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An investigation into the linguistic encoding of spatial scenes

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ABSTRACT

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Previous attempts at characterizing the semantics of spatial terms are based on examinations of individual languages and place primary importance on either geometric or functional information. These attempts yield approaches to the meanings of spatial terms that cannot account for every use of a given term. Furthermore, these approaches are unable to provide an explanation for both the similarities and the variation evident in spatial terms across languages. In this dissertation, I describe a unified approach to the semantics of spatial terms motivated by an examination of their uses in multiple languages.

I first present an elicitation study in which speakers of sixteen languages from twelve language families described a set of scenes which would be described using the prepositions *in, on,* or *over* in English. This study revealed that there are significant similarities in how languages encode the

concepts contact, relative vertical position, and inclusion. I then present a set of experiments that look at the ways in which a few particular attributes of a scene affect speakers' uses of the English prepositions *in* and *on*. The experiments showed that geometry, function, and animacy of the Figure and the Ground all influence English speakers' choice between *in* and *on*, both individually and in concert with one another. I conclude from the results of the experiments that a representation of the semantics of spatial terms must take into account a complex set of interacting factors.

Based on the cross-linguistic elicitation study and the set of experiments, I propose that the meanings of spatial terms are built from a universal set of weighted abstract attributes. The lexical entries of individual spatial terms are created by specifying the values for the attributes, as I illustrate with the English prepositions *in* and *on*. Because the meanings of all spatial terms are based upon the same set of abstract attributes, it is to be expected that similarities such as those identified in this dissertation will be found across diverse languages. Further, because each lexical entry individually specifies the values for the attributes, it is to be expected that these similarities will coexist with significant variation.

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1.0 Introduction

One challenge for researchers in semantics is to determine the mapping of concepts between the world and language. As Gentner (1981, 1982) has pointed out, this challenge is particularly striking for relational terms such as verbs and prepositions, which are used to describe a relation between two entities. Relational terms appear particularly challenging due to the fact that they are more likely to describe a wide range of concepts than are concrete nouns. For example, the variability in the set of actions described by the verb *play* is far greater than that in the set of objects described by the noun *car*.

One set of relational terms that has received a lot of attention in recent years is the set of terms used to encode the spatial relations that can hold between physical objects in the world (Bowerman, 1996; Bowerman & Choi, in press; Bowerman & Pederson, 1992, 1996; P. Brown, 1994; Brugman, 1988; Carlson-Radvansky & Regier, 1997; Cienki, 1989; Clark, 1973; Coventry, Carmichael, & Garrod, 1994; Gentner & Bowerman 1996, 2000; Herskovits, 1986; Landau, 1996; Landau & Jackendoff, 1993; Levinson, 1996a, 1996b; Neumann, 1995; O'Keefe, 1996; Regier, 1995, 1996; Sinha & Kuteva, 1995; Sinha & Thorseng, 1995; Sinha, Thorseng, Hayashi, & Plunkett, 1994;

Talmy, 1983, 1985, 1988; Taylor, 1988; Vandeloise, 1991, 1994). This set of terms includes spatial prepositions like English *in* and *on*, locative adpositions like the Turkish suffix *-da,* and relational nouns like Japanese *ue* and *naka*. Each of these terms can be used to describe a set of spatial relations holding between two or more entities in the world. For example, the English preposition *on* can be used to describe the relation holding between a piece of paper and the desk atop which it lies (1a), a picture and the wall against which it hangs (1b), a magnet and the refrigerator to which it is stuck (1c), and a door and the hinges which hold it up (1d).

(1) a) The paper is *on* the desk.

b) The picture is *on* the wall.

c) The magnet is *on* the refrigerator.

d) The door is *on* its hinges.

Various treatments of spatial language have called the located entity (the paper, the picture, the magnet, and the door in example (1)) the trajector (Langacker, 1987; Regier, 1995, 1996; Vandeloise, 1991) or the Figure (Herskovits, 1986; Talmy, 1983); the reference entity (the desk, the wall, the refrigerator, and the hinges) has been referred to as the landmark (Langacker, 1987; Regier, 1995, 1996; Vandeloise, 1991) or the Ground (Herskovits, 1986; Talmy, 1983). Following Herskovits (1986) and Talmy

(1983), the terms Figure and Ground, which were borrowed from work in Gestalt psychology, will be adopted in this dissertation.

Spatial relational terms provide an interesting domain for semantic research in part due to the fact that the relations being described could be said to exist objectively in the world, separate from linguistic conceptualization. For example, one does not need a linguistic term describing the relation between the pear and the bowl in Figure 1.1 in order to understand the spatial relation between the pear and the bowl. Furthermore, one can act on this relation without making use of the term that would describe it, for example, by removing the pear.

Figure 1.1 A pear *in* a bowl

Because spatial relational terms exist separately from the relations being described, this is a domain in which linguistic conceptualizations might be compared with what exists objectively in the world. This contrasts with other domains in which it might be argued that the entities described do not exist apart from their linguistic conceptualizations. A case in point is the domain of time: entities such as hours and minutes come into being due to humans' ability to talk about them. Similarly, speech acts such as promises

and threats, which are purely linguistic constructs, cannot be said to exist separate from the language used to describe them. As these are not separate entities easily observable in the world, it would be harder to compare linguistic conceptualizations with the state of the world in the domains of time and speech acts than in the domain of space.

In addition to the fact that spatial relations exist objectively in the world, the groupings of spatial relations into categories, as evidenced by a language's spatial terms, seem clear and logical to native speakers. To illustrate, monolingual English speakers will often give quick, sure judgments about the relation between two entities in space, as represented by the term naming the relation, and these judgments tend to agree quite well across speakers. For example, sentence (2) would be accepted as a description for the scene in Figure 1.1 by all native speakers of English.

(2) The pear is *in* the bowl.

To monolingual speakers, categorizations of spatial relations as represented by the spatial relational terms of their language are self-evident. The average monolingual speaker finds it strange to think that space can be categorized in a different way from that to which he is accustomed.

In striking contrast to the certainty of the monolingual speaker's judgments is the variety of ways in which different languages categorize

space, evident from a cross-linguistic examination of spatial terms (see Chapter 2 for a fuller examination). The variety of categorization options available cross-linguistically demonstrates that the categories defined by spatial terms in any one language are not so straightforward as they may seem to the monolingual speaker. For example, two scenes that may be placed into separate categories in one language (i.e., the spatial relations that they depict are described by different terms) may be placed into the same category in another (i.e., the spatial relations that they depict are described by the same term), as shown in the English and Spanish examples in (3) and (4). In Spanish, the term used to describe the relation of coffee to the cup that contains it also describes the relation of a cup to the table that supports it; in English, these two relations are described by different terms.

(3) a) The coffee is *in* the cup. (English)

b) El café está *en* la taza. (Spanish)
the coffee is *en*[1] the cup

(4) a) The cup is *on* the table. (English)

b) La taza está *en* la mesa. (Spanish)

the cup is *en* the table

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[1] Because the aim here is to examine differences in use between spatial relational terms across languages, I have left these terms untranslated in the glosses.

It is this contrast between the self-evidence of spatial relations to monolingual speakers and the variety of ways in which different languages categorize spatial relations that makes the study of the semantics of spatial relational terms so intriguing.

Finally, space has been shown to be the source domain for many metaphors (Lakoff, 1987), as can be seen from the examples in (5). Example (5a) shows the use of the English preposition *in* to communicate about the location of a physical entity, a ball, in space. Examples (5b) and (5c) demonstrate how the English preposition *in* can be used to communicate about the domain of time. In example (5b), *in* is used to specify the period in time at which an event occurred. In example (5c), *in* is used to delimit the length of time one must wait for an event to occur. Finally, examples (5d) and (5e) illustrate uses of the English preposition *in* to indicate that a specific state holds of the subject of the utterance: in (5d), the state is that of being enamored; in (5e), the state is that of being unprepared to deal with issues that have arisen.

(5) a) The ball is *in* the box.

b) She arrived *in* September.

c) I'll be there *in* a minute.

d) They are *in* love.

e) He's *in* over his head.

A more thorough understanding of the semantics of spatial relational terms may help illuminate the conceptual domains described metaphorically from the source domain of space. I leave this possibility to be explored in future research.

In this dissertation, I will pursue a clear understanding of the semantics of spatial relational terms for a small set of terms in a variety of languages, illustrated by concrete scenes that would be described using *in* and *on* in English. There are a number of reasons that these terms were chosen as the topic of this dissertation. First, these terms tend not to require that the speaker utilize a frame of reference (see section 1.1.3), which would add an additional point of variation to the cross-linguistic study (Chapter 2). Second, these terms seem a good place to begin a study of space because they are the first spatial terms learned by children (R. Brown, 1973; P. Brown, 1994). The concepts that they are taken to encode — containment, support, and contiguity (see section 1.2.1) — are hypothesized to be prelinguistic elements of perceptual space onto which the child maps linguistic forms (Clark, 1973). Finally, *in* and *on* are used for a wide variety of spatial configurations (see Chapter 2), including one entity containing another (as the bowl contains the pear in Figure 1.1), one entity attached to the side of

another (such as a magnet attached to the side of a refrigerator), and one entity supported by another from below (such as a coffee cup supported by a desk atop which it rests), with some overlap in their ranges of application. The range of configurations that *in* and *on* describe allowed me to examine the ways in which different languages describe a wide variety of scenes, while the potential overlap in their ranges of application allowed a closer look at the fluidity of these terms.

In this dissertation, I describe a study eliciting terms in a variety of languages as they are used to describe a single set of pictures (Chapter 2), the aim of which was to determine whether it is viable to pursue a framework for the meanings of spatial relational terms that can be applied to the terms of multiple languages. I then describe an experimental examination of how controlled manipulations of a small set of pictures influence the use of *in* and *on* in English (Chapter 3) as a step towards representing the meanings of these two terms. Finally, I present a new approach to the representation of the meanings of spatial relational terms informed by these two studies (Chapter 4). In the rest of this chapter, I introduce the issue of spatial relational terms (section 1.1), the previous attempts to describe the meanings of spatial relational terms (section 1.2), and the approach to the meanings of

spatial relational terms that I propose (section 1.3). I conclude with an overview of the dissertation in section 1.4.

1.1 Space and language

Although there are infinite possible configurations of two objects in space, languages offer few words that can be used to describe spatial relations, forcing us to group sets of configurations together in categories in order to communicate about them. This has resulted in the existence of categories whose members might appear to be unrelated to one another. One example of such a grouping, from the point of view of an English speaker, is the Spanish categorization of the relation of coffee to a cup that contains it with the relation of a cup to a table upon which it is situated, illustrated in examples (2) and (3). When examining the uses of spatial relational terms, one arrives at the question of whether the set of configurations described by a given spatial relational term has some common elements that might form the basis of the meaning of the term.

1.1.1 Spatial terms and locations in the world

One of the primary uses of spatial relational terms is to describe the location of a static Figure with respect to a static Ground. Examinations of the set of static configurations of Figure and Ground categorized by a given spatial relational term have revealed that spatial relational terms encode a variety of attributes of the scenes they are used to describe (Bowerman, 1996; Levinson, 1996b; Sinha & Thorseng, 1995). These attributes are abstract characteristics of the scene and the entities therein, including both physical and conceptual information about the Figure, the Ground, and the relation between them. Among the attributes hypothesized to be encoded by spatial relational terms are *geometry*, including the geometry of the Ground (Jackendoff & Landau, 1991; Landau & Jackendoff, 1993; Talmy, 1983), the geometry of the Figure (Brown, 1994; Levinson, 1996b), and the geometric relation between the Figure and the Ground (Bennett, 1975; Bowerman & Pederson, 1992, 1996; Carlson-Radvansky & Regier, 1997; Herskovits, 1986; Lindkvist, 1950; Miller & Johnson-Laird, 1976; Regier, 1996; Talmy, 1983); the *function* of the Ground and the resulting functional relation between the Figure and the Ground (Coventry, Carmichael, & Garrod 1994; Vandeloise, 1991, 1994), and *qualitative physical* characteristics of the scene, such as whether one of the entities supports the other against gravity (Bowerman &

Choi, in press; Bowerman & Pederson, 1992, 1996; Forbus, 1983, 1984; Talmy, 1988).

Each of the attributes has a value in physical scenes depicting objects and relations between them. The shapes of the physical objects, along with information about their sizes and the presence or absence of concavities in their surfaces, constitute the value for the *geometry* of the Figure and the Ground. The value for the *geometrical relation* between the Figure and the Ground includes such information as their relative vertical and horizontal positions and their proximity to one another, with containment being the closest possibility and contact being the next closest (Jackendoff & Landau, 1991), and their relative sizes. The value for the *functional relation* between the Figure and the Ground is determined from knowledge about the normal uses (if any) of the objects (particularly the Ground), knowledge about whether or not the Figure and Ground normally interact, and knowledge of the manner in which they are interacting in the scene being described. Finally, the value for the attribute *qualitative physics* depends on information about the physics of the configuration, such as the presence or absence of a support relation and the ability of one entity to control the movement of the other. In the rest of this dissertation, I will refer to values of the abstract attributes such as the ones mentioned in this paragraph as

attribute values or as *values of the attributes*; I will refer to the abstract attributes themselves as *attributes*.

Whether an attribute is encoded by a term varies from term to term and language to language, complicating the enterprise of describing the semantics of spatial relational terms. As a case in point, although most English spatial prepositions appear not to encode detailed information about the geometry of the Figure (Landau & Stecker, 1990; Talmy, 1983), the spatial relational terms of Mayan languages such as Tzeltal do encode such information (P. Brown, 1994; Levinson, 1996b). For example, the Tzeltal term that would be used to describe the relation between an upright oblong object (e.g., a vase) supported from below by a table would differ from that used to describe the relation between a rounded concave object (e.g., a bowl) supported from below by a table, while both relations would be described using *on* in English. Similarly, some information about the geometry of the Figure seems to be encoded by three spatial prepositions in English: *across, along,* and *around* (Jackendoff & Landau, 1991), the use of which depends on the orientation of the linear axis of the Figure. I will return to the issue of how abstract attributes are manifested in scenes described by spatial relational terms in section 2.1.

1.1.2 Spatial terms and trajectories

In addition to describing the location of a stationary Figure with respect to a Ground, spatial relational terms may be used to describe the trajectory, or path of motion, of a moving Figure.

Talmy (1985) has shown that there are two options for the lexicalization of paths of motion across the world's languages. One option is to create a verb which lexicalizes the path of motion of the Figure along with the fact of motion. This option is illustrated in (6), in which the verb, *enter*, provides information both about the fact that the Figure has moved, and about its path, in this case to the interior of the Ground. The second option is to lexicalize the path of motion as a separate spatial relational term, which Talmy (1985) refers to as a satellite of the verb. This option is illustrated in (7), using the preposition *into* to communicate that the path of motion is to the interior of the Ground; the fact of motion in this example is lexicalized along with the manner of motion by the verb *walk*.

(6) Leif *entered* the room.

(7) Leif walked *into* the room.

Talmy (1985) goes on to show that, although both options may be available in all languages, as the examples suggest for English, some languages tend to make greater use of verbs which lexicalize the path of

motion along with the fact of motion (e.g., French), while other languages make greater use of verb-satellite combinations (e.g., English). These differences in the lexicalization of paths of motion are a source of variation that may complicate an examination of spatial relational terms across languages: some terms may incorporate not only information about the spatial relation holding between the Figure and the Ground, but also additional factors about the scene being described (e.g., path of motion). As the examination of spatial relational terms to be undertaken in this dissertation will include usages of terms in a variety of languages, I chose to avoid this additional source of variation, opting instead to limit my study to descriptions of static configurations of objects.

1.1.3 Frames of reference

Many spatial relational terms need to be interpreted with respect to a specific frame of reference (Miller & Johnson-Laird, 1976) which serves to define the space surrounding the Ground. Levinson (1996a, 1996b) has noted that there are three particularly important frames of reference found in language, which he refers to as relative, intrinsic, and absolute.

Descriptions making use of the relative frame of reference are dependent on the position and point of view of the speaker. Thus, these

descriptions necessarily change as the position of the describer changes. This change is illustrated in Figure 1.2 and example (8), in which the people labeled *A* and *B* are describing the same relation between the circle and the square, although their positions with respect to the scene differ. This difference leads them to produce opposite descriptions of the scene when both are facing the circle and the square: from A's point of view, the circle is to the left of the square, while from B's point of view, it is to the right.

(8) A: The circle is *to the left of* the square.

B: The circle is *to the right of* the square.

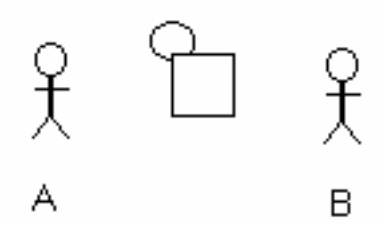

Figure 1.2 Two people observing a scene from opposite sides

In contrast to descriptions making use of the relative frame of reference, descriptions making use of the intrinsic frame of reference rely on orientational features of the Ground, as illustrated in (9). In this example, the ball's position is described as the space adjacent to the front part of the cat. Because this description relies on a fixed part of the Ground, it remains true regardless of the position and point of view of the speaker.

(9) The ball is *in front of* the cat.

In contrast to descriptions using the other two frames of reference, descriptions making use of the absolute frame of reference rely on "fixed bearings" (Levinson, 1996a) such as the cardinal directions, as illustrated in (10). In this example, neither the position of the speaker nor features of the Ground are understood to be part of the description of the location of the Figure. Rather, the Figure is located by reference to a known direction unrelated to any entities in the scene.

(10) The ball is *north of* the cat.

Despite the necessity of frames of reference for the interpretation of many spatial relational terms, the English prepositions *in* and *on* appear not to make use of any of these frames of reference. For example, the description of the location of the sticker in (11) does not change when the position of the speaker changes, as with the relative frame of reference. Additionally, this description need not make reference to any specific part of the Ground (the sticker could be lying on top of the table or it could be stuck to the side), as with the intrinsic frame of reference. Finally, this description does not make reference to directions separate from the Figure and the Ground, as with the absolute frame of reference.

(11) The sticker is *on* the table.

As this dissertation will be examining the terms *in* and *on*, along with terms in other languages used to describe scenes for which English uses *in* and *on*, none of which involves frames of reference, a thorough examination of frames of reference and their influence on the use of spatial relational terms is beyond the scope of this dissertation.

1.1.4 Spatial terms across the world's languages

A language's system of spatial relational terms is responsible for allowing people to communicate about the positions in which objects in the world can be located. These systems, however, tend to be restricted; there are relatively few spatial relational terms available to describe relatively many configurations of a Figure with respect to a Ground (Landau & Jackendoff, 1993). Thus, each spatial relational term must name a group of configurations that form a natural class or share certain properties.

Languages make different choices about which configurations of Figure and Ground are similar enough to be placed into the same group. Additionally, for any given set of configurations, languages vary with respect to the number of groups into which the configurations are placed (and therefore the number of spatial relational terms). These choices have given rise to the cross-linguistic variation already alluded to, as will be further

shown in this section's examination of cross-linguistic variation in the categorization of configurations commonly labeled as *in* or *on* in English (see Chapter 2, Table 4, for more evidence of this variation).

One source of differences between spatial relational terms across languages is the number of categories into which spatial configurations may be grouped. For instance, Landau and Jackendoff (1993) observe that the categories corresponding to English *in* and *on* are collapsed into one category, labeled *en*, in Spanish (see examples (3) and (4) above). As Bowerman (1993) points out, the category labeled *on* in English is subdivided into three categories corresponding to *op, aan,* and *om* in Dutch (see Chapter 2, section 2.1.5). As these examples demonstrate, oppositions found in one language may be neutralized by the categorization system of another.

Even when languages use the same number of categories, they may choose to group different configurations together. For example, Finnish, like English, uses two categories for the range of configurations that would be labeled *in* or *on* in English, but the set of configurations in each category in Finnish is quite different from that in English, as seen in Table 1.1 (adapted from Bowerman, 1996, Figure 4).

