Grounds, and all five labeling conditions

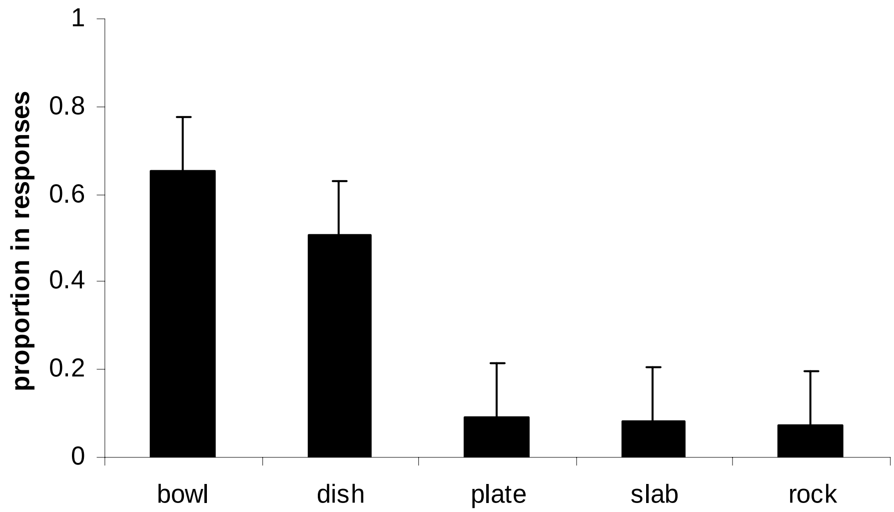

Figure 6 Effect of labeling condition, inanimate Ground, averaged across all three concavities and both Figures

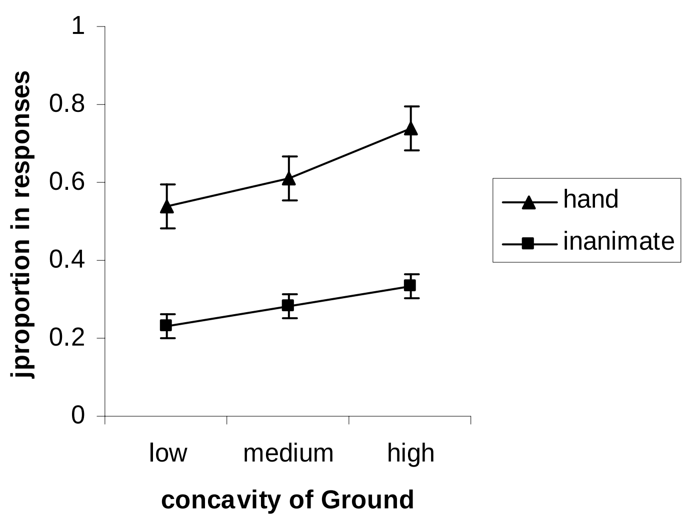

Figure 7 Interaction of animacy of the Ground and concavity, whereby the increase in *in* responses with increased concavity is sharper for the hand than for the inanimate Ground

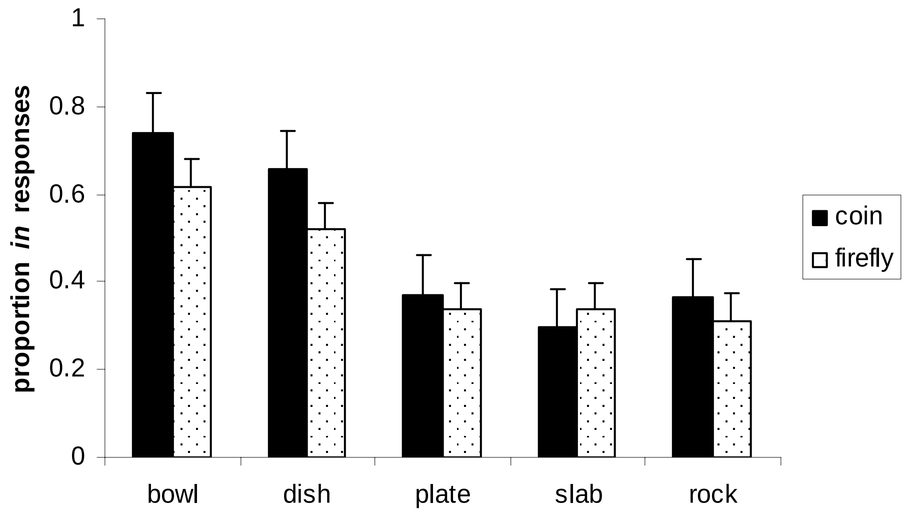

Figure 8 Interaction of labeling condition and animacy of the Figure, whereby the difference between responses to the coin and the firefly appear predominantly when the Ground is labeled as a functional container

Table 1 Languages surveyed in the crosslinguistic study

Language	Language Family	Number of speakers in sample
Polish	Indo-European, Slavic, West, Lechitic	3
Russian	Indo-European, Slavic, East	2
Croatian	Indo-European, Slavic, South, Western	1
German	Indo-European, Germanic, West, Continental, High	3
Swedish	Indo-European, Germanic, North, East Scandinavian	1
Italian	Indo-European, Italic, Romance, Italo-Western, Italo-Romance	1
French	Indo-European, Italic, Romance, Italo-Western, Western, Gallo-Romance, North	2
Hindi	Indo-European, Indo-Iranian, Indo-Aryan, Central zone, Western Hindi, Hindustani	2
Hebrew	Afro-Asiatic, Semitic, Central, South, Canaanite	3
Hungarian	Uralic, Finno-Ugric, Ugric, Hungarian	2
Cantonese	Sino-Tibetan, Chinese	1
Telegu	Dravidian, South-Central, Telugu	1
Turkish	Altaic, Turkic, Southern, Turkish	1
Tagalog	Austronesian, Malayo-Polynesian, Western Malayo-Polynesian, Meso Philippine, Central Philippine, Tagalog	2
Japanese	Japanese, Japanese	1
Korean	Language Isolate[1]	1

[1] There is a difference of opinion among scholars as to whether or not Korean is related to Japanese. Further, Korean is possibly distantly related to Altaic.

Table 2 Representative terms

Term	Figure higher than Ground	Contact	Ground supports Figure	Inclusion
[σ□N] (Cantonese)	+			
taas (Tagalog)	+			
[nad] (Russian)	+	-		
[μ↔?αλ] (Hebrew)	+	-		
sotto (Italian)	-	+		
sous (French)	-	+		
na (Polish)		+	+	
på (Swedish)		+	+	
auf (German)		+		
an (German)		+		
u (Croatian)				+
[la], [λoπ↔λα] (Telegu)				+
iqinde (Turkish)				+
[τΣ↔] (Cantonese)				-