Table 1.1 English and Finnish categorizations of some configurations of Figure and Ground

	apple in bowl	handle on pan	bandaid on leg	ring on finger	fly on door	picture on wall	cup on table
English coding	*in*	*on*	*on*	*on*	*on*	*on*	*on*
Finnish coding	inessive case	inessive case	inessive case	inessive case	inessive case	adessive case	adessive case

Table 1.1 shows that the set of configurations *apple in bowl, handle on pan, bandaid on leg, ring on finger, fly on door, picture on wall,* and *cup on table* is divided into two groups by both Finnish and English. However, in English the configuration *apple in bowl* is separated from the rest, while in Finnish *apple in bowl* is grouped with *handle on pan, bandaid on leg, ring on finger,* and *fly on door,* while *picture on wall* and *cup on table* form the second group.

In addition to cross-linguistic differences in the number of categories of spatial configurations and the sets of configurations placed into each of the categories, there is variation in how individual spatial configurations fit into the available categories. These examples may indicate differences in speakers' conceptions of individual configurations. For instance, a meadow may be considered an interior in English but a surface in Polish and Russian (which both use the cognate prepositions *na*; see Chapter 2, Table 2.6, for a listing of attributes encoded by Polish *na* and Russian *na*), as seen in (12) (Cienki, 1989, p. 29).

(12) a) He fell asleep *in* the meadow.

b) Zasnal *na* lace. (Polish)
He fell asleep *on* the meadow.

c) On zasnul *na* lugu. (Russian)
He fell asleep *on* the meadow.

In this instance, Russian and Polish display similar categorizations, which are distinct from that of English. In other examples, however, this may not be the case, as seen in (13).

(13) Russian: *v* pustyne; English: *in* the desert; Polish: *na* pustyni
in desert *on* desert

(Cienki, 1989, p.74)

Here, Russian fails to categorize in the same manner as its Slavic relation, opting instead for a categorization like that found in English. In addition, although Polish has a cognate to Russian *v* that is used for most of the same scenes, in this instance Polish uses *na*. This difference is even odder due to the fact that both deserts and meadows are flat geographical expanses, which might lead one to expect that the same spatial relational term would be used for both kinds of Ground. However, although this is the case in English and in Polish, it is not the case in Russian. Thus, the manner in which a language categorizes a spatial configuration involving one Ground does not

always predict how it will categorize spatial configurations involving other Grounds[2].

In addition, it is possible to conceive of a given spatial configuration in different ways, even within one language, as evidenced by the appropriate use of alternate spatial relational terms. One example of this is the way English speakers talk about people's relations to the vehicles in which they are travelling, as shown in (14), in which the spatial relation between *the man* and *the bus* remains constant regardless of the preposition used. In (14a), this relation is grouped with examples of containment through the use of the preposition *in*, while in (14b), it is grouped with examples of contiguity and support through the use of the preposition *on*.

(14) a) The man is *in* the bus/plane/train.

b) The man is *on* the bus/plane/train.

The alternate conceptualizations of the relation between *the man* and *the bus* shown in (14) are not encoded in all languages. For example, in Polish, only the containment conceptualization, indicated by the use of the preposition *w* (the cognate to the Russian preposition *v*; see Chapter 2, Table

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[2] It would require a close look at the spatial systems of a variety of languages to determine the point at which a number of exceptions becomes a systematic variation from the general rule. Although this is an important issue, such an examination is beyond the scope of this dissertation.

6) can be used to talk about people's relations to the vehicles in which they are travelling. Use of the preposition *na* would indicate that the man in question is on top of the bus (Cienki, 1989), an interpretation that, although possible, is dispreferred in English in the absence of further context. This results in another source of cross-linguistic variation in spatial language: the difference in the number of permissible conceptualizations for a given scene. This phenomenon can also be seen in the distinctions between the French prepositions *dans* and *sur*, noted by Vandeloise (1991, p. 229, examples (50) and (51)), that do not necessarily hold for the comparable English prepositions, *in* and *on,* as illustrated in (15) and (16):

(15) a) l'huissier est assis *sur* (**dans*) la chaise (French)

b) the notary is sitting *on* (*in*) the chair

(16) a) le chef comptable est assis *dans* (**sur*) le fauteuil (French)

b) the head accountant is seated *in* (?*on*) the armchair

In these examples, it is possible that the speaker of English conceives of the acts of sitting in a chair and of sitting in an armchair as more similar than they would seem to the speaker of French. In English, each type of chair can be considered either as a container within which one sits or as a surface on which one sits, but in French only the armchair can function as a container; only the chair, as a surface.

The cross-linguistic variation evident in spatial language has led to a special set of challenges for scholars who choose to do cross-linguistic research in this domain. One such challenge is to determine whether there is overlap in the range of application to scenes in the world of spatial relational terms in different languages. Should there be overlap, it is then left to be determined how much overlap in meaning is necessary for two words to be comparable, or "translation equivalents." A related challenge is to devise a theory of spatial relational meaning which can be descriptively adequate both within a language and across languages.

Although there are many challenges, cross-linguistic variation may provide the possibility for gaining deep insights into how humans talk about spatial relations between objects. An understanding of the meanings of spatial relational terms may provide insights into how speakers conceptualize scenes in the world, as linguistically relevant attributes of spatial scenes may correspond to cognitively relevant attributes. Studying the ways in which spatial relational terms overlap in meaning may allow us to see which attributes of spatial scenes are important components of the meanings of spatial relational terms in general, while examining points of variation may lead to the discovery of additional linguistically relevant attributes.

1.2 Approaches to characterizing the meanings of spatial relational terms

As mentioned in section 1.0 and illustrated in section 1.1, any given spatial relational term can be used to communicate that one of a diverse set of configurations holds. The task of describing the semantics of these terms involves an exploration into the ranges of configurations for which the terms under study are appropriate. Within a set of configurations that can be named by a given term, one can determine which attribute values, if any, the configurations have in common. These attributes may then be posited as forming the basis for the meaning of the spatial relational term. However, because there appear to be configurations categorized by the same term yet unrelated to one another, precise descriptions of spatial relational terms have proven difficult to elaborate. In order to arrive at a semantics of spatial relational terms, many researchers have looked into similarities between the configurations that are categorized together by virtue of being named by the same term, adopting the abstract attribute for which they found the greatest similarity as the defining attribute for the semantics of spatial relational terms in general. However, as will be shown in this section, such approaches are often left with configurations that must be treated as exceptions.

In the rest of this section I will discuss previous approaches to the semantics of spatial relational terms. In section 1.2.1, I will examine

approaches that are based on the geometry of the scenes described. Although geometry-based approaches have provided significant insights into the meanings of spatial relational terms, they are not without problems. I will present some problems with geometry-based approaches in section 1.2.2. Following that, in section 1.2.3, I will consider two classes of alternatives to geometry-based approaches: those that combine geometry with additional considerations, such as pragmatics (section 1.2.3.1), and those based on functional considerations (section 1.2.3.2).

1.2.1 Geometry-based approaches

The importance of geometry to the characterization of the meaning of spatial relational terms has been noted by many researchers (Bennett, 1975; Carlson-Radvansky & Regier, 1997; Herskovits, 1986; Landau, 1996; Lindkvist, 1950; Miller & Johnson-Laird, 1976; Talmy, 1983). Perhaps because geometry is such an easily accessible feature of scenes involving two or more objects, geometric descriptions are prominent in both lexicographers' definitions and linguists' treatments of spatial terms. For example, the *Oxford English Dictionary* makes use of the notion of inclusion in the definition of the general sense in the entry for *in* given in (17).

(17) The preposition expressing the relation of inclusion, situation, position, existence, or action, within limits of space...

(*Oxford English Dictionary*, second edition, online version)

Similarly, in his study of the semantics of spatial prepositions in English, Lindkvist (1950) attempts to "classify the various kinds of expressions according to *the physical reality* they serve to express" (Lindkvist 1950, p. 15, italics his). An examination of the cases considered by Lindkvist reveals that the physical reality to which he is referring is in large part geometrical, including notions such as enclosure in his characterization of *in* and notions such as nearness and contact in his characterization of *on* (Lindkvist 1950).

In a similar manner, Bennett's (1975, p.71) proposal for the meaning represented by the English spatial preposition *in* is the highly geometrical description in (18).

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

From descriptions of the meaning of *in* such as these, one can easily explain why the sentence in (2), repeated here as (19), means that the pear is located at the bowl's interior: the meaning of *in* places the Figure at the interior of the Ground.

(19) The pear is *in* the bowl.

Geometric descriptions provide an appropriate explanation for the applicability of example (19) as a description of a picture such as that depicted in Figure 1.1, in which the pear actually is located at the bowl's interior.

Talmy (1983) proposes that spatial terms relate to scenes in the world through a process that he calls "schematization." Schematization "involves the systematic selection of certain aspects of a referent scene to represent the whole, while disregarding the remaining aspects" (p. 1). The selected aspects are, overall, geometric, and Talmy goes on to discuss the range of geometries of the Figure and the Ground that receive attention from the schemas.

There are a number of specific geometric factors that have been proposed to explain the use of spatial relational terms, including contact between the Figure and the Ground (said to be important to the use of English *on*), inclusion of the Figure in the Ground (said to be important to the use of English *in*), and the relative vertical position of the two objects (said to be important to the use of English *over* and *under*). Carlson-Radvansky and Regier (1997) present experimental evidence for the importance of two additional geometric factors, center-of-mass orientation (the spatial relation between the centers of mass of two objects) and proximal orientation (the

spatial relation between the objects' nearest edges) to English speakers' use of the terms *above, below, left,* and *right*.

In addition to noting the importance of geometry at the level of the scene, various researchers have focussed on the role played by geometry at the level of the participants in the scene, particularly the Ground. For example, many definitions for *in*, including Bennett's (1975; cited above in (18)) and Herskovits' (1986; cited in Section 1.2.3.1, (24) below) require that the geometry of the Ground be such that there is an interior at which the Figure can be located. Feist and Gentner (1997, 1998) found that changes in the geometry of the Ground object can result in changes in the extent to which the Ground has an interior and concomitant changes in the applicability of the English spatial prepositions *in* and *on*, providing evidence that geometry is an important factor in the meanings of these terms (see also Chapter 3).

Geometrical concepts also figure prominently in descriptions of spatial terms in languages other than English aimed at an audience of English speaking learners of those languages. For example, Batchelor and Pountain (1992) provide two spatial meanings for the Spanish preposition *en*, both of which are characterized through geometrical descriptions. The basic meaning is said to refer to "position above; correspond[ing] to English *on*" (p.

192); this meaning is illustrated in (20). Another meaning is explained as "position within; correspond[ing] to English *in*" (p. 192); this meaning is shown in (21).

(20) *en* el tejado

on the roof

(21) *en* la caja

in the box

For both of these examples, common scenes that could be described with these phrases meet the geometric descriptions provided. For example, (20) can be used to describe the position of the box in Figure 1.3, while (21) can be used to describe the position of the ball in Figure 1.4.

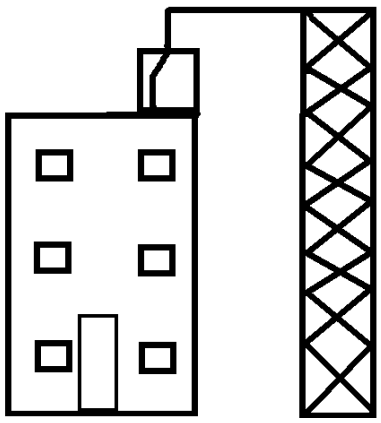

Figure 1.3 La caja está *en* el tejado
The box is *on* the roof

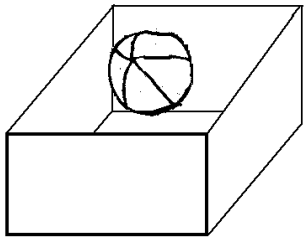

Figure 1.4 La pelota está *en* la caja
The ball is *in* the box

Many characterizations of the meanings of spatial relational terms are based on one prominent abstract attribute of spatial scenes: the geometry of the scenes. A geometrical approach is intuitively appealing, as it is the geometry of the scene that is most easily accessible to perception. In addition, geometric characterizations are able to account for many uses of spatial relational terms, as has been shown in this section. The geometric approaches to the semantics of spatial relational terms that have been proposed in the literature have provided important insights into similarities among the members of categories defined by spatial relational terms.

1.2.2 Problems with geometry-based approaches

Despite the intuitive appeal of a geometry-based approach to the semantics of spatial relational terms, a closer examination of the uses of these terms reveals important problems for such an approach. These problems can be grouped into two classes: (a) geometrical descriptions are unable to account for the full range of uses of spatial relational terms, and (b) certain geometric configurations may be described by more than one spatial relational term.

1.2.2.1 Geometric descriptions do not cover the range of uses

Although geometric descriptions are able to account for many uses of spatial relational terms, there remains a significant subset of the range of uses of many spatial relational terms that cannot be adequately explained by such a description. Consider again the sentence in (2), repeated as (22).

(22) The pear is *in* the bowl.

According to the geometric treatments of spatial semantics considered above, this sentence describes a scene in which the Figure, a pear, is included in, or located at, the interior of the Ground, a bowl (Figure 1.5a). Such treatments provide a sufficient representation of the elements of meaning

contributed by *in* just in case *in* is applicable to only those scenes in which the Figure is found at the interior of the Ground.

In English and many other languages, however, the relation of full inclusion is not the only relation to which the term *in* (and other terms used to describe scenes involving full inclusion) can be applied (cf. Chapter 2, Table 4). In fact, *in* can be applied to a range of configurations, including ones in which the Figure is partially included in the Ground (Figure 1.5b), and scenes in which the Figure itself is not actually located at the interior of the Ground (Figure 1.5c). To account for this, the geometric approach must appeal to the notion that the pear is part of an aggregate, part of which is located at the interior of the bowl.

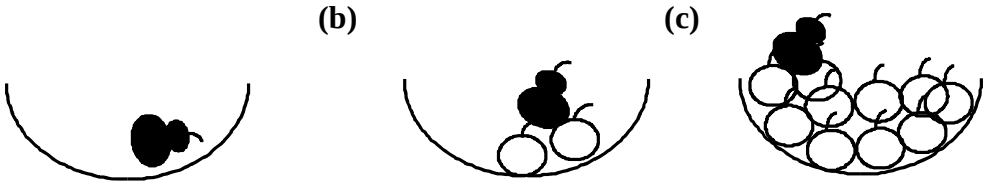

Figure 1.5 The pear is *in* the bowl

The inability of geometric descriptions such as those considered above to straightforwardly account for the range of situations depicted in Figure 1.5 suggests that they are inadequate as complete descriptions of the meanings of spatial relational terms.

1.2.2.2 One configuration, two spatial terms

There exist configurations for which English prepositions can be exchanged without a concomitant change in the spatial relation between the Figure and the Ground in the scene being described. For example, although the prepositions *in* and *on* have been interchanged in (23), both sentences can describe the same spatial relation between the children and the field (adapted from Taylor, 1988, p. 305).

(23) a) The children are *on* the field.

b) The children are *in* the field.

Although it can be argued that there are different shades of meaning that apply to the two variants shown in (23), it cannot be denied that the geometry of the scene remains constant. This presents a problem for a purely geometric approach to spatial semantics, as such an approach would be incapable of explaining the applicability of both *on* and *in* to a single geometric configuration. Furthermore, given such overlapping terms, in certain situations a speaker must make a choice between possible spatial relational terms to use to describe a scene. In addition to being unable to explain the applicability of more than one term to a given scene, geometrical approaches by themselves are unable to provide a full account of how a speaker chooses between competing spatial terms to describe one scene.

1.2.3 Other approaches

Due to the inability of a purely geometry-based approach to fully account for the semantics of spatial relational terms, representations involving other attributes of the described scenes have been proposed. These proposals have taken one of two forms. In one type of proposal, an approach based primarily on the attribute *geometry* has been augmented by appealing to additional considerations, such as pragmatics and world knowledge. In the other type of proposal, *geometry* is not given a primary role. Rather, the usage of spatial relational terms is said to depend on functional considerations. If *geometry* is given a prominent role at all in such a theory, it is said to be important in that it implies the relevant functional relation.

1.2.3.1 Geometry combined with additional considerations

Augmenting a geometry-based approach, Herskovits (1986; see also Cienki, 1989) proposes that spatial prepositions in English are associated with *ideal meanings*, which are largely geometric, and *use types*, which incorporate world knowledge. Ideal meanings in Herskovits' theory act as prototypes from which one can derive actual uses of prepositions. The use types are conventions of use applying the ideal meanings to real-world objects

and are stored in the lexical entries of prepositions. Appropriate uses of spatial prepositions may differ from the ideal meanings and the use types according to pragmatic principles and "near-principles" involving such factors as *salience, relevance, tolerance,* and *typicality*.

For example, Herskovits proposes the ideal meaning for *in* cited in (24) and the set of use types cited in (25). The italicized phrase under each use type illustrates the use type.

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

(Herskovits, 1986, p. 48)

(25) a) Spatial entity in container

the milk in the glass

b) Gap/object "embedded" in physical object

the nail in the board

c) Physical object "in the air"

the bird in the air

d) Physical object in outline of another, or of a group of objects

the bird in the tree

e) Spatial entity in part of space or environment

the chair in the middle of the room

f) Accident/object part of physical or geometric object

the muscles in his legs

g) Person in clothing

a man in a red hat

h) Spatial entity in area

a line in the margin

i) Physical object in a roadway

a truck in the road

j) Person in institution

the man in jail

k) Participant in institution

My son is in college.

(Herskovits, 1986, pp. 149-155)

Similarly, Herskovits proposes the ideal meaning for *on* cited in (26) and the set of use types cited in (27). The italicized phrase under each use type illustrates the use type.

(26) *On*: for a geometric construct *X* to be contiguous with a line or surface *Y*; if *Y* is the surface of an object O_Y, and *X* is the space occupied by another object O_X, for O_Y to support O_X.

(Herskovits, 1986, p. 49)

(27) a) Spatial entity supported by physical object

the man on the chair

b) Accident/object as part of physical object

the carving on the stone

c) Physical object attached to another

a dog on a leash

d) Physical object transported by a large vehicle

the children on the bus

e) Physical object contiguous with another

the lock (of hair) on his forehead

f) Physical object contiguous with a wall

a chest of drawers on the left wall

g) Physical object on part of itself

the man on his back

h) Physical object over another

the dark clouds on the island

i) Spatial entity located on geographical location

the players on the football field

j) Physical or geometric object contiguous with a line

a point on the bisector line

k) Physical object contiguous with edge of geographical area

a shop on the main square

(Herskovits, 1986, pp. 140-148)

In the ideal meanings, Herskovits captures the unifying geometric notions underlying appropriate uses of the prepositions: inclusion for *in* and contiguity and support for *on*. As its name suggests, however, the ideal meaning is an idealization; the ideal meaning refers to geometric constructs, while speakers refer to objects and entities in the world. According to Herskovits' theory, speakers' uses of the preposition are instances of one of the use types, which in turn are real-world instantiations of the ideal meaning. However, as Herskovits notes, there are many appropriate uses that, strictly speaking, conform neither to the ideal meaning nor to one of the use types. Herskovits claims that these uses can be explained through the pragmatic properties of *salience, relevance, tolerance,* and *typicality*.

Salience explains that an expression can make use of an object or a part of one if there is "an experience shared by all speakers in which the

relevant part is salient" (p.74). In example (28), the visible part of the house, but not its foundation, is referred to by the subject *the house*; the visible part is in fact *on top of* the hill, but the foundation, which would be dug into the hill, is not. Since part of the house is actually *in* rather than *on* the hill, one would not expect *on* to be appropriate based on the ideal meaning and the use types. *On*'s acceptability is explained by the fact that the salient part of the house, that which is visible, is also the relevant part.

(28) The house is *on* top of the hill.

Relevance is defined relative to the speaker's communicative goals, and foregrounds objects or relations that may not otherwise be salient in the shared context of both speaker and hearer, as can be seen from the contrast in (29). Both (29a) and (29b) can be used to describe a situation in which some quantity of milk is located at the interior surface of a bowl, yet what is communicated by the two sentences is quite different. In (29a), the use of *in* communicates that the bowl contains some quantity of milk, which may or may not actually be in contact with the bowl (for instance, if the bowl were lined with plastic wrap). In (29b), on the other hand, the use of *on* communicates that the milk is in contact with the bowl, yet may or may not be adequately contained (for instance, if the bowl were cracked, with milk

leaking out). Further, one might expect that the quantity of milk described by (29a) is greater than that described by (29b).

(29) a) There is milk *in* the bowl.

b) There is milk *on* the bowl.

Tolerance allows for shifts from a preposition's ideal meaning and for approximations of participants in a scene to geometric entities such as points, lines, and surfaces. For example, tolerance would allow the man in (30) to be conceptualized as a point, resulting in the sentence describing a situation that fits the ideal meaning for *in*: a one-dimensional geometric construct, the man conceptualized as a point, would be included in a two-dimensional geometric construct, the area of the earth's surface corresponding to the field.

(30) The man is *in* the field.

Finally, *typicality* refers to the assumption that hearers make that the scene being described is like other scenes that have been described with the same term. For example, the use of *behind* in (31) motivates the assumption that the park is adjacent to the school, although this is not explicitly stated, because *behind* is typically used in cases where the Figure is close to, in addition to being in back of, the Ground.

(31) The park is *behind* the school.

Through the application of use types and pragmatic principles, Herskovits is able to improve upon a geometric approach to the semantics of English prepositions, arriving at an account that is not limited to those uses of prepositions that conform to a geometric ideal. However, in order to account for those uses that might be exceptions in a purely geometric approach, Herskovits posits that a great deal of world knowledge is stored in the lexical entry in the form of use types. Furthermore, the listing of use types in the lexical entry is not unlike the listing of exceptions necessary in a purely geometric approach.

1.2.3.2 Function

Not all researchers agree that *geometry*, either at the level of the scene or at the level of the participants, is of primary importance to the selection of an appropriate spatial term. Some have suggested that functional considerations, either in the form of the typical function of the Ground (Coventry, Carmichael, & Garrod, 1994) or in the form of the functional relation between the Figure and the Ground resulting from the Ground fulfilling its function (Vandeloise, 1991, 1994), that are the major determinants of which preposition appropriately describes a scene. Functional interactions other than those resulting from the function of the

Ground have not been considered in previous work; I likewise leave their examination to future research (see Chapter 5). Further, if *geometry* is given a prominent place in functional accounts, it is said to be important as a characteristic of the functional relation (Vandeloise, 1991) due to the fact that it may facilitate the Ground's ability to fulfill its functional role. For example, in the case of *in*'s applicability to Figure 1.5 above, the geometric relation of inclusion facilitates the bowl's functional role as container for the pear.

One example of a functional approach to the semantics of spatial relational terms is Vandeloise's (1991) account, in which he provides the usage rule in (32) for the French prepositions *dans* and *hors de* (used to describe many of the same configurations as English *in* and *out of*, respectively) and the one in (33) for the French prepositions *sur* and *sous* (used to describe many of the same configurations as English *on* and *under*, respectively). Through these usage rules, Vandeloise introduces the functional relations *container/contained* and *bearer/burden*, which he claims are central to the meanings of *dans* and *sur*, respectively.

(32) 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)

(33) S: *a est* [=is] *sur/sous b* if its target is the second/first element of the bearer/burden relation and its landmark the first/second element of this relation.

(Vandeloise, 1991, p. 195)

Also relying on function, Coventry (as cited in Coventry et al., 1994) proposes the definition in (34) for *in*.

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

According to a functional approach, the use of *in* to describe the relations between the pears and the bowls in Figure 1.5 above would be motivated in each case by the fact that the bowl is fulfilling its function as a container, regardless of whether or not the pear is actually located at the bowl's interior. In these instances, this type of explanation seems superior to that provided by a geometric approach in that it appears able to straightforwardly account for the appropriate use of *in* for Figure 1.5c. One problem with functional accounts, however, is that by relying on functional relations alone, they are unable to explain the appropriate use of spatial

relational terms for scenes in which neither object has a function, which I will call afunctional situations. For example, most English speakers would agree that example (35) is an appropriate description of Figure 1.6, yet it seems incorrect to claim that the rectangle is fulfilling the function of container for the circle.

(35) The circle is *in* the rectangle.

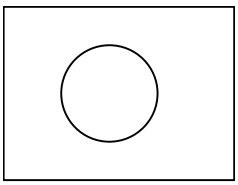

Figure 1.6 A circle *in* a rectangle

1.3 The current approach

Although both functional approaches such as those of Vandeloise (1991, 1994) and Coventry and his colleagues (Coventry et al., 1994) and geometric approaches augmented with additional considerations such as that of Herskovits (1986) overcome the problems inherent in a purely geometric account of the semantics of spatial relational terms, these approaches have disadvantages relative to a geometric approach. The adoption of a functional approach does not adequately take into account the importance of the

connection between the description of a scene and the perceptual properties of the scene, in addition to being unable to account for scenes for which function is not a consideration. The adoption of the augmented geometric approach incorporates a large amount of world knowledge specific to each term, which must be stored in a manner similar to the storing of exceptions in a purely geometric account. The problems associated with each of these approaches suggest the need to incorporate a larger set of attributes of spatial scenes into characterizations of spatial relational terms.

In order to overcome the problems associated with previous approaches to spatial relational terms, I will investigate some of the factors that make up the meanings of the words that humans use to communicate about spatial relations. In this section, I will describe the methodology adopted in this research, followed by an introduction to the approach to characterizing the meanings of spatial relational terms proposed in this dissertation.

1.3.1 Methodology

The methodological approach taken in this dissertation is to complement linguistic elicitation with psychological experimentation in order to observe both naturally occurring descriptions of simple spatial scenes and descriptions elicited in a more controlled situation. Through linguistic

elicitation, I collect descriptions of a variety of spatial scenes from speakers of multiple languages. This variety facilitates an examination of the attributes of scenes in the world that tend to be encoded in language and the patterns of co-occurrence of these attributes in spatial relational terms. Through psychological experimentation, I conduct a closer examination of how variations in the value of a given attribute influence the use of terms in a single language which encode the attribute.

1.3.1.1 Linguistic elicitation

In order to examine the use of spatial relational terms across languages, Melissa Bowerman of the Max Planck Institute for Psycholinguistics created a series of line drawings intended to elicit spatial descriptions (Melissa Bowerman's Topological Picture Series). The pictures typically depicted a static situation involving two objects: one colored yellow, the other left in black and white, in order to facilitate the identification of the Figure and Ground. In order to examine the terms used in situations where English employs the prepositions *in* and *on*, the pictures depicted a wide range of spatial configurations involving the attributes "containment, encirclement, contact, and related functional and causal notions like support from various directions, attachment, adhesion, and hanging" (Bowerman &

Choi, in press, p. 20; see also Gentner & Bowerman, 1996, 2000); for example, a cup on a table, an apple in a bowl, a picture hanging on a wall.

Using these pictures, Bowerman and Pederson (1992, 1996) created a methodology with which spatial terms across languages could be examined and compared (see Chapter 2, section 2.2.2, for a description of the work of Bowerman and Pederson). The method consisted in asking speakers to describe the simple drawings in Melissa Bowerman's Topological Picture Series. Inspired by their research, I conducted a similar cross-linguistic survey. Informants in my study were presented with pictures from Melissa Bowerman's Topological Picture Series in addition to a few similar pictures and were asked to describe the position of the yellow object with respect to the other object in their native language; in this way, the Figure was identified in each picture without input from the experimenter during the elicitation (see Chapter 2 for further description of this study).

1.3.1.2 Psychological experimentation

In order to examine the influence of any given attribute, it is desirable to hold as many other attributes constant as possible. This problem is nontrivial, as will be demonstrated by the frequent co-occurrence of contact (a value of the attribute *geometry*) and support (a value of the attribute

qualitative physics) discussed in Chapter 2, section 2.1.4. 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 and Gentner (1997, 1998; see also Chapter 3) adapted a method developed by Labov (1973) to study complex interacting factors in the use of English nouns.

Labov presented his participants with similarly shaped objects for which the relative dimensions had been varied systematically, allowing him to examine the way in which small changes in shape would affect object naming. For example, Labov's stimuli included drawings of approximately cylindrical containers: some had a small height to width ratio, others were taller than they were wide, and others were wider than they were tall. These objects received the names *cup*, *vase*, or *bowl* from his participants. By changing the height to width ratio in small increments, Labov was able to see at what ratio an object ceases to be called a *cup* and comes to be called a *vase* (or, in the other direction, a *bowl*).

In the set of experiments presented in Chapter 3 (see also Feist & Gentner, 1997, 1998), we adapted Labov's methodology in order to examine the way changes in *geometry* are related to the usage of English *in* and *on*. In this experiment, we presented participants with pictures in which the geometry of the Ground is changed incrementally, asking them to choose

either *in* or *on* to describe each scene. In addition, we manipulated functional information about the Ground by changing the name applied to it and conceptual information about the Ground by presenting one of two different objects as Ground (a hand or a dishlike tray) in each of the pictures. Finally, we manipulated conceptual information about the Figure by presenting pictures depicting one of two very different objects (a coin or a firefly). These manipulations, which were each achieved independent of the others, allowed a close examination of the influence of a small set of attributes and their values on the use of two spatial relational terms in English, in addition to an examination of the ways in which attributes of scenes interact to influence the use of spatial relational terms.

1.3.2 A set of weighted attributes

As discussed in section 1.3.1, I employed two complementary lines of research in this dissertation to examine the meanings of a small set of spatial relational terms. The first line of research is a relatively broad cross-linguistic elicitation study, aimed at exploring the attributes of spatial scenes that influence the meanings of spatial relational terms (Chapter 2). The results of this study demonstrate that there are significant similarities in the meanings of spatial relational terms across languages and in the ways that

the value of one important attribute of spatial scenes, *geometry*, is encoded by spatial terms, suggesting that it is viable to pursue a framework that can represent the spatial relational terms of many languages. The second line of research involves a set of controlled psycholinguistic experiments aimed at probing the influence of a small set of attributes on the use of the English spatial prepositions *in* and *on* in order to arrive at a representation of their meanings in terms of a cross-linguistically viable framework (Chapter 3). The results of the psychological experiments suggest that a variety of attributes of spatial scenes exert significant influence on the ways in which speakers choose to apply spatial prepositions in English. These include *geometry*, *the function of the Ground, animacy of the Ground,* and *animacy of the Figure*.

As a result of these two lines of research, I propose a working framework for the semantics of spatial relational terms inspired by the cross-linguistic regularities and based on the examination of English *in* and *on* (Chapter 4). In laying out this framework, I aim to be as explicit and specific as possible. However, it is important to bear in mind that this analysis is based on only a subset of the possible English examples and is therefore provisional.

The fact that I found that certain attributes of spatial scenes influence the use of spatial relational terms led me to adopt a componential approach, with these attributes as components of the meanings of the terms. In so doing, I am not claiming that the attributes are completely independent of one another, but rather that they form a useful set of distinctions for characterizing the spatial relational meanings considered in my studies. As I will show in Chapter 3, the influence of the various attributes is unequal. To account for this, I propose that the attributes influencing the use of spatial relational terms are weighted. I propose that the lexical entry for each spatial relational term specifies an optimal value for each of the attributes, which influences the acceptability of a spatial relational term in a manner similar to the functioning of a preference rule (cf. Jackendoff, 1983, 1985). Preference rules are non-necessary rules pertaining to the application of a word in a given context. If all the rules are satisfied, the word is deemed appropriate; if a given rule is not satisfied, application of the other rules is necessary to determine whether the word will be appropriate. Similarly, I propose that the values specified for each of the attributes are optimal values for the use of the term. According to this approach, the comparison between the values of the attributes in a scene in the world and those specified in the lexical entry of a candidate term is what determines the goodness of a use of

the term. While it is not necessary for all the values to match in order for a term to be deemed appropriate, I hypothesize that scenes which match more highly weighted attributes exemplify better uses of the term in question than scenes which match lesser-weighted attributes.

I expect that the set of weighted attributes does not represent the entirety of the knowledge that speakers utilize when employing spatial relational terms. Rather, speakers may also make direct use of knowledge about spatial templates (Carlson-Radvansky & Regier, 1997; Hayward & Tarr, 1995; Logan & Sadler, 1996) and schemas (Talmy, 1983; see section 1.2.1); I leave an examination of this issue to future research. However, this framework may provide the basis for a unified means of representing the spatial relational terms of multiple languages.

1.4 Overview of the dissertation

In the next chapter, I will describe the cross-linguistic elicitation study. The aims of the study are to examine the influence of various attributes on the use of the spatial relational terms of a variety of languages and to investigate the co-occurrences of influential attributes as apparent components of the meanings of the terms. In Chapter 3, I will describe a series of psycholinguistic experiments, designed to obtain empirical

verification of the importance of a small set of attributes to the use of the English prepositions *in* and *on*. In addition, I endeavor through these experiments to verify both the graded nature of the influence of attributes of a scene on the spatial relational terms that may be used to describe the scene, and the notion that the attributes important to the meanings of spatial relational terms exert unequal influence on the use of the terms. In Chapter 4 I will present my proposal for the representation of the meanings of spatial relational terms, taking into account the findings of the studies described in the previous two chapters. Finally, in Chapter 5 I will review key points made in the dissertation and suggest avenues for future research.

Chapter 2: The encoding of attributes across languages

2.0 Introduction

Lexicographic and linguistic studies of the semantics of spatial relational terms have identified various attributes of spatial scenes and specific attribute values about which these terms tend to impart information. As discussed in Chapter 1, the abstract attributes about which spatial relational terms tend to impart information include *geometry*, *function*, and *qualitative physical* properties. The values for the attribute *geometry* that have been identified include *contact* between the Figure and Ground (Bowerman & Pederson, 1992, 1996; Cienki, 1989; Herskovits, 1986; Lindkvist, 1950; Miller & Johnson-Laird, 1976; Oxford English Dictionary, second edition, online version), use of a *vertical axis* (Bowerman & Pederson, 1992, 1996; Lindkvist, 1950; Miller & Johnson-Laird, 1976; O'Keefe, 1996; Vandeloise, 1991), and *inclusion* of the Figure by the Ground (Bowerman & Pederson, 1992, 1996; Cienki, 1989; Herskovits, 1986; Lindkvist, 1950; Miller & Johnson-Laird, 1976; Oxford English Dictionary, second edition, online version; Vandeloise, 1991). The values for the attribute *qualitative physics* that have been identified include *support* of the Figure by the Ground (Bowerman & Pederson, 1992, 1996; Cienki, 1989; Herskovits, 1986; Lindkvist, 1950; Miller & Johnson-Laird, 1976; Vandeloise, 1991) and the

nature of the support (Bowerman & Pederson, 1992, 1996; Gentner & Bowerman, 1996, 2000). These values of the attributes, along with a value of the attribute *function*, will be illustrated in section 2.1

While researchers have found evidence for the importance of each of these attributes and attribute values to the use of at least one spatial relational term, less work has been done examining the possibility that usage of some terms may involve multiple attributes. In addition, little work has been done examining the ways in which the same attributes and attribute values influence the use of terms in various languages. In this chapter, I will describe a cross-linguistic study that I performed eliciting spatial relational terms describing a group of pictures in sixteen languages. The purposes of this study were to find out which attributes and combinations of attributes are important to the use of spatial relational terms across languages and to determine whether there were cross-linguistic similarities in the encoding of attributes and attribute values, suggesting that it would be viable to pursue a framework that can represent the spatial relational terms of many languages.

Before describing the study itself, I will discuss each of the attribute values mentioned above in turn, focusing on how they have been shown to influence the use of spatial relational terms (section 2.1). Following that, in

section 2.2, I will discuss the enterprise of examining the role of attributes of spatial scenes and their values in the use of spatial terms across languages. In section 2.2.1, I will focus on the role of cross-linguistic variation in the identification of those attributes that are most important to word choice. In section 2.2.2, I will introduce the seminal work of Bowerman and Pederson, upon which my own work is based. Next, in section 2.2.3, I will present the cross-linguistic elicitation study. Following the presentation of the study, in section 2.2.4, I will discuss a set of possible implicational universals suggested by the data. I will conclude in section 2.3 by summing up the main points of the chapter.

2.1 Values of attributes of spatial scenes important to spatial terms

As mentioned in section 2.0, there are many attributes of spatial scenes and attribute values about which spatial relational terms have been shown to impart information. In this section, I will illustrate each of the attribute values in (1), examining how each interacts with the use of a spatial relational term. For ease of exposition, most of the examples in this section will be taken from English.

(1) a) *contact* between the Figure and Ground

b) use of a *vertical axis*

c) *inclusion* of the Figure by the Ground

d) *support* of the Figure by the Ground

e) the *nature of the support*, if any, afforded the Figure by the Ground

f) the *functional relation* between the Figure and the Ground

2.1.1 Contact *between the Figure and the Ground*

The first of the attribute values in (1) is *contact* between the Figure and the Ground. Many characterizations of the English preposition *on* highlight the importance of contact to the use of the term (Cienki, 1989; Herskovits, 1986; Lindkvist, 1950; Miller & Johnson-Laird, 1976; Oxford English Dictionary, second edition, online version), as seen in the definitions in (2) and (3).

(2) General Sense: The preposition expressing primarily the relation of *contact* with or proximity to the surface of anything, and so that of being supported or upheld by it.

(Oxford English Dictionary, second edition, online version, emphasis mine)

(3) *On*: for a geometric construct *X* to be *contiguous* with a line or surface *Y*; if *Y* is the surface of an object O_Y, and *X* is the space occupied by another object O_X, for O_Y to support O_X.

(Herskovits, 1986, p. 49, emphasis mine)

Such characterizations posit that use of the preposition *on* is appropriate only in cases in which the Figure is in contact with the Ground, or in which such contact is approximated[3]. It is important to also note that both of these characterizations mention support of the Figure by the Ground, which often co-occurs with contact (as in the examples in Figure 2.1 below); I will return to the importance of support in section 2.1.4.

The importance of contact to the use of *on* helps explain why *on* may be used in certain situations and not in others. For example, sentence (4) would be appropriate as a description of both Figure 2.1a, in which the Figure is in contact with the Ground, and Figure 2.1b, in which that contact is

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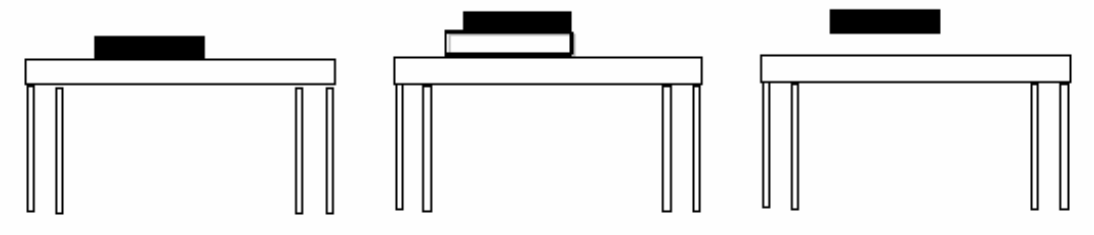
[3] The situations that count as approximating contact are still a matter of investigation and seem to differ from language to language.

approximated by the Figure's contact with an object which is in turn in contact with the Ground. If the contact were neither actual nor approximated, as in Figure 2.1c, sentence (4) would not be an appropriate description.



(a) (b) (c)

Figure 2.1 The black book is *on* the table in (a) and (b), but not (c)

(4) The black book is *on* the table.

2.1.2 Use of a vertical axis

The use of a *vertical axis* is apparent in the semantics of such terms as the English pairs *above/below* and *over/under* (O'Keefe, 1996). According to an analysis such as O'Keefe's, in order to use the terms *above, below, over,* and *under,* the positions of the Figure and the Ground must be projected along a vertical axis and compared. Once this has been accomplished, the

terms *above* and *over* are considered appropriate if the vertical position of the Figure is greater than that of the Ground (i.e., the Figure is higher than the Ground) and the reverse for *below* and *under*. The use of a vertical axis is necessary in order to examine the relative vertical positions of the Figure and the Ground and, hence, in order to determine the applicability of *above, below, over,* and *under*. Following this analysis, Figure 2.2 could be appropriately described by either (5) or (6) because the circle's position as projected onto the vertical axis of the page is greater than that of the square.

(5) The circle is *over/above* the square.

(6) The square is *under/below* the circle.

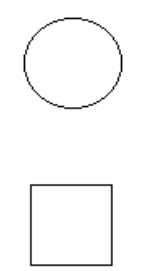


Figure 2.2 A circle and a square with differing vertical positions

2.1.3 Inclusion *of the Figure by the Ground*

Inclusion of the Figure by the Ground has been suggested as also important, encoded by the English preposition *in* (Cienki, 1989; Herskovits, 1986; Lindkvist, 1950; Miller & Johnson-Laird, 1976; Oxford English Dictionary, second edition, online version), as seen in the definitions in (7) and (8).

(7) The preposition expressing the relation of *inclusion*, situation, position, existence, or action, within limits of space, time, condition, circumstances, etc.

(Oxford English Dictionary, second edition, online version, emphasis mine)

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

(Herskovits, 1986, p. 48, emphasis mine)

From these definitions, one can see that *in* is appropriate in situations in which the Figure is located, wholly or in part, at the interior of the Ground. For example, sentence (9) can be used to describe the scene in Figure 2.3, because the pear is located wholly at the interior of the bowl.

(9) The pear is *in* the bowl.

Figure 2.3 A pear *in* a bowl

2.1.4 Support *of the Figure by the Ground*

Support of the Figure by the Ground is lexicalized in terms such as the English preposition *on* (Bowerman & Pederson, 1992, 1996; Cienki, 1989; Herskovits, 1986; Lindkvist, 1950; Miller & Johnson-Laird, 1976)[4], as exemplified in the definition in (3), repeated here as (10).

(10) *On*: for a geometric construct *X* to be contiguous with a line or surface *Y*; if *Y* is the surface of an object O_Y, and *X* is the space occupied by another object O_X, for O_Y to *support* O_X.

(Herskovits, 1986, p. 49, emphasis mine)

This value of the attribute *qualitative physics* refers to the Ground's exerting a force on the Figure that counteracts the force of gravity. This force can

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[4] The Oxford English Dictionary also mentions the importance of support in the meaning of *on* (see (2) above), but the notion of support is mentioned as a consequence of contact, rather than being important in its own right (see discussion in section 2.2). Because support usually necessitates contact, it is understandable that such an assumption would be made; however, since contact without support is not always sufficient for the use of *on*, it seems that support is in fact important in its own right.

come from below, as when a book rests atop a table, from the side, as when a magnet is stuck to a refrigerator, or from above, as when a puppeteer moves a marionette. In addition to being able to come from a variety of directions, support can be provided at many points, as when a magnet is stuck to a refrigerator, or at few, as when a picture hangs from a nail (see discussion of the nature of the support, section 2.1.5).

In all of these examples, support and contact pattern together. Thus, on the basis of this evidence, one cannot choose one over the other as the determining factor in the use of *on*. However, the independent importance of support can be demonstrated by the unacceptability of sentence (11) to describe Figure 2.4, in which the two boxes are side by side and touching, but neither supports the other against gravity.

(11) #The black box is *on* the gray box.

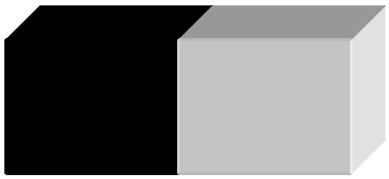

Figure 2.4 The black box is in contact with, but does not support, the gray box.

Additionally, support in the absence of contact can be sufficient for use of *on*, as Boggess (1978) points out. Boggess mentions (p. 67) that a fan on a box on a table can be said to be *on the table*, despite the lack of contact between the fan and the table. This instance of support without contact being described as *on* provides further evidence of the independent importance of support.

2.1.5 The nature of the support *afforded the Figure by the Ground*

The *nature of the support* afforded the Figure by the Ground has been suggested as the basis for the difference between the Dutch prepositions *op* and *aan* (Bowerman & Pederson, 1992, 1996; Gentner & Bowerman, 1996, 2000). If the Figure is supported at multiple points, as in Figure 2.5, the scene can appropriately be described using *op*, but if the Figure is supported at one or a few points, as in Figure 2.6, *aan* is the more appropriate term.

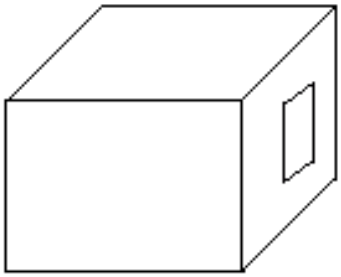

Figure 2.5 The sticker's relation to the box would be described using *op*

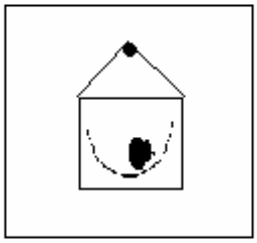

Figure 2.6 The picture's relation to the wall would be described using *aan*

The English contrast between *around* and *on* and the Dutch contrast presented by *om* and *op* also reflect the nature of the support afforded the Figure by the Ground (Gentner & Bowerman, 1996, 2000). If the Figure encircles the Ground, as in Figure 2.7, *around* and *om* may appropriately describe the relation. In such situations, if the Ground supports the Figure, it does so at multiple points along the interior surface of the Figure. In contrast, *on* and *op,* which may be also used when the Figure is supported at

multiple points, do not require that the Figure have an interior surface, as illustrated in Figure 2.5.

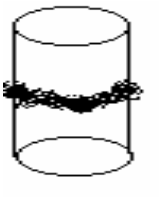

Figure 2.7 The black band is *around* the cylinder

2.1.6 The functional relation *between the Figure and the Ground*

Finally, the *functional relation* between the Figure and the Ground has been proposed as a determinant of the appropriate use of spatial relational terms, as discussed in Chapter 1, section 1.2.3.2. Functional relations include *containment*, which is said to be important to the meaning of English *in* (Coventry, Carmichael, & Garrod, 1994) and French *dans* (Vandeloise, 1991, 1994), and *the bearing of a burden*, said to be important to the meaning of French *sur* (Vandeloise, 1991). Following functional proposals, the use of a spatial relational term is appropriate if and only if the particular functional relation specified in the meaning of the term holds between the Figure and the Ground. For instance, the definition for the French term *dans* in (12)

requires that the Figure and the Ground participate in the functional relation "container/contained."

(12) *A est dans…b* [A is *dans* B] if the [Ground] and the [Figure] are…the first and second elements in the container/contained relation.

(Vandeloise, 1991, p.222)

Similarly, the definition for the English term *in* in (13) requires that the Ground fulfill a containment function.

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

(Coventry, as cited in Coventry et al., 1994)

Because the bowl acts as a container for the pear (the contained) in all of the pictures in Figure 2.8, example (14) provides an appropriate description for each of the scenes.

(14) The pear is *in* the bowl.

(a) (b) (c) (d)

Figure 2.8 A continuum from no inclusion to full inclusion

2.2 Testing the importance of the attributes

2.2.1 Cross-linguistic validity of attributes of the scene

Despite the fact that all humans can perceive the same range of possible spatial relations between two objects, there is an astonishing amount of cross-linguistic variation in how speakers talk about these relations (see, e.g., Bowerman & Choi, in press; Bowerman & Pederson, 1992, 1996; Brown, 1994; Gentner & Bowerman 1996, 2000; Pederson et al., 1998; Sinha & Thorseng, 1995; Sinha, Thorseng, Hayashi, & Plunkett, 1994), as discussed in Chapter 1 (section 1.1.4). Often, one language will have two terms which are distinguished based on an attribute of a scene or an attribute value that

does not form the basis for a distinction in another language. For example, spatial relational terms in Berber fail to make a distinction between inclusion and contact with/support via an external surface of the Ground (Bowerman & Choi, in press) akin to the English *in-on* distinction. "What is important for the Berber prepositions *x* and *di* is the distinction between 'being loosely in contact' with the Ground versus 'being "incorporated" into' the Ground – with 'incorporation' covering both being inside and being tightly attached to an external surface or point" (Bowerman & Choi, in press, pp. 22-23). Thus, both relations pictured in Figure 2.9 would be described using the Berber preposition *di*, expressing "incorporation", while English would describe Figure 2.9a using *on*, as shown in (15a) and Figure 2.9b using *in*, as shown in (15b).

(15) a) a handle *on* a cup

b) a pear *in* a bowl

(a) (b)

Figure 2.9 A handle *on* cup and a pear *in* a bowl

As this example suggests, in order to identify a comprehensive set of linguistically relevant attributes of spatial scenes and their relevant values it is essential to examine a wide variety of languages.

2.2.2 Spatial terms across languages: The work of Bowerman and Pederson

In a wide-reaching cross-linguistic survey, Bowerman and Pederson (1992, 1996) presented a set of carefully drawn pictures to speakers of thirty-four languages. As described in Chapter 1, section 1.3.1.1, each picture depicts a spatial relation, with the Figure colored in yellow and the Ground in black and white. Informants provided descriptions of each of the pictures, including the spatial relational term that would most naturally be used to describe the relation depicted.

Bowerman and Pederson examined the ways in which the languages in their survey grouped the spatial relations in their pictures, as defined by description by the same term. From this examination, they were able to infer the kinds of semantic distinctions that tend to be made in spatial relational language. They found that, although no language in their sample failed to group spatial configurations, the ways in which the configurations were grouped varied from language to language (cf. the English *in-on* distinction, which is not made in Berber, discussed in section 2.2.1 above).

In addition to finding significant cross-linguistic variation, Bowerman and Pederson discovered a "similarity gradient" (Bowerman & Choi, in press) along which they could arrange the scenes from their study. On one end of the gradient lie spatial configurations in which a Figure is supported from below by a Ground (e.g., a cup on a table); on the other end lie spatial configurations in which a Figure is completely included within a Ground (e.g., the pear in the bowl in Figure 2.9b above) (Bowerman & Choi, in press). In between lie spatial configurations bearing similarities to both situations, arranged according to whether they are more similar to support from below or to complete inclusion. In addition, on the other side of support from below, Bowerman and Pederson (1992, 1996) added configurations in which a Figure is higher than a Ground, without contact between them. The resulting

similarity gradient, along with an example of each configuration, is presented in Table 2.1. The names of the configurations are taken from Bowerman and Pederson (1996); the examples are modified from their examples.

Table 2.1 Bowerman and Pederson's similarity gradient (adapted from Bowerman & Pederson, 1996)

Spatial relation	**Example**
"higher than, no contact"	Clouds over a city
"support from below"	An apple resting on a table
"marks on a surface"	An address written on an envelope
"clingy attachment"	Gum stuck to a table
"hanging over/against"	A picture hanging on a wall
"fixed attachment"	A doorknob on a door
"point-to-point attachment"	An apple hanging from a branch
"encircle with contact"	A ring on a finger
"impaled/spiked on"	An apple on a stick
"pierces through"	A stick through an apple
"partial inclusion"	Flowers in a vase
"inclusion"	Soup in a bowl

Bowerman and Pederson arranged the terms they collected in a chart which they entitled the "Summary of Extensions of *On*." The rows in their chart correspond to languages in their sample; the columns correspond to different spatial relations as represented by their pictures, ordered along the similarity gradient that they posited. For each language, Bowerman and Pederson placed the term(s) used to describe instances of "support from below" in the column headed by each of the other configurations for which the

term(s) can be used[5]. By reading across a row of the chart, one can see the range of spatial configurations that can be described by a single term in the language.

Although languages grouped configurations together differently, as evidenced by the application of their spatial relational terms, Bowerman and Pederson found the cross-linguistic variation to be systematic. No language in their sample was found to have a word which grouped together non-adjacent configurations without including all configurations which would fall between them. For example, no term was found which could be used to describe a situation in which a Figure is supported from below by a Ground (e.g., an apple resting on a table) and a situation in which a Figure is completely included within a Ground (e.g., soup in a bowl) but no situation in between.

Bowerman and Pederson's results both illustrate the cross-linguistic variation found in the inventories of spatial terms and demonstrate that languages exhibit striking similarities in their grouping of spatial configurations. In addition, their discovery of a similarity gradient suggests that languages across the world may respect the same high-level similarities

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[5] I am told that there exists a corresponding chart for equivalents of *in*; however, only the "Summary of Extensions of *On"* has been made available to me.

despite having grouped spatial relations in varying ways as evidenced by the range of application of spatial relational terms.

2.2.3 Experiment examining cross-linguistic variation in spatial semantics

In a study inspired by Bowerman and Pederson's work, I examined the cross-linguistic validity of many attributes of spatial scenes and attribute values that have been identified in connection with the semantics of spatial relational terms. I applied Bowerman and Pederson's technique for collecting spatial terms in order to investigate the importance of different attributes and attribute values instantiating relations along Bowerman and Pederson's similarity gradient. I chose this set of scenes because they tend to be described by the prepositions *in* and *on* in English, with *on* describing scenes ranging from "support from below" to "impaled/spiked on" and *in* being used for "pierces through", "partial inclusion", and "inclusion" (see Table 2.1 above). As discussed in Chapter 1, *in* and *on* are among the first spatial relational terms learned by children (P. Brown, 1994; R. Brown, 1973), describing scenes which are characterized by such attribute values as *inclusion*, *support,* and *contact*. These values have been suggested as prelinguistically available concepts onto which a child maps the terms of her

language (Clark, 1973). In addition, the choice to study *in* and *on* allowed me to factor out one source of cross-linguistic variation, frames of reference (see Chapter 1, section 1.1.3), as these terms do not require a frame of reference.

The data set that I collected extended the line of research begun by Bowerman and Pederson. One of the aims was to replicate the data in their "Summary of Extensions of *On"*; toward that aim, I was able to collect terms from thirteen of the thirty-four languages that they examined. A second aim was to extend the data set by adding any languages available to me through the Northwestern/Evanston community. Toward that aim, I was able to add three languages that were not included in Bowerman and Pederson's survey, Russian, Croatian, and Turkish. Additionally, as mentioned in section 2.2.2 above, the data available to me from Bowerman and Pederson (1996) was limited to terms used to describe pictures at the *on* end of the similarity gradient. Thus, a third aim was to collect terms used to describe pictures at the *in* end of the similarity gradient. Finally, through an examination of the uses of spatial relational terms across a variety of languages, I aimed to determine whether the encoding of attributes and their values was sufficiently similar to suggest that it would be viable to pursue a semantic framework capable of representing the meanings of spatial relational terms from multiple languages.

2.2.3.1 The language sample

The languages examined in this study made up a sample of convenience; in lieu of choosing a set of languages to examine and then seeking out speakers of those languages to participate in this study, I recruited members of the Northwestern University community (and one family friend) who were native speakers of a variety of languages. The languages, their genetic affiliations, and the number of speakers participating in this study are listed in Table 2.2[6].

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

Table 2.2 Languages included in this study

Language	**Language Family**	**Number of speakers in sample (see also section 2.2.3.3)**
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[7]	1

[7] 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.

2.2.3.2 Stimuli

The stimulus set in this study consisted of twenty-nine line drawings, each depicting two objects in a simple spatial relation. Following the methodology of Bowerman and Pederson, one of the objects in each picture, corresponding to the Figure, is colored yellow; the other, the Ground, is black and white. Twenty-seven of the twenty-nine drawings used as stimuli in this study were borrowed from Melissa Bowerman's Topological Picture Series; one of the remaining two, the picture of an address on an envelope, was modified from a picture in Melissa Bowerman's Topological Picture Series, and the picture of flowers in a vase was borrowed from Coventry (see section 2.2.3.5, Table 2.4, for a listing of the pictures).

I chose these pictures due to their simplicity, with the hope that this simplicity would lead all participants to be describing what is arguably the same spatial relation[8].

[8] While all participants saw the same simple pictures, it could be argued that descriptions highlighting different aspects of the scene are descriptions of different spatial relations. However, I believe that due to the simplicity of the pictures and the fact that all participants saw the same pictures, the participants can be treated as describing the same spatial relations.

2.2.3.3 Participants

The participants for this study were recruited from around the Northwestern/Evanston community with the exception of one family friend residing in the New York area. They ranged in age from 18 to 69, and were all native speakers of the languages in which they participated.

Two of the participants were born in the US; the others immigrated to the US between age three and adulthood. One of the participants was raised speaking two non-English languages; she participated in the study as an informant for both. Six of the other participants were raised speaking more than one language; an additional five attended schools in which the primary language was not their first. None of the other participants was exposed to a second language before the native language was firmly entrenched. Table 2.3 presents vital characteristics of the participants: the first column lists the native language; the second column contains the birthplace, followed by other places in which the participant lived (separated from the birth place by a slash); the third column presents details on the participant's language experience. For ease of exposition, Table 2.3 appears in three parts.

Table 2.3 Characteristics of the participants

Native Language	Born/lived	Language experience
Cantonese	unavailable/came to US at age 9	Currently use of Cantonese is only with parents
Croatian	Rijeka, Croatia/came to US Sept 1990	Grew up speaking Croatian, heard German, bilingual (Italian-Croatian) school since age 7, all subjects in Italian; studied 4 years German, doesn't speak it
French	Nantes (Loire valley), France/5 years in US	Studied 5 years German and Ancient Greek (age 13-18)
French	Orleans, France/other parts of France; spent one summer in US	Studied 10 years English, 4 years Spanish
German	?[9]	?
German	US/lived in US except ages 15-23 and half a year at 25 in Germany	German only until kindergarten, when she started learning English. Schooled in German. Didn't really start speaking English until 3rd grade, when it was a subject in school. 2 years French; 7 years Latin; 3 years ancient Greek; Yiddish in grad school; reads Dutch; some modern Greek and Spanish.
German	Near Bremen, Germany/age 3 months, moved near Hanover; age 14, moved to Iowa; lower Saxony age 18-19; 1 year Paris after college; 1 year Italy in grad school	Began English at age 10 in NY for 6 months, speaks a little French, Italian, Spanish, Greek, Latin
Hebrew	Israel/US age 11-15; returned to US age 25 (1995)	Started English in 3rd grade; 1 year high school Spanish, 6 months travel in South America; 1 year junior high Arabic
Hebrew	Israel/lived in US age 8-10, 9th grade in London, 1.25 year in France 1990, 1991-present in US	90% of speaking now in Hebrew
Hebrew	US/lived in Israel ~11 years including 1st-6th grade	Grew up bilingual: English and Hebrew

[9] Due to experimenter error, detailed characteristics of this native German speaker have been lost.

Native Language	**Born/lived**	**Language experience**
Hindi	Leningrad, Russia/Age 9 months-3.5 years in Bydgoszcz, Poland; 3.5 - 6.5 years in New Delhi, India; 6.5 - 9 years in Bydgoszcz, Poland; 9 - 19.5 years in New Delhi, India; 19.5 - 24.5 in Warsaw, Poland; came to US at 24.5 (1992)	First language was Polish; spoke Hindi ages 4-7, forgot it, and relearned it at 9; started English and Russian at age 4; studied 2 years French; some Punjabi. Participated in the current study as both a Hindi and a Polish informant.
Hindi	Hyderabad, India/US Dec 1996; 2 years in Pana, Marashtra	Grew up speaking Hindi, Telegu and Marathi; English age 3; some Tamil, Gujarati, Farsi
Hungarian	Budapest, Hungary/came to US in 1989	Studied 6 years German, 10 years Russian; began English in 1987 or 1988; mostly learned by living here
Hungarian	Budapest, Hungary (1929)/London 1947-1952; then US in 1952	German as a child: had an Austrian governess who spent more time with her than her parents; studied 8 years German in school, 1 year French, 8 years Latin, 2 years English (started age 17)
Italian	Milan, Italy/arrived US one week before study	Studied ~ 10 years English, 5 years French, 2 years Spanish
Japanese	Kyoto, Japan/moved to Yokohama; lived 2 (disjoint) years in US; grad school in English in Japan	Started English at age 13
Korean	Seoul, Korea/US since 1993 (age 25)	7 years English before coming to US; 1 year French
Polish	Poland/India age 3-6, then Poland, then US at 14.5	Spoke English in preschool, forgot it, relearned it in adulthood
Polish	Leningrad, Russia/Age 9 months-3.5 years in Bydgoszcz, Poland; 3.5 - 6.5 years in New Delhi, India; 6.5 - 9 years in Bydgoszcz, Poland; 9 - 19.5 years in New Delhi, India; 19.5 - 24.5 in Warsaw, Poland; came to US at 24.5 (1992)	First language was Polish; spoke Hindi ages 4-7, forgot it, and relearned it at 9; started English and Russian at age 4; studied 2 years French; some Punjabi. Participated in the current study as both a Hindi and a Polish informant.

Native Language	Born/lived	Language experience
Polish	Poland/US 1967	Started English 1968; studied 7 years Russian, 4 years German, 2 years Latin
Russian	Kiev, Ukraine/came to US in 1993 (age 15)	Started learning English at 12, started studying it seriously at 15; studied 8 years Ukrainian; 12 years Spanish; 2 years French.
Russian	Moscow, Russia/came to US age 6.5	Speaks French, a little German, Italian
Swedish	Sweden/came to US for college	English age 4; German age 13; Tagalog 1992; father spoke Spanish; reads Icelandic; understands Dutch, Norwegian, Danish; studied French, Italian, martial arts (Japanese)
Tagalog	Manila, Phillippines /unavailable	Learned English and Tagalog together; currently uses English more
Tagalog	Manila, Phillippines/Angelus, Pampanga through grade school, high school and college in Manila, then to US	Family spoke Tagalog at home; school and TV were in English; currently uses Tagalog at home, more comfortable in Tagalog
Telegu	Hyderbad, India/US since age 8	Mom spoke Telegu; Dad, English; spoke English at home until 14, returned to India (3.5 weeks), began speaking Telegu with Mom.
Turkish	Istanbul, Turkey/US for college (arrived Sept 1997)	Studied English 6.5 years before college, studied 9 years German

2.2.3.4 Procedure

Each person participated individually in a session lasting an average of one hour (length varied due to participants' questions and level of interest during the translation elicitation). In the first part of the session, participants were shown each picture in the set individually. They were asked to provide a description in their native language of the location of the

yellow object in the picture with respect to the other object. The experimenter tape-recorded this portion of the session, in addition to transcribing the responses. When all of the pictures had been described, the participant and the investigator went back through the descriptions, providing as close to a morpheme-by-morpheme translation as could be elicited.[10] Finally, for languages written with the same orthography as English, participants were asked to provide a written record of their responses.

2.2.3.5 Coding

In order to compare the range of application of the terms in the languages studied, a chart was created in which the columns represent the participants (coded only for their language) and the rows represent the pictures (Table 2.4; see Appendix for a chart created only from participants raised speaking one language). The order of the languages is based on the order in Bowerman and Pederson's "Summary of Extensions of *On*." In

[10] Variation in the exactness of the morpheme-by-morpheme translations resulted from subjects' inability and/or unwillingness to provide translations lower than the level of the word.

Bowerman and Pederson's chart, the languages are ordered according to the range of application of the terms that can describe scenes at the end of the continuum for which English uses *on*. The languages in which those terms can be applied to all the configurations in the similarity gradient are placed at the top, while other languages in which those terms display a more restricted range of application are placed successively lower. As a function of the participants, languages define columns in my chart; the languages placed to the left correspond to those at the top in Bowerman and Pederson's chart. Languages that were not included in Bowerman and Pederson's study were incorporated into the chart based on the range of application of the terms they use to describe instances of "support from below." Due to the large number of columns, Table 2.4 is presented in six parts.

For each participant, the each cell is filled in with the spatial relational term used to describe the picture which defines the row. For languages that do not share the English alphabet, phonetic transcription of the terms are provided and written in square brackets. Most of the elicited terms are free morphemes; those that are bound morphemes include a hyphen, whose position indicates whether the morpheme is a prefix or a suffix. In some cases, rather than using a spatial relational term, participants employed a circumlocution such as "tied to." Such cases are

noted in the table using the informant's translation into English of the circumlocution, given in quotation marks. A designation of *N/A* indicates that the picture defining the row was not presented to the participant; a designation of *?* indicates that the participant did not produce a description for the picture.

Table 2.4 Elicited terms

Pictures	Polish	Polish	Polish	Russian	Russian	Croatian
lamp over table	nad	nad	ponad	[nad]	[nad]	nad
cloud over mountain	nad	nad	ponad	[nad]	[nad]	nad
cup on table	na	na	na	[na]	[na]	na
book on shelf	na	na	na	[na]	[na]	na
cat on mat	na	na	na	[na]	[na]	na
face on stamp	na	na	na	[na]	[na]	na
address on envelope	N/A	N/A	na	N/A	[na]	na
stamp on envelope	na	na	na	[na]	[na]	na
butter on knife	na	na	na	[na]	[na]	na
bandaid on leg	na	na	na	[na]	[na]	na
jacket on hook	na	na	na	[na]	[na]	na
picture on wall	na	na	na	[na]	[na]	na
phone on wall	na	na	na	[na]	[na]	na
handle on door	na	na	na	[na]	[na]	na
balloon on stick	"tied to"	na	na	[na]	[na]	N/A
apple on branch	na	na	na	[na]	[na]	na
laundry on clothesline	na	na	na	[na]	[na]	na
ribbon on candle	[do kowa]	[naŁkowo]	[naŁkowo]	[na]	[va kruk]	oko
ring on finger	na	na	na	[na]	[na]	na
papers on spindle	na	na	na	[na]	[na]	na
apple on stick	na	na	na	[na]	[na]	na
arrow in apple	w	przez	"pierced"	[v]	[v]	u
earring in ear	w	w	w	[v]	[v]	u
box in purse	"peeking out from"	w	w	[v]	[v]	u
dog in dogbed	w	na	na	[v]	[na]	N/A
cork in bottle	w	w	na	[v]	[v]	u, (na)
flowers in vase	N/A	N/A	w	N/A	[v]	u
apple in bowl	w	w	w	[v]	[v]	u
owl in tree	w	w	"looks out from"	[v]	[v]	u

Pictures	Swedish	Italian	French	French[11]
lamp over table	över	sopra	au-dessus	au dessus de
cloud over mountain	ovanför	sopra	au-dessus	au dessus de
cup on table	på	sopra	sur	sur
book on shelf	på	su	sur	sur
cat on mat	på	su	sur	sur
face on stamp	på	"in the middle"	au centre de	sur
address on envelope	(på)	su	sur	sur
stamp on envelope	på	sopra	sur	sur
butter on knife	på	su	le long de	sur
bandaid on leg	på	su	sur	à
jacket on hook	på	a	à la gauche	à, sur
picture on wall	på	a	à	à, sur
phone on wall	på	a	à	à, sur
handle on door	på	su	sur	sur
balloon on stick	"tied to"	N/A	N/A	N/A
apple on branch	på	sotto	sous	sur
laundry on clothesline	på	sotto	à	sur
ribbon on candle	runt	attorno	autours de	au milieu de
ring on finger	på	a	à, (sur)	à
papers on spindle	på	nel	sur	“pierced by”
apple on stick	på	"crossed by"	"crossed by"	?
arrow in apple	i genom	attraverso	"goes through"	“crosses”
earring in ear	i	"hangs from"	dans	à
box in purse	i	nel	dans	dans
dog in dogbed	i	N/A	N/A	N/A
cork in bottle	på	su	dans	sur
flowers in vase	N/A	"coming out"	dans	dans
apple in bowl	i	dentro	dans	au fond de
owl in tree	inne	nel	dans	dans

[11] Due to time constraints, this participant was unable to provide translations for all of the descriptions. The translations included in this column are from *Cassell's French Dictionary*, Concise Edition (1968).

Pictures	Hebrew	Hebrew	Hebrew	Hungarian
lamp over table	[mŁAcn_	[mŁAcn_	[mŁAcn_	fölött
cloud over mountain	[mŁAcn_	[mŁAcn_	[mŁAcn_	fölött
cup on table	[al]	[al]	[al]	tetején
book on shelf	[al]	[al]	[al]	-on
cat on mat	[al]	[al]	[al]	-en
face on stamp	[al]	[al]	[al]	-en
address on envelope	N/A	[al]	[al]	-on
stamp on envelope	"pasted to"	[al]	[al]	-en
butter on knife	[al]	[al]	[al]	-en
bandaid on leg	[al]	[al]	[al]	-on
jacket on hook	[al]	[al]	[al]	-ón
picture on wall	[al]	[al]	[al]	-on
phone on wall	[al]	[al]	[al]	-én
handle on door	"connected to"	[al]	[al]	-ón
balloon on stick	"tied to"	[al]	"connected to"	N/A
apple on branch	"connected to"	[mitax at], [al]	[al]	-on
laundry on clothesline	[al]	[al]	[al]	-en
ribbon on candle	[misaviv]	[al], [misaviv]	[misaviv]	-án
ring on finger	[al]	[al]	[al]	-on
papers on spindle	[al]	([b]), [al]	[bŁtox]	-n
apple on stick	[al]	[misaviv]	[bŁtox]	"pierced with needle"
arrow in apple	"crosses"	[dG}Gx], ([bŁtox])	[bŁtox]	-ban
earring in ear	[bŁ_	[bŁtox]	[b], *[bŁtox][12]	-ben
box in purse	[bŁvqz_	[bŁtox]	[bŁtox]	-ban
dog in dogbed	[bŁvqz_	[bŁtox]	[bŁtox]	N/A
cork in bottle	[bŁvqz_	[bŁtox], ([al])	[bŁtox]	-ben
flowers in vase	N/A	[bŁtox]	[b]	-ban
apple in bowl	[bŁvqz_	[bŁtox]	[bŁtox]	-ban
owl in tree	[bŁvqz_	[bŁtox]	[bŁtox]	-ban

[12] As is the practice in linguistics, unacceptable forms are marked with an asterisk.

Pictures	Hungarian	Hindi	Hindi	Cantonese	Telegu
lamp over table	felett	[upar]	[par]	[hai...s–Pdkp]	[rcfpL]
cloud over mountain	felett	[upar]	[upar]	[hai...s–Pdkp]	[rcfpL]
cup on table	-on	[par]	[par]	[hai...s–Pdkp]	[o kFL]
book on shelf	-on	[par]	[par]	[hai...s–Pdkp]	[o kFL]
cat on mat	-en	[par]	[par]	[hai]	[o kFL]
face on stamp	-en	[par]	[par]	[hai...s–Pdkp]	[o kFL]
address on envelope	-on	N/A	[par]	N/A	N/A
stamp on envelope	-on	[par]	[par]	[hai]	[o kFL]
butter on knife	N/A	[par]	[par]	[hai]	[o kFL]
bandaid on leg	-on	[par]	[par]	[hai]	[o kFL]
jacket on hook	-on	[par]	"hung"	[hai]	[o kFL]
picture on wall	-on	[par]	[par]	[hai]	[o kFL]
phone on wall	-on	[par]	[par]	[hai]	"attached"
handle on door	-ra, -ón	[par]	[par]	[hai...tULdkp_	[o kFL]
balloon on stick	N/A	"tied from the stick	"tied to"	[hai]	"tied to"
apple on branch	-on	[par], ([se])	"hanging from"	[hai]	[o kFL]
laundry on clothesline	-en	[par]	[par]	[hai]	[o kFL]
ribbon on candle	körül	[par]	"tied to"	[hai...s–Pdkp]	[tUGaw_
ring on finger	-on	[par]	[par]	[hai]	[o kFL]
papers on spindle	-ra	[par]	[par]	[hai]	didn't know
apple on stick	-ra	[me se]	didn't know	[hai...n–jfdk–]	didn't know
arrow in apple	-ban	[me se]	[andar]	"punctures"	[la]
earring in ear	-ben, (-an)	[se]	[par]	[hai]	[o kFL]
box in purse	-ben	[andar]	"look out"	[hai...n–jfdk–]	[la]
dog in dogbed	(-ban)	[me]	[me]	[hai]	[la]
cork in bottle	-ban	[par]	[andar]	[hai]	[la]
flowers in vase	-ban	N/A	didn't know	N/A	N/A
apple in bowl	-ban	[andar]	[me]	[hai...n–jfdk–]	[la]
owl in tree	-ban	[andar]	"look out"	[hai...n–jfdk–]	[nqrLnc]

Pictures	German	German	German	Turkish
lamp over table	über	über	über	tepesinde
cloud over mountain	über	über	über	üzerinde
cup on table	auf	auf	auf	üzerinde
book on shelf	auf	auf	auf	-ta (üzerinde)
cat on mat	auf	auf	auf	üzerinde
face on stamp	auf	auf	auf	üzerinde
address on envelope	N/A	N/A	auf	üzerinde
stamp on envelope	auf	auf	auf	üzerinde
butter on knife	an	an, auf	an	üzerinde
bandaid on leg	auf, an	an, (auf)	an	-da
jacket on hook	an	an	an	-da
picture on wall	an	an	an	-da
phone on wall	an	an	an	-da
handle on door	an	an	an	üzerinde
balloon on stick	an	an	N/A	N/A
apple on branch	an	an	an	-ta
laundry on clothesline	an	an, (auf)	an	-da
ribbon on candle	an	um	um	etrafinda
ring on finger	an, auf	an	an	-da
papers on spindle	auf	auf	auf	"stuck to"
apple on stick	an	auf	auf	"stuck to"
arrow in apple	durch	in, durch	durch	iqinden
earring in ear	an, in	an, in	in	-da
box in purse	in	in	in	iqinde
dog in dogbed	in	in	N/A	N/A
cork in bottle	in	in	in (auf possible but worse)	"at the mouth of"
flowers in vase	N/A	N/A	in	-da
apple in bowl	in	in	in	iqinde
owl in tree	in	in	in	-da

Pictures	Korean	Japanese	Tagalog	Tagalog
lamp over table	[viG]	ue	nasataas	nasataas
cloud over mountain	[viG]	ue	sa taas	nasataas
cup on table	[viG]	ue	sa taas	nasataas
book on shelf	[viG]	ue	nasataas	sa
cat on mat	[G], [viG]	ue	nasataas	sa
face on stamp	[G]	naka	sa	sa
address on envelope	N/A	ni	N/A	nasa
stamp on envelope	[G]	no	"stuck"	sa
butter on knife	[G]	ni	sa	sa
bandaid on leg	[G]	ni	--	sa
jacket on hook	[G]	ni	sa	sa
picture on wall	[G]	ni	sa	sa
phone on wall	[G]	ni	sa	sa
handle on door	[G]	no	nasagitna…sa	nasa
balloon on stick	[G]	N/A	sa	N/A
apple on branch	[G]	ni, no	sa	sa
laundry on clothesline	[G]	ni	sa	sa
ribbon on candle	[G]	ni	sa	sa
ring on finger	[G]	ni	nasa	sa
papers on spindle	[G]	ni	sa taas	sa
apple on stick	[G]	ni	nasaloob	sa
arrow in apple	"skewered"	ni	sa loob	sa
earring in ear	[G]	ni	sa	sa
box in purse	[ane]	naka	nasaloob	nasaloob
dog in dogbed	[G]	N/A	nasaloob	N/A
cork in bottle	[G]	no	nasataas…sa	sa
flowers in vase	N/A	no	N/A	nasa
apple in bowl	[ane]	naka	sa loob	nasaloob
owl in tree	[ane]	naka	sa loob	nasaloob

In order to determine whether there were attributes or attribute values that united multiple uses of individual spatial relational terms, I coded each of the pictures for whether it matched each of a small set of possibly relevant attribute values. *Relative vertical position* (coded as *verticality* and, for those pictures in which the vertical position of the Figure and the Ground differed, with the higher entity coded), *contact*, *inclusion*, *functional relatedness* resulting from the Ground's function, and *support* by the Ground have all been suggested in the literature as important to the meaning of spatial relational terms (see Section 2.1), validating their inclusion in this set of attributes. *Relative size* was coded (in terms of the bigger entity) because a larger Ground might facilitate the matching of other attribute values, such as *support* or *inclusion* of the Figure. The coding for *animacy* of the Figure and Ground and ability of the Ground to exert *control* over the Figure was done despite the fact that these have not been identified in characterizations of the meanings of spatial relational terms. Nonetheless, there is evidence that both may influence speakers' decisions to employ spatial prepositions in English (Feist & Gentner, 1997, 1998; see also Chapter 3), suggesting that a cross-linguistic examination might prove informative. More specifically, control by the Ground may be important both because it determines the existence of some functional relations (such as

functional containment; see Coventry et al., 1994) and because the Ground's ability to control the Figure might cause the configuration to seem less subject to outside forces and thus more likely to remain as pictured. Finally, animate entities are more able than inanimate ones to control the fates of themselves and others. For example, control is more likely from an animate Ground (such as a hand) than an inanimate one (such as a dish); similarly, only an animate Figure (such as a firefly) is able to enter and exit a configuration at will (see Chapter 3).

The results of this coding are presented in Table 2.5. As discussed in section 1.3.2 of Chapter 1, the extent to which scenes in the world match a given attribute value appears to be graded, allowing the possibility that in some cases the match will be marginal. For example, there is a continuum between no inclusion and full inclusion, with varying amounts of partial inclusion in between (see Figure 2.8, section 2.1.6 above). Toward the end of the continuum anchored by the no inclusion case (e.g., the pear atop a pile of apples, above the plane through the rim of the bowl that contains them), inclusion might be considered marginal. I have used parentheses in the table to code marginal matches for attribute values. Attribute values that are not applicable to a scene are marked "N/A."

Table 2.5 Pictures and values of attributes

Picture Description	verticality	higher entity	contact	inclusion	bigger entity	control by Ground	animacy	functional relation	support by
lamp over table	vertical	Figure	no	no	Ground	no	neither	no	neither
cloud over mountain	vertical	Figure	no	no	Ground	no	neither	no	neither
cup on table	vertical	Figure	yes	no	Ground	no	neither	yes	Ground
book on shelf	vertical	Figure	yes	no	Ground	no	neither	yes	Ground
cat on mat	vertical	Figure	yes	no	Ground	no	Figure	no	(Ground)
face on stamp	N/A	N/A	yes	N/A	Ground	yes	(Figure)	no	(Ground)
address on envelope	N/A	N/A	yes	N/A	Ground	yes	neither	no	(Ground)
stamp on envelope	N/A	N/A	yes	no	Ground	yes	neither	(yes)	(Ground)
butter on knife	N/A	N/A	yes	no	Ground	yes	neither	yes	Ground
bandaid on leg	N/A	N/A	yes	no	Ground	yes	Ground	no	Ground
jacket on hook	N/A	N/A	yes	no	Figure	yes	neither	yes	Ground
picture on wall	horizontal	N/A	yes	no	Ground	no	neither	no	Ground
phone on wall	horizontal	N/A	yes	no	Ground	no	neither	no	Ground
handle on door	horizontal	N/A	yes	no	Ground	yes	neither	yes	Ground
balloon on stick	N/A	N/A	yes	no	Figure	yes	neither	yes	Ground
apple on branch	vertical	Ground	yes	no	Ground	no	neither	no	Ground
laundry on clothesline	vertical	Ground	yes	No	Figure	no	neither	yes	Ground
ribbon on candle	N/A	N/A	yes	Ground included	Ground	yes	neither	no	Ground
ring on finger	N/A	N/A	yes	Ground included	Ground	yes	Ground	no	Ground
papers on spindle	N/A	N/A	yes	Ground included	Figure	yes	neither	yes	(Ground)
apple on stick	N/A	N/A	yes	Ground included	Figure	yes	neither	yes	Ground
arrow in apple	N/A	N/A	yes	partial	Ground	yes	neither	no	Ground
earring in ear	N/A	N/A	yes	partial	Ground	yes	Ground	no	Ground
box in purse	horizontal	N/A	yes	partial	(Ground)	yes	neither	yes	Ground
dog in dogbed	(vertical)	(Figure)	yes	partial	(Figure)	no	Figure	yes	(Ground)
cork in bottle	N/A	(Figure)	yes	partial	Ground	yes	neither	yes	Ground
flowers in vase	(vertical)	(Figure)	yes	partial	Figure	yes	neither	yes	(Ground)
apple in bowl	N/A	N/A	yes	yes	Ground	yes	neither	yes	Ground
owl in tree	N/A	N/A	yes	yes	Ground	no	Figure	(yes)	(Ground)

Next I examined each of the terms that had been elicited. For each term, I grouped together the pictures that the term had been used to describe. I then isolated the attribute values that were common to each group of same-term pictures. This led to the characterizations of the terms presented in Table 2.6. For each term, attribute values matched by the entire set of pictures described by the term are marked with a plus, attribute values unmatched by all pictures in the set are marked with a minus, and attribute values matched by only some of the pictures are left unmarked. There were attribute values which were coded in Table 2.5 which were not found to be common to any of the groups of pictures described by a single spatial relational term; the value in this group are: relative size, control by the Ground, animacy, and the presence of a functional relation; these are omitted in Table 2.6. For ease of exposition, Table 2.6 is presented in two parts.

Table 2.6 Terms and attributes

Meaning class (see text)	Term	Figure higher than Ground	Contact	Ground supports Figure	Inclusion
(a)	*sopra* (Italian)	+			
(a)	*[u-P]* (Cantonese)	+			
(a)	*üzerinde* (Turkish)	+			
(a)	*[xkG]* (Korean)	+			
(a)	*ue* (Japanese)	+			
(a)	*taas* (Tagalog)	+			
(b)	*nad, ponad* (Polish)	+	-		
(b)	*[nad]* (Russian)	+	-		
(b)	*nad* (Croatian)	+	-		
(b)	*över, ovanför* (Swedish)	+	-		
(b)	*au dessus* (French)	+	-		
(b)	*[oLAcr]* (Hebrew)	+	-		
(b)	*fölött, felett* (Hungarian)	+	-		
(b)	*[upar]* (Hindi)	+	-		
(b)	*[rckpL]* (Telegu)	+	-		
(b)	*tepesinde* (Turkish)	+	-		
(b)	*über* (German)	+	-		
(c)	*sotto* (Italian)	-	+		
(c)	*sous* (French)	-	+		
(d)	*na* (Polish)		+	+	
(d)	*[na]* (Russian)		+	+	
(d)	*na* (Croatian)		+	+	
(d)	*på* (Swedish)		+	+	
(d)	*sur* (French)		+	+	
(d)	*[al]* (Hebrew)		+	+	
(d)	*tetején, -Vn, -ra* (Hungarian)[13]		+	+	
(d)	*[par]* (Hindi)[14]		+	+	

[13] The vowels in the Hungarian bound morphemes *-Vn* and *–bVn*, which involve vowel harmony, have been specified as *V* in lieu of listing all of the elicited forms, which are listed in Table 2.4.

Meaning class (see text)	Term	Figure higher than Ground	Contact	Ground supports Figure	Inclusion
(d)	*[oːkʰɸɭ]* (Telegu)		+	+	
(e)	*auf* (German)		+		
(e)	*an* (German)		+		
(f)	*w* (Polish)				+
(f)	*[v]* (Russian)				+
(f)	*u* (Croatian)				+
(f)	*i, inne* (Swedish)				+
(f)	*nel* (Italian)				+
(f)	*dentro* (Italian)				+
(f)	*dans* (French)				+
(f)	*[b], [dɛvqz]* (Hebrew)				+
(f)	*-bVn* (Hungarian)				+
(f)	*[andar], [oːg]* (Hindi)				+
(f)	*[nɨk]* (Cantonese)				+
(f)	*[la], [ɳqrɬnc]* (Telegu)				+
(f)	*iqinde* (Turkish)				+
(f)	*in* (German)				+
(f)	*[ane]* (Korean)				+
(f)	*naka* (Japanese)				+
(f)	*loob* (Tagalog)				+
(g)	*[vɐɬ]* (Cantonese)				-
(h)	*[hai]* (Cantonese)				
(h)	*-da, -ta* (Turkish)				
(h)	*[ɡ]* (Korean)				
(h)	*ni* (Japanese)				
(h)	*no* (Japanese)				
(h)	*sa, nasa* (Tagalog)				

[14] See discussion in section 2.2.4.2.

The terms elicited in this study represent the eight different classes of potential spatial relational meaning listed in (16).

(16) 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

h) Generalized spatial term (no attribute values encoded)

The most common of these meanings were (16b), which refers to a difference in the vertical position of the Figure and the Ground, (16d), which encodes the presence of support and of contact, and (16f), which encodes the presence of inclusion. The frequent appearance of these meanings reinforces the importance of relative vertical position, contact, support, and inclusion to the meanings of spatial relational terms. In addition, the encoding of these attribute values by the terms elicited in this study suggests some robust tendencies in the co-occurrence patterns of individual attributes and their values, as will be described in section 2.2.4.1.

2.2.4 Discussion

Although the terms elicited in this study grouped spatial configurations in a variety of ways, this variation appeared to be constrained. Specifically, four values of attributes of spatial scenes — *relative vertical position, contact, support,* and *inclusion* — recurred in the meanings of the elicited terms. In section 2.2.4.1, I examine the co-occurrence patterns of these attribute values and note general tendencies that may lead to a set of implicational universals. In section 2.2.4.2, I examine apparent exceptions to these tendencies and suggest explanations for these exceptions. Finally, in section 2.2.4.3, I compare the results of the study reported in this chapter to the similarity gradient discovered in Bowerman and Pederson's study.

2.2.4.1 Implicational near-universals

Although in principle the four attribute values — *relative vertical position* of the Figure and the Ground, *contact* between the Figure and the Ground, *support* of the Figure by the Ground, and *inclusion* of the Figure by the Ground — could be lexicalized in a variety of combinations, in practice I found that this was not the case. Rather, I found a disjunction between the

encoding by a term of the Figure higher than the Ground, contact between the Figure and the Ground, and inclusion of the Figure by the Ground (see Table 2.6 above). In addition, I found that all the terms encoding the Ground supporting the Figure also encoded contact between the Figure and the Ground, possibly due to the difficulties involved in dissociating these two attributes demonstrated in section 2.1.4.

For the purposes of the following discussion, I will be treating *inclusion* as a specialized form of *contact*, and I will examine these two attribute values in opposition to *relative vertical position*. Although it is possible for one physical entity to include another without being in contact with it, as when the included entity is in the center of a group of included entities (Figure 2.10), this was not the case for the scenes involving *inclusion* in the current study.

Figure 2.10 The pear is included by, but not in contact with, the bowl

Because *inclusion* always involved *contact* for the data set collected, the conclusions that I was able to draw about the lexicalization of *inclusion*

are dependent on the lexicalization of *contact*. Although I expect that these conclusions will be true for cases of *inclusion* that do not involve *contact*, further experimentation will be necessary to verify this. Further, as the pictures used in this study also failed to provide evidence about the independent contribution of *support*, the importance of which was demonstrated in section 2.1.4 above, I will limit my discussion to the contributions of *relative vertical position* and *contact*. Further study will be required to understand how *contact*, *support,* and *inclusion* differ in lexicalization.

As shown by the list of spatial meanings in (16), the set of terms elicited in this study tended either to communicate information about the presence or absence of *contact* (including *inclusion*), or to communicate information about *relative vertical position*. As expected given the range of scenes described, few of the terms failed to communicate information about either attribute value. For example, I found that terms that did not communicate information about *contact* between the Figure and the Ground were very likely to communicate information about their *relative vertical position*. One example of such a term elicited in this study is the Japanese term *ue*, which was used for only five scenes: the lamp over the table, the cloud over the mountain, the cup on the table, the book on the shelf, and the

cat on the mat. Similarly, terms that did not communicate information about the *relative vertical position* of the Figure and the Ground were likely to communicate information about *contact*. One such term in this data set is the Polish term *na*, which was used in a variety of *contact* situations including the cup on the table, the jacket on the hook, and the apple on the branch, but not in any non-contact situations.

More interestingly, the data revealed a separation between these two key properties for this set of terms: (a) if a term communicates the presence of *contact*, it is likely not to communicate information about *relative vertical position* (as was the case for twenty-eight of thirty terms), and (b) if a term communicates either the absence of *contact* or no information about *contact*, it is likely to communicate information about *relative vertical position*, specifically that the Figure is higher than the Ground (as was the case for all seventeen terms collected). An example of the first kind of term is Polish *na*, discussed in the previous paragraph; examples of the second are Turkish *tepesinde*, which was only used to describe the scene depicting the lamp over the table, and Japanese *ue*, discussed in the previous paragraph.

Finally, in my data the terms that encode *inclusion* tended to be used for both full and partial inclusion (as was the case for sixteen of the nineteen terms collected), as does German *in*, which was used for a variety of *inclusion*

scenes including a cork partially included in a bottle and an apple fully included in a bowl. This suggests that partial and full inclusion may not be treated as categorically different in the languages I sampled.

These observations lead to the general patterns listed in (17) for the set of terms communicating spatial locational information pertaining to the range of scenes studied in the languages sampled.

(17) a) Terms encode the presence of *contact* or the presence of a difference in *relative vertical position* of the Figure and the Ground.

b) Terms are unlikely to encode both the presence of *contact* and the presence of a difference in *relative vertical position* of the Figure and Ground.

c) If a term encodes *inclusion* of the Figure in the Ground, it is likely to be acceptable for both full and partial inclusion.

If these patterns can be shown to hold in a larger sample of carefully chosen languages and to extend to a larger range of scenes, then they may form the basis for a set of implicational universals. I leave this as an avenue for future research.

2.2.4.2 Dealing with possible exceptions

There are a few terms which seem neither to communicate information about *contact* nor about *relative vertical position*[15] based on their apparent range of application to the scenes in this study. Most notable among these are general terms, such as Japanese *ni*, that can be used for all the scenes included in my sample. These terms communicate only the fact of location (Young & Nakajima-Okano, 1984, for Japanese *ni*). In addition to Japanese *ni*, the general spatial terms that my participants produced were Japanese *no*[16], Cantonese *hai*, Turkish *–da* and *–ta*, Korean *[G]*, and Tagalog *sa* and *nasa*. These terms are best glossed as *be-located*, taking advantage of default expectations about the spatial relations of Figures and Grounds. For example, in normal circumstances it is to be expected that the relation between a cup and a table is that the two are in contact and the table supports the cup from below; this is the configuration that would be expected if a speaker used a general spatial term to describe the relation between the

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[15] Melissa Bowerman (personal communication) informs me that this situation is rare across the world's languages.

[16] Although it is the genitive marker, Japanese *no* can act as a general spatial term, as illustrated in this study (see also Young & Nakajima-Okano, 1984).

cup and the table. Since the general spatial terms communicate at a different level of detail from the other terms in the study, they fall outside the domain of the possible implicational universals proposed in section 2.2.4.1.

In addition to the general location terms, I found two exceptions to the general patterns noted in section 2.2.4.1: Hindi [*par*] and Cantonese *seungbin* appeared to communicate information about neither *contact* nor *relative vertical position* in the data set collected.

In addition to the range of *contact* situations for which Hindi [*par*] was used, one speaker produced this term to describe the scene which depicted a lamp over a table. As this was the only instance in which [*par*] appeared to be an exception to the general patterns in (17), this occurrence may have been idiosyncratic to this person's speech or due to speaker error. Moreover, this speaker seemed to have trouble understanding the task, suggesting that this occurrence of [*par*], rather than being an exception, was likely the result of confusion on the part of the speaker. Further work with Hindi speakers would be required to evaluate the status of [*par*].

Similarly, due to the fact that there was only one informant for Cantonese, it is possible that the problematic use of the term *seungbin* is likewise idiosyncratic or due to speaker error. In addition to using *seungbin*

to describe situations in which the Figure was higher than the Ground, with or without contact, my informant used *seungbin* to describe the scene which depicted a face on a stamp and the scene which depicted a ribbon on a candle. Matthews and Yip's (1994) grammar of Cantonese suggests that *seungbin* does, in fact, conform to the generalizations listed in (17): Matthews and Yip gloss *seungbin* as *on (top of)* (p. 118), which suggests that the term communicates about *relative vertical position* of the Figure and the Ground. As with Hindi [*par*], the semantics of *seungbin* could best be probed with additional informants.

In addition to the possible exceptions found in the data from the current study, an examination of the data in Bowerman and Pederson's "Summary of Extensions of *On"* turned up additional apparent exceptions to the possible implicational universals in (17). The terms Spanish *sobre*, Mandarin *shàng*, Fulfulde *dow*, Mopan Maya *wich*, Italian *sopra* and *su*, Hindi *per* ([*par*]), Cantonese *seungbin*, Tamil *meelee*, and Telegu *payna* appeared in their data not to communicate information about either *relative vertical position* of the Figure and the Ground or *contact* between the Figure and the Ground.

As discussed in section 2.2.2, the terms included in Bowerman and Pederson's "Summary of Extensions of *On"* are grouped according to the

spatial relation that elicited them. However, each spatial relation could be exemplified by a variety of scenes; the terms mentioned in the previous paragraph appear to be exceptions due to my default assumptions about the scenes illustrating each of the spatial relations. For example, my default assumption about the relation *clingy attachment* involves no difference in the relative vertical position of the Figure and the Ground, despite the fact that *clingy attachment* can be achieved with the Figure higher than the Ground (as when a sticker is stuck on the upper surface of a box). Without knowing the specifics of the pictures that elicited the terms in Bowerman and Pederson's study, it is impossible to determine whether these terms present actual exceptions to the possible implicational universals in (17).

Finally, German *auf* and Dutch *op* present apparent exceptions to generalization (17b), as both appear (from Bowerman and Pederson's data) to communicate both the presence of *contact* and the position of the Figure as higher than the Ground. In the current study, however, German *auf* was used in a number of contact situations, regardless of the relative vertical positions of the Figure and the Ground, including a scene depicting papers impaled on a spindle and a scene depicting a bandage on a leg, suggesting that a difference in vertical position is not necessary for an appropriate use of *auf*. Similarly, as shown above in Figure 2.4, Dutch *op* does not require that

the Figure be located higher than the Ground for its use (Gentner & Bowerman, 1996). Thus, upon closer examination, both German *auf* and Dutch *op* appear to conform to generalization (17b).

2.2.4.3 Compatibility with Bowerman and Pederson's similarity gradient

Overall, the terms elicited in my study did appear to respect the similarity gradient that Bowerman and Pederson discovered. However, there were a few cases in which a term was used to describe scenes exemplifying two nonadjacent spatial relations without describing scenes exemplifying spatial relations in between. Close examination of many of these cases suggests that they reflect alternate conceptualizations of the scenes presented rather than discontinuities in the use of the terms relative to the similarity gradient.

For example, a number of terms that were used to describe pictures at the *on* end of the similarity gradient (the end anchored by "support from below"; see section 2.2.2 above) were also used for two examples of the relation "partial inclusion," a cork partially in a bottle and a dog in a dogbed, but were not used for any examples of the relation "pierces through" (see Table 2.1, repeated as Table 2.7).

Table 2.7 Bowerman and Pederson's similarity gradient (adapted from Bowerman & Pederson, 1996)

Spatial relation	**Example**
"higher than, no contact"	Clouds over a city
"support from below"	An apple resting on a table
"marks on a surface"	An address written on an envelope
"clingy attachment"	Gum stuck to a table
"hanging over/against"	A picture hanging on a wall
"fixed attachment"	A doorknob on a door
"point-to-point attachment"	An apple hanging from a branch
"encircle with contact"	A ring on a finger
"impaled/spiked on"	An apple on a stick
"pierces through"	A stick through an apple
"partial inclusion"	Flowers in a vase
"inclusion"	Soup in a bowl

This discontinuity may not be a problem for the similarity gradient, however. A cork partially in a bottle is placed at the bottle's inherent top. Thus, the cork may be conceived of as being "supported from below", a relation within the continuous (in terms of the similarity gradient) range of application of each of these terms. Regarding the dog in the dogbed, the raised sides of a dogbed may have been ignored, causing the scene to be conceived of as a dog lying atop the flat part of the dogbed, also a case of "support from below."

A similar explanation may be applied to Italian *sopra*'s being used for the relations "support from below" and "clingy attachment," but not the

intervening relation "marks on a surface." The one instance of "clingy attachment" for which *sopra* was used was a picture depicting a stamp on an envelope. Since in many cases stamps are placed on the top face of the envelope, it is possible that this picture could be conceived of as an instance of "support from below."

Finally, Japanese *naka* was used for the relations "marks on a surface" and "partial inclusion," but for no relation in between. The one instance of "marks on a surface" that was described using *naka* was a picture depicting a face on a stamp. It is possible that the face was conceived of as being within the borders of the stamp, however, causing it to become an instance of the relation "inclusion," for which *naka* was also used.

The remaining problems are (a) Cantonese [u–P], used for the relations on the *on* end of the continuum up to "marks on a surface" and for one instance of the relation "encircle with contact," ribbon on candle, but for no relations in between; (b) Turkish *üzerinde,* used for the relations on the *on* end of the continuum up to "clingy attachment" and for the relation "fixed attachment," but not for the relation "hanging over/against"; and (c) German *auf,* used for the relations on the *on* end of the continuum up to "clingy attachment" and for the relation "impaled on" with only two uses, ring on finger and laundry on clothesline, in between. Due to the small number of

speakers of each language participating in this study, it is unclear whether these problems arose due to idiosyncrasies in the participants' speech, due to speaker error, or due to actual instances of terms whose range of application is discontinuous with respect to the similarity gradient. I leave the resolution of this problem to future empirical work.

In addition to collecting individual terms which respected Bowerman and Pederson's similarity gradient, my study validates the gradient further by showing that cross-linguistic phenomena can be described as tendencies or potential implicational universals stated over this gradient.

2.3 Conclusions

In the study described in this chapter, I presented speakers of sixteen languages with pictures depicting simple spatial relations. For each picture, I asked participants to describe the location of one of the objects relative to the other. I then analyzed each of the pictures to determine which were the important attributes and attribute values for the scene, and examined the terms used in each of the languages sampled to determine which were the attributes and attribute values about which the terms communicated. After characterizing each term, I compared the terms and investigated the ways in

which attributes of spatial scenes and their values are lexicalized in the languages sampled, arriving at a set of general tendencies in the encoding of a few important values of attributes of spatial scenes. Finally, I compared the ranges of application of the terms collected in this study with the similarity gradient discovered by Bowerman and Pederson (1992, 1996).

As in the study of Bowerman and Pederson from which this study drew inspiration, there were significant cross-linguistic similarities that appeared alongside cross-linguistic variation in the lexicalization of spatial relations. Firstly, I found that, with few exceptions, the terms collected in my study respected the similarity gradient discovered by Bowerman and Pederson. Secondly, I found similarities with respect to the ways in which spatial relational terms communicate information about three values of attributes of spatial scenes: *relative vertical position* of the Figure and the Ground, *contact* between the Figure and the Ground, and *inclusion* of the Figure by the Ground. In general, if situations involving either the presence of *contact* (including *inclusion*) or a difference in *vertical position* between the two entities are included in the range of application of a term, the term will communicate information about at least one of these attribute values. Further, such terms are more likely to communicate information about only one of these than to communicate information about both. Finally, if a term

is used to communicate information about *inclusion*, that term will generally be acceptable both for cases of full inclusion and for cases of partial inclusion. However, as my sample was a sample of convenience, further work with a wider range of languages would be required to determine whether the generalizations can be stated as implicational universals. As discussed in section 2.2.4.2, there are a number of possible exceptions to the generalizations whose status can only be determined through continued careful study.

As discussed in section 2.1, a number of attributes of spatial scenes and attribute values have been shown to be part of the information communicated by spatial relational terms. While each of these plays an important role in the meanings of the spatial relational terms that communicate about it, only the three values of the attribute *geometry — relative vertical position*, *contact,* and *inclusion* — were found to behave similarly across a set of languages. This suggests that *geometry* may play a privileged role in the semantics of spatial relational terms. I will return to this issue in Chapter 4.

While there are many differences in the terms languages provide to talk about space, this study has shown that there are also important similarities. The presence of these similarities suggests that it may be a viable enterprise to pursue a framework for the representation of the

meanings of spatial relational terms that can be applied to the terms of many languages.

Chapter 3: The HAND experiments: Complex interactions between attributes of a scene

3.0 Introduction

In this chapter, I probe the influence of a small set of attributes on the use of the English spatial prepositions *in* and *on* in order to arrive at a representation of their meanings in terms of a cross-linguistically viable framework. Since these attributes can relate to the scene as a whole or to the individual participants in the scene, it is important to look not only at the scene, but also at the Ground and the Figure individually. The attributes to be examined in this study were chosen based on their prevalence in theories of spatial relational meaning (e.g., *geometry*, *function*) and on their importance to the nature of the Figure and the Ground (e.g., *animacy*).

The importance of *geometry* to the choice among spatial relational terms has been noted by many researchers (Bennett, 1975; Carlson-Radvansky & Regier, 1997; Cienki, 1989; Herskovits, 1986; Landau, 1996; Lindkvist, 1950; Miller & Johnson-Laird, 1976; Talmy, 1983; see also Chapter 1, section 1.2.1). There are a number of values of the attribute *geometry* that have been proposed to explain the use of spatial relational terms, including inclusion of the Figure in the Ground (said to be important

to the use of *in*), contact between the Figure and the Ground (said to be important to the use of *on*) and a difference in the vertical position of the two objects (said to be important to the use of *over* and *under*) (see Chapter 2, section 2.1). In addition, various researchers note the role played by the geometry of the Ground. For example, many definitions for *in* require that the geometry of the Ground be such that there is an interior at which the Figure can be located. In keeping with this notion, Feist and Gentner (1997, 1998) found that changes in the geometry of the Ground object can result in changes in the extent to which the Ground has an interior and concomitant changes in the applicability of the spatial prepositions *in* and *on*.

However, not all researchers agree that *geometry*, either of the scene or of the Ground, is of primary importance to the selection of an appropriate spatial term. Some have suggested that it is *functional* considerations, usually regarding the typical function of the Ground, that are the major determinants of which term appropriately describes a scene (Coventry, Carmichael, & Garrod 1994; Vandeloise, 1991, 1994; see also Chapter 1, section 1.2.3.2 and Chapter 2, section 2.1.6).

In contrast to the roles attributed to the geometry and function of the Ground, the contribution of attributes of the Figure to the use of English spatial prepositions has been largely discounted (Landau & Stecker, 1990;

Talmy, 1983). Landau and Stecker (1990) showed participants novel objects being placed on a box while introducing a novel term, either as a noun ("This is a *corp*") or as a preposition ("This is *acorp* my box"). They found that while participants attended to the object's shape in the noun condition, they tended to ignore it in the preposition condition. The fact that the geometry of the Figure was not used for the extension of the novel preposition suggests that specifics of the geometry of the Figure are unimportant for the selection of spatial prepositions. However, it is not the case that the Figure is considered unimportant for the selection of spatial terms in all languages. For example, Mayan languages such as Tzeltal, which have spatial systems that are organized quite differently from that of English, appear to accord particular importance to the nature of the Figure when assigning spatial relational terms to a scene (P. Brown, 1994; Levinson, 1996b). The prominent role played by the Figure in these languages suggests that it would be prudent to re-examine the role played by the Figure in the spatial semantics of English.

Finally, although a number of attributes of spatial scenes influencing the use of spatial relational terms have been identified (see Chapter 2, section 2.1), researchers do not agree on the importance of each of the identified attributes. Furthermore, while theoretical claims about the semantics of spatial relational terms center on these attributes and their

values (see Chapter 1, section 1.2), their influence on speakers' use of spatial terms awaits controlled experimental investigation.

In this chapter, I present the results of an experiment in which I examine the way independent changes in geometric and conceptual/functional information are related to the usage of English *in* and *on*. In section 3.1, I will describe my research questions and discuss the attributes of spatial scenes upon which my research questions are based. In section 3.2 I will describe a set of experiments designed to address the research questions laid out in section 3.1, including a series of experiments that examine alternative answers to these questions. I will conclude in section 3.3 by summing up the main points of the chapter.

3.1 An experimental investigation

In these experiments, I examine the influence of four attributes of a spatial scene and its participants on the applicability of the English spatial prepositions *in* and *on*. These attributes motivate the following four questions as empirical problems:

- Is the geometric relation between the Figure and the Ground, as a function of the geometry of the Ground, important?

- Is general conceptual information about the Ground important?
- Is specifically functional information about the Ground important?
- Is general conceptual information about the Figure important?

In order to address these questions, I adapted a method developed by Labov (1973) to study complex interacting factors in the use of English nouns (see Chapter 1, section 1.3.1.2). Labov presented his participants with similarly shaped objects, for which the relative dimensions had been varied systematically. This allowed him to examine the way in which small changes in shape would affect object naming because there are different names and functions attached to similarly-shaped household objects (e.g., *cup, bowl, vase*). In a similar manner, I present participants with similar spatial scenes for which information relating to my research questions has been varied systematically in order to examine the way small changes in geometric, conceptual, and functional information about the scene, the Figure, and the Ground affect preposition use. In the rest of this section, I will motivate and describe each of the manipulations I employ.

3.1.1 Geometry

From the point of view of a geometric approach to the semantics of spatial relational terms, appropriate uses of *in* require that the Figure be located at the interior of the Ground and, as a result, that the Ground have an interior (see Chapter 2, section 2.1.3), while appropriate uses of *on* require that the Figure be in contact with the surface of the Ground and, as a result, that the Ground have a surface (see Chapter 2, section 2.1.1). Because variations in the concavity of the Ground change the extent to which it is perceived to have an interior, such variations should also affect the use of spatial prepositions. By placing the Figure in contact with the surface of the Ground, then manipulating the concavity of the Ground such that the surface in contact with the Figure becomes an interior, one can manipulate the extent to which the geometric relation portrayed fits the requirements of either *in* or *on*. This is illustrated in Figure 3.1: the Ground in Figure 3.1a has high concavity, resulting in the presence of an interior which would allow the use of *in*; the Ground in Figure 3.1b has low concavity, resulting in the existence of a flat surface which is in contact with the Figure, allowing the use of *on*.

(a) (b)

Figure 3.1 Two scenes differing in the concavity of the Ground

This difference motivated the variations in the geometry of the Grounds depicted in the set of scenes used in the first experiment. Assuming the importance of geometry to prepositional choice, I predict that greater concavity of the Ground will correspond to a higher proportion of *in* responses from my participants.

3.1.2 General conceptual information about the Ground

It is possible that background information about the Ground contributes to a speaker's decision to use a given spatial term. There are many different kinds of background information that may contribute to this decision, including specifically functional information about the Ground (see section 3.1.3), such as is usually mentioned in functional accounts of the meanings of spatial relational terms, and more general conceptual knowledge

about the Ground. Such conceptual knowledge may include the animacy of the Ground and the degree of control that can be attributed to it.

There are many reasons to believe that the animacy of the Ground may affect the applicability of spatial relational terms. First, animacy plays a role in other linguistic phenomena, including the dative alternation[17] (Levin, 1993) and classifier usage (Comrie, 1981; Lucy, 1994). Additionally, it is possible that the animacy of the Figure plays a role in the use of the Dutch preposition *aan*[18] (Bowerman, 1996). Finally, an animate Ground may be able to exert volitional control over other objects, and specifically over the location of the Figure. If the Ground is able to exert volitional control over the location of the Figure, it will be better able to serve as a container for the Figure, as it could prevent the Figure from exiting the configuration. As the Ground better serves as a container for the Figure, the applicability of *in* should increase. In keeping with this hypothesis, previous research found that scenes depicting an animate Ground did receive a higher proportion of *in* responses than did scenes depicting an inanimate Ground (Feist & Gentner,

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[17] The dative alternation refers to the equivalence of alternate forms such as *I sent the book to Sue* and *I sent Sue the book*. However, recipient of the action must be animate in order to appear outside of a prepositional phrase; we can only say *I sent the book to Spain* and not *I sent Spain the book.*

[18] Eric Pederson (personal communication) suggests that animacy may be the indirect correlate and that the use of *aan* for animate as well as for inanimate Figures may be due to the way in which the Figure attaches to the Ground.

1997; Gentner & Feist, in press). I investigate the role of the animacy of the Ground in the first experiment by having each of the scenes shown to participants depict either a hand (animate Ground) or a dishlike tray (inanimate Ground). I predict that the usage of *in* will be more prevalent for scenes involving the animate Ground than for those involving the inanimate one.

3.1.3. Functional information about the Ground

According to a functional approach to the semantics of spatial relational terms, functional information about the Ground is paramount to the selection of spatial terms (see Chapter 1, section 1.2.3.2). More specifically, the typical function of the Ground and the extent to which the Ground is fulfilling its typical function are thought to influence this selection. For example, Coventry and his colleagues (Coventry et al., 1994) found empirical evidence that information about the typical function of the Ground influences the use of English spatial prepositions. In their study, the usage of *in* was found to be more prevalent when solid Figures (such as apples) were placed with respect to a bowl (which typically holds solids) than when they were placed with respect to a jug (which typically holds liquids).

One source of information about the typical function of the Ground is the label applied to it. Labov (1973) found that the functional context in which a specific object was introduced (neutral, holding coffee, holding food, etc.) influenced participants' choice of nouns to apply to the object. The same object, when introduced in different functional contexts, was labeled with different nouns, suggesting that the noun used to label an object carries functional information. Thus, introducing a Ground with a specific label is hypothesized to influence the typical function associated with the Ground. Coventry et al. (1994) found that this manipulation influenced the usage of *in* and *on* when the Ground object, a shallow dish, was labeled as either a *dish* or a *plate*.

In order to investigate the possibility that functional information about the Ground, as communicated through its label, influences the use of the English spatial prepositions *in* and *on*, I varied the noun applied to the inanimate Ground in the current experiment. The five labeling conditions introduced the animate Ground as a *hand* and the inanimate Ground as one of: *dish, plate, bowl*, *slab,* or *rock*. Taken in isolation, the noun *bowl* tends to denote objects that function as containers; the noun *plate*, objects that function as surfaces; the noun *slab*, afunctional surfaces; and the noun *rock*, afunctional solids. The fifth noun, *dish*, is a superordinate of both *bowl* and

plate and is therefore expected to have a function that is ambiguous between a container and a surface: a dish might sometimes be considered a container and sometimes a surface. Assuming the importance of functional information about the Ground, I predict that I will find the highest proportion of *in* responses for the inanimate Ground when it is labeled as a *bowl*, a somewhat lower proportion when it is labeled as a *dish*, a still lower proportion when it is labeled as a *plate*, and the lowest proportion when it is labeled with the afunctional *slab* or *rock*.

3.1.4. General conceptual information about the Figure

Finally, despite the lack of an effect of the Figure on the use of English prepositions noted in previous work (Landau & Stecker, 1990; Talmy, 1983), there are potentially many ways in which the Figure could have an effect on the use of spatial terms. Some of these are demonstrated by the myriad spatial terms dependent on the Figure found in Mayan languages such as Tzeltal (P. Brown, 1994; Levinson, 1996b), suggesting that a re-examination of the Figure's role in English terms may be in order.

In this study, I decided to explore the possibility that the animacy of the Figure influences preposition choice in English. In a previous study

(Feist & Gentner, 1997), it was found that the animacy of the Ground is important to the choice between the prepositions *in* and *on*, raising the possibility that animacy more generally plays a role in preposition choice. Additionally, the animacy of the Figure plays a role in some of the factors that Sinha and Kuteva (1995) found to determine preposition selection, including *attributed intention*, in which the intention attributed to the Figure as a motive for entering the spatial relation influences preposition choice, as in the contrast shown in (1) and (2) (Sinha & Kuteva, 1995, examples (27) and (28)). The use of *in* suggests that the Ground is the Figure's final destination, while the use of *at* suggests that the Figure has merely reached the Ground en route to its final destination.

(1) Rommel is *in* Cairo.

→ Figure's attributed intention = Ground as goal

(2) Rommel is *at* Cairo.

→ Figure's attributed intention = Ground as sub-goal

Finally, the fact that an animate Figure is able to exert control over its own position, thereby entering and exiting a configuration at will, suggests that it might be a less ideal participant than an inanimate Figure in what Vandeloise (1991, 1994) has called the container/contained relationship. I investigate the role of the animacy of the Figure in the first experiment by

varying whether the Figure is a firefly (animate Figure) or a coin (inanimate Figure). I expect to find a lower proportion of *in* responses to scenes depicting the animate Figure than to comparable scenes depicting the inanimate one.

3.2 The Experiments

3.2.1 Experiment 1

Experiment 1 was designed to examine the influences of the geometrical relation between the Figure and the Ground, general conceptual information about the Ground, specifically functional information about the Ground, and general conceptual information about the Figure on the use of *in* and *on* to describe scenes in English.

Method

Participants 91 Northwestern University undergraduates received course credit for their participation in this experiment. All reported being fluent speakers of English.

Stimuli A set of concavity-matched stimuli were used in this experiment (see Feist & Gentner, 1997). These stimuli depicted two Figures (a firefly and a coin) paired with two Grounds (an ambiguous dishlike tray and a hand) at three levels of concavity, for a total of twelve pictures. Example stimuli are shown in Figures 3.2 and 3.3.

Figure 3.2 Dishlike tray paired with firefly at three concavity levels: low (approximately flat), medium, and high (deeply curved)

Figure 3.3 Hand paired with firefly at three concavity levels: low (approximately flat), medium, and high (deeply curved)

Procedure Stimuli were presented in two randomized blocks, each consisting of the entire set of twelve pictures in random order. Each of the

stimuli was presented for five seconds on a computer screen. Participants were given answer sheets containing sentences of the form:

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

where *Figure* was filled in with the noun referring to the Figure (i.e., *firefly* or *coin*), and *Ground* was filled in with *hand* when the animate Ground was shown and the noun corresponding to the labeling condition (*dish, plate, bowl, slab,* or *rock*) when the inanimate Ground was shown.

Participants were told to circle *in* or *on* to make each sentence describe the corresponding picture on the computer screen.

Design I used a 2 (Ground: hand or dishlike tray) x 2 (Figure: firefly or coin) x 3 (concavity) x 5 (labeling condition) design. Ground, Figure and concavity were varied within subject and labeling condition was varied between subjects, with each participant being given only of the five labels for the inanimate Ground.

Results and Discussion

As predicted, I found that participants' choice of *in* or *on* to describe the scenes was influenced by the Ground's concavity, the animacy of the Ground, the animacy of the Figure, and the labeling condition in which the participant was placed. These results were confirmed by a 2 (Ground: hand or dishlike tray) x 2 (Figure: firefly or coin) x 3 (concavity) x 5 (labeling condition) repeated measures analysis of variance (ANOVA).

The effect of the Ground's concavity was demonstrated by an increase in *in* responses as the concavity was increased (Figure 3.4). Averaged across both Figures, both Grounds and all five labeling conditions, the proportion *in* responses to scenes depicting low concavity was .38; medium concavity, .46; and high concavity, .54, $F(2,172) = 28.336$, $p < .0001$.

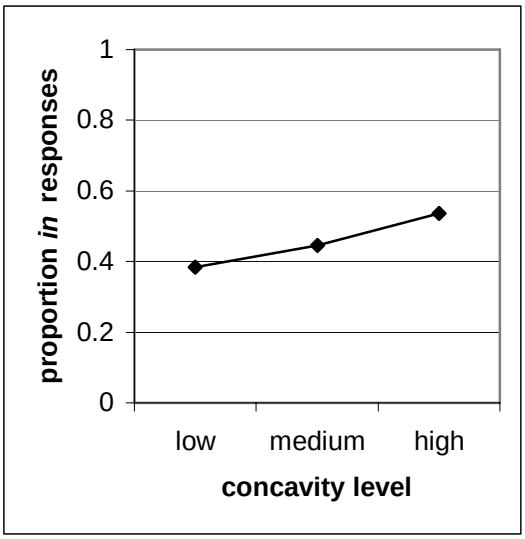

Figure 3.4 Proportion *in* responses as a function of concavity, averaged across both Figures, both Grounds, and all five labeling conditions

The animacy of the Ground influenced participants' choice between *in* and *on* as shown by the fact that scenes depicting an animate Ground received a higher proportion *in* responses than did those depicting an inanimate one (Figure 3.5). Averaged across both Figures, all five labeling conditions and all three concavities, the proportion *in* responses to scenes depicting the hand was .63; to scenes depicting the dishlike tray, .28, $F(1,86) = 65.593$, $p < .0001$.

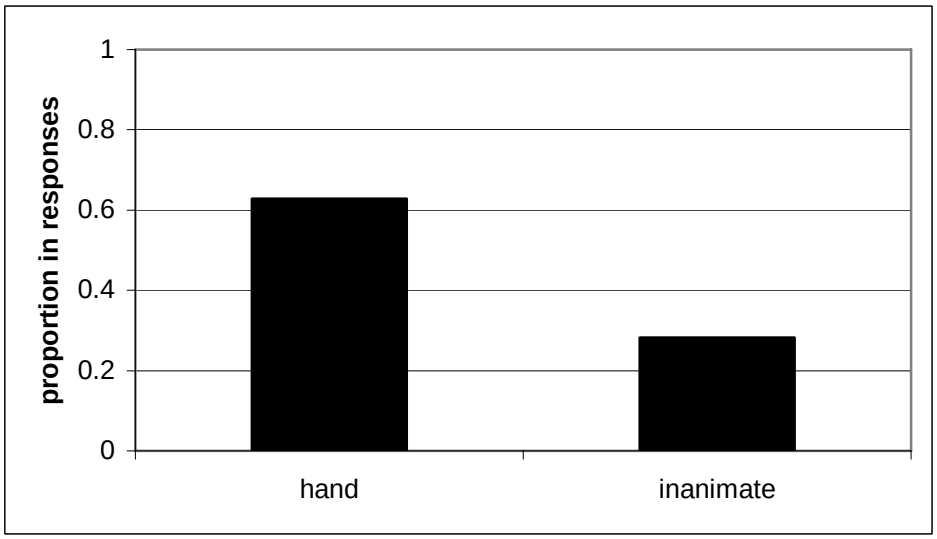

Figure 3.5 Proportion *in* responses as a function of animacy of the Ground, averaged across both Figures, all three concavities, and all five labeling conditions

I found that participants' choice between *in* and *on* to describe the scenes was influenced by functional information about the Ground, as communicated by the label applied to it ($F(4,86) = 10.766$, $p < .0001$). Furthermore, as expected, I found an interaction between the animacy of the Ground and the labeling condition ($F(4,86) = 5.434$, $p = .001$), likely due to the fact that the label was only changed for the inanimate Ground. When the inanimate Ground was referred to as a *bowl*, which is expected to function as a container, the proportion *in* responses was highest (mean proportion *in* responses = .65). When I referred to the inanimate Ground as a *plate*, which is expected to function as a surface, the proportion *in* responses was quite low

(mean proportion *in* responses = .09). When it was labeled as a *dish*, which is the superordinate term for *bowl* and *plate*, the proportion *in* responses was in between (mean proportion *in* responses = .50), although closer to the proportion received by *bowl* than to that received by *plate*. I will return to this issue in section 3.3. Finally, the proportion *in* responses was low when the afunctional labels *rock* and *slab* were applied (mean proportion *in* responses for *slab* = .08; for *rock* = .07) (Figure 3.6).

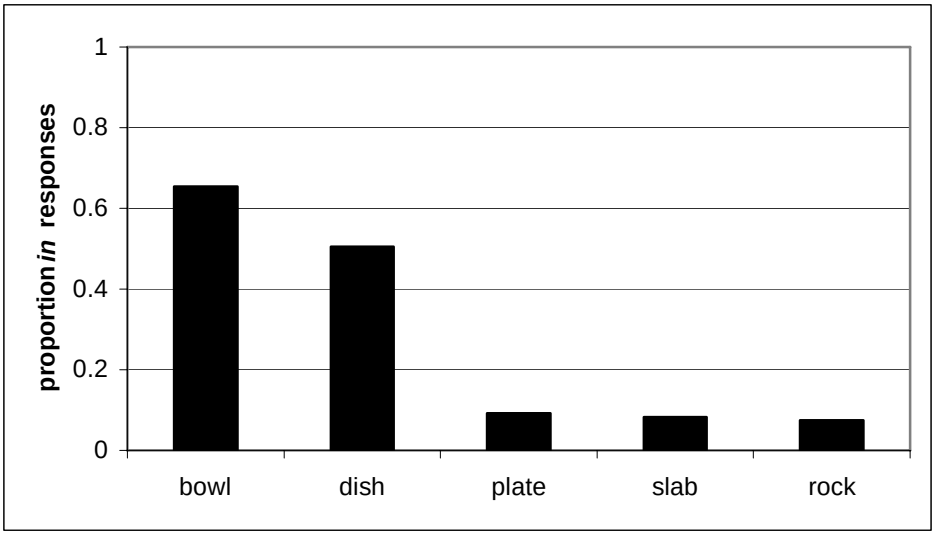

Figure 3.6 Proportion *in* responses to the inanimate Ground as a function of the labeling condition averaged across both Figures and all three concavities

Finally, participants were more likely to choose *in* to describe scenes depicting the inanimate Figure than to describe those depicting the animate Figure (Figure 3.7). Averaged across both Grounds, all three concavities, and

all five labeling conditions, the proportion *in* responses for *coin* as Figure was .49; for *firefly* as Figure, .43, ($F(1, 86) = 9.685$, $p < .005$). Although this result is significant, the effect of the animacy of the Figure is smaller than I had expected for reasons that are unclear. I leave a deeper investigation into the influence of general conceptual information about the Figure to future research.

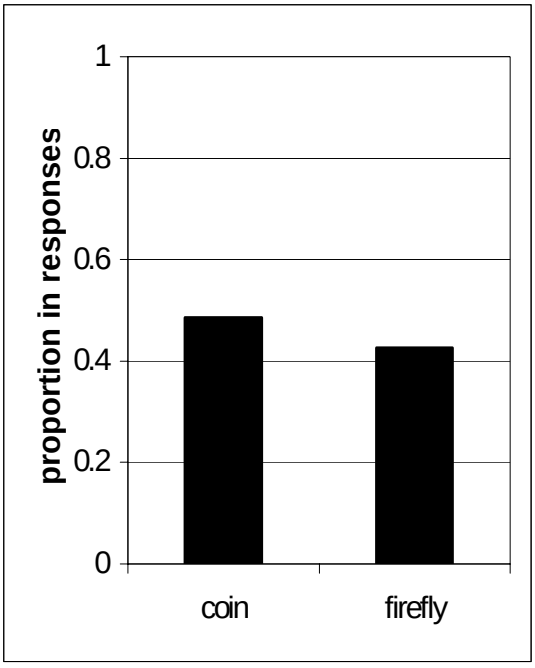

Figure 3.7 Proportion *in* responses as a function of the animacy of the Figure, averaged across both Grounds, all three concavities, and all five labeling conditions

The effects of geometry, conceptual information about the Ground, functional information about the Ground, and conceptual information about

the Figure were not independent. Rather, I found a number of ways in which one of these factors influenced the effect of another.

First, as noted above, I observed the expected interaction between the animacy of the Ground and the labeling condition. Second, I found an interaction between conceptual information about the Figure and the labeling condition: the extent to which scenes depicting the coin received a higher proportion *in* responses than did scenes depicting the firefly varied across the labeling conditions (Figure 3.8) ($F(4,86) = 2.730$, $p < .05$). Notably, the extent to which *coin* received more *in* responses than did *firefly* is greater in the *bowl* and *dish* conditions than in the other three conditions. This difference may arise from the relative familiarity of coins being placed in dishes and bowls, as near the cash register in many convenience stores.

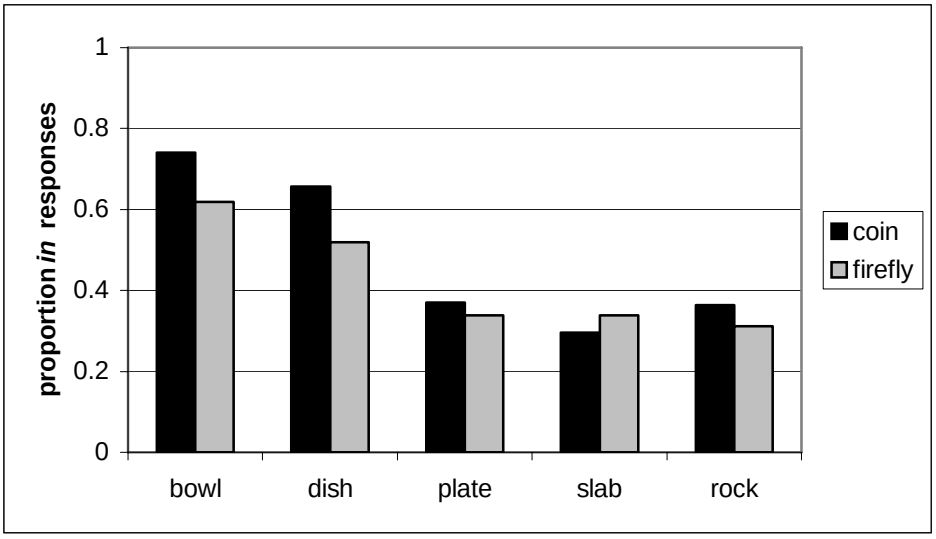

Figure 3.8 Proportion *in* responses as a function of Figure and labeling condition, averaged across both Grounds and all three concavities

Third, I found an interaction between the animacy of the Ground and its concavity: I observed a greater change in the proportion *in* responses as a function of concavity for the hand than for the inanimate Ground (Figure 3.9) ($F(2,172) = 5.495$, $p = .005$). This difference may be due to the relative amount of control that each of the Grounds can exert over the movement of the Figure. Because it can continue to close, a hand may be conceived of as having more control as it becomes more concave (i.e., more closed), while an inanimate object's amount of control, like its ability to continue closing, would not be conceived of as changing across concavities.

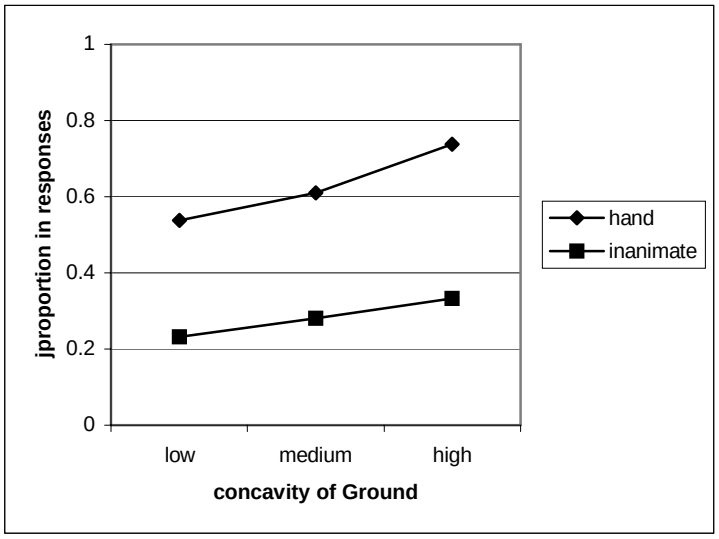

Figure 3.9 Proportion *in* responses as a function of concavity and animacy of the Ground, averaged across both Figures and all five labeling conditions

While I would like to conclude that speakers' choice between English *in* and *on* is indeed influenced by a set of attributes rather than one attribute alone, as suggested by the results of Experiment 1, I must first further examine the pattern of results found in Experiment 1. Experiment 2 presents further support for the effects found in Experiment 1, while Experiments 3 and 4 provide controls for Experiment 1.

3.2.2 Experiment 2

Experiment 2 was designed to examine the independent effects on preposition choice of the pictures and the lexical items used in Experiment 1. In Experiment 2a, I asked naïve participants to describe the scenes by choosing *in* or *on* to complete sentences in which neither the Figure nor the Ground was labeled, allowing me to examine the independent effect of the pictures from Experiment 1. In Experiment 2b, I asked a new set of participants to choose *in* or *on* to complete sentences in the absence of pictures, allowing me to examine the independent effect of the lexical items from Experiment 1.

3.2.2.1 Experiment 2a

In Experiment 2a, naïve participants were asked to choose *in* or *on* to describe the scenes shown in Experiment 1 in the absence of nouns labeling the Figure and the Ground. The purpose of the experiment was to observe the independent effect of the pictures on preposition choice.

Method

Participants 20 Northwestern University undergraduates received course credit for their participation in this experiment. All reported being fluent speakers of English.

Stimuli The stimuli used were the same as in Experiment 1.

Procedure The procedure was the same as in Experiment 1 except for the following changes: participants were given answer sheets containing sentences of the form:

A is IN/ON B.

and participants were given a pre-training in which they were told that each of the pictures they would see would depict two objects. Participants were instructed that the smaller object would be referred to as *A* and the larger as *B*.

Design I used a 2 (Ground: hand or dishlike tray) x 2 (Figure: firefly or coin) x 3 (concavity) design. All three variables were varied within subject.

Results and Discussion

In this experiment, I replicated the effects of the animacy of the Ground, the concavity of the Ground, and the interaction between the two, suggesting that the use of *in* and *on* is at least partially influenced by these aspects of the visual scene being described. These results were confirmed by a 2 (Ground: hand or dishlike tray) x 2 (Figure: firefly or coin) x 3 (concavity) repeated measures analysis of variance (ANOVA). No other significant effects or interactions were found.

As in Experiment 1, scenes depicting the animate Ground received a higher proportion of *in* responses than did those depicting the inanimate Ground (Figure 3.10), although the proportion of *in* responses for both Grounds was lower than in Experiment 1 (see Figure 3.5). Averaged across both Figures and all three concavities, the proportion *in* responses for the animate Ground was .44, for the inanimate Ground, .02, $F(1,19) = 21.623$, $p < .0001$.

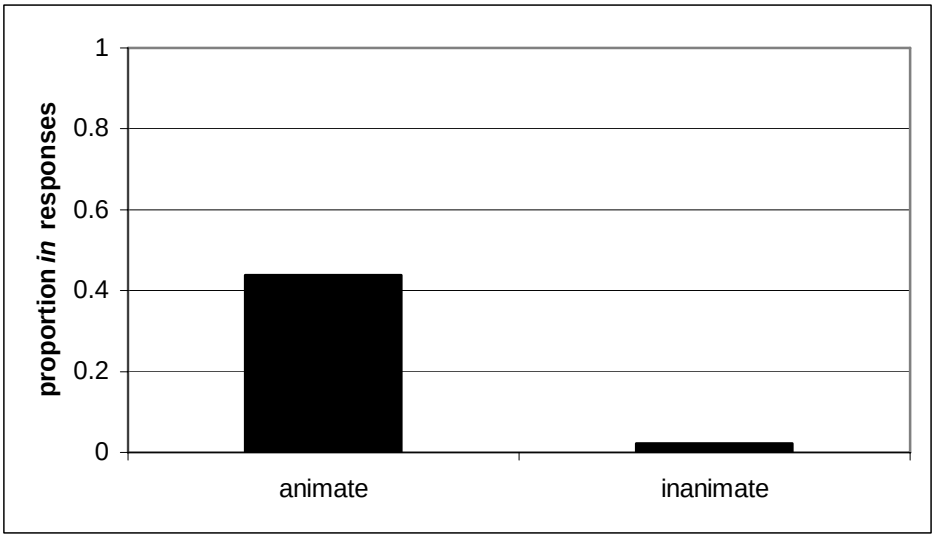

Figure 3.10 Proportion *in* responses as a function of animacy of the Ground, averaged across both Figures and all three concavities

Additionally, as in Experiment 1, a higher concavity led to a higher proportion *in* responses (Figure 3.11). Averaged across both Figures and both Grounds, the proportion *in* responses to scenes depicting low concavity was .14; medium concavity, .22; and high concavity, .33, $F(2,38) = 9.126$, $p = .001$.

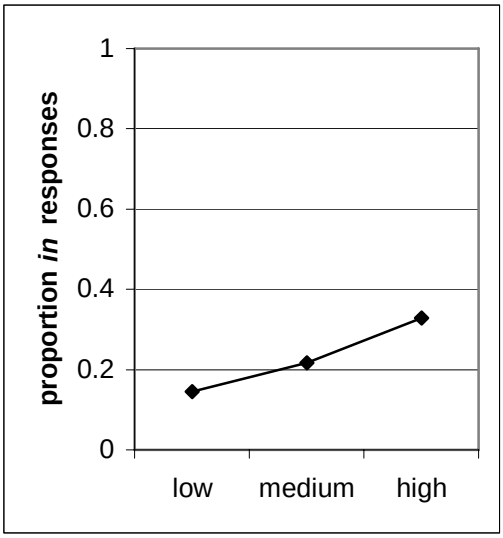

Figure 3.11 Proportion *in* responses as a function of concavity, averaged across both Figures and both Grounds

Finally, I again observed an interaction between the animacy of the Ground and its concavity in which the effect of concavity was more pronounced for the animate than for the inanimate Ground (Figure 3.12), $F(2,38) = 5.400$, $p < .01$.

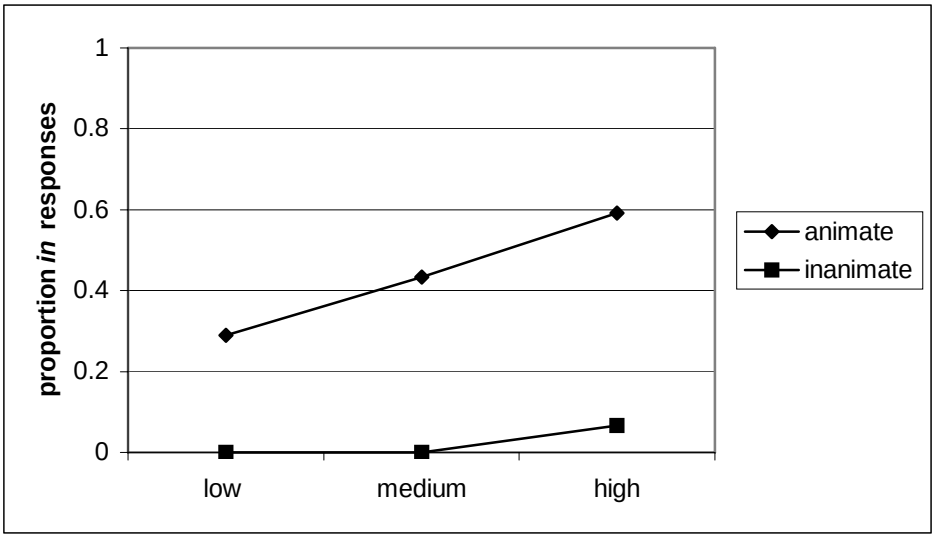

Figure 3.12 Proportion *in* responses as a function of concavity and animacy of the Ground, average across both Figures

Although the proportion *in* responses was generally lower in Experiment 2a than in Experiment 1, the pattern was very similar. This pattern of results suggests that information gained purely from the visual examination of a scene is used for the selection of an appropriate spatial preposition, reducing the likelihood that the results of Experiment 1 were due solely to the lexical items chosen. However, the lower proportion *in* responses found in this experiment relative to the results of Experiment 1 suggests that information gained from a visual examination of the scenes is not the sole determinant of spatial preposition usage in English. I will explore this issue further in Experiment 2b.

3.2.2.2 Experiment 2b

In Experiment 2b, naïve participants were asked to choose *in* or *on* to complete the sentences presented on the answer sheets in Experiment 1 in the absence of pictures. The purpose of the experiment was to observe the independent effect of the lexical items referring to the Figure and the Ground on preposition choice.

Method

Participants 24 Northwestern University undergraduates received course credit for their participation in this experiment. All reported being fluent speakers of English.

Stimuli Answer sheets containing the following four sentences in random order:

The coin is IN/ON the hand.

The coin is IN/ON the dish.

The firefly is IN/ON the hand.

The firefly is IN/ON the dish.

Procedure Participants were asked to circle either *in* or *on* in order to complete each of the four sentences in the most natural-sounding way.

Results and Discussion

In this experiment, I replicated the effects of the animacy of the Ground and the animacy of the Figure found in Experiment 1, suggesting that the use of *in* and *on* is at least partially influenced by information about the animacy of the participants gleaned from the lexical items used to refer to them. These results were confirmed by a 2 (Ground: hand or dishlike tray) x 2 (Figure: firefly or coin) repeated measures analysis of variance (ANOVA). No other significant effects or interactions were found.

Sentences mentioning the animate Ground, a *hand*, received a higher proportion *in* responses than did those mentioning the inanimate Ground, a *dish* (Figure 3.13). Averaging across both Figures, the proportion *in* responses when *hand* was the Ground was .63; when *dish* was the Ground, .31, $F(1,23) = 7.805$, $p = .01$.

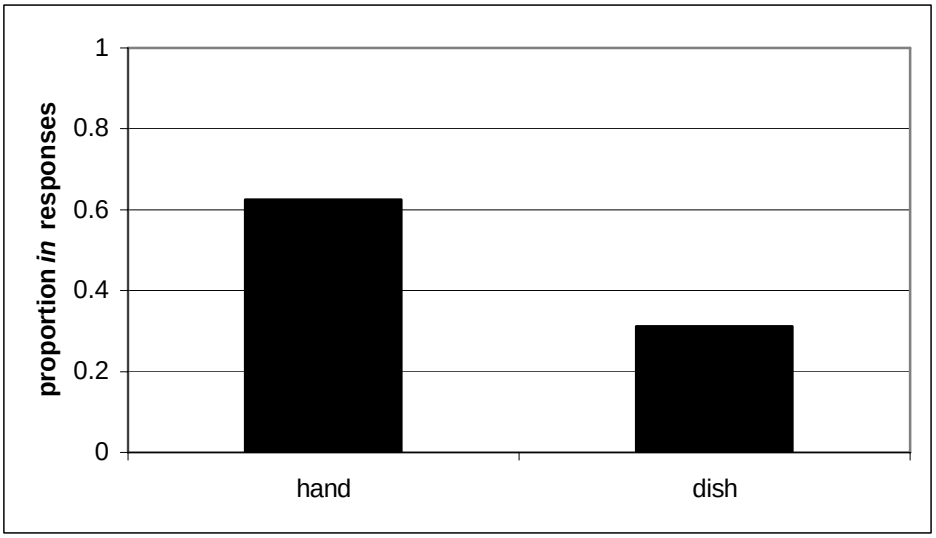

Figure 3.13 Proportion *in* responses as a function of animacy of the Ground, averaged across both Figures

Similarly, sentences mentioning the inanimate Figure, a *coin*, received a higher proportion *in* responses than did those mentioning the animate Figure, a *firefly* (Figure 3.14). Averaging across both Grounds, the proportion *in* responses when *coin* was the Figure was .71; when *firefly* was the Figure, .23, $F(1,23) = 46.262$, $p < .0001$.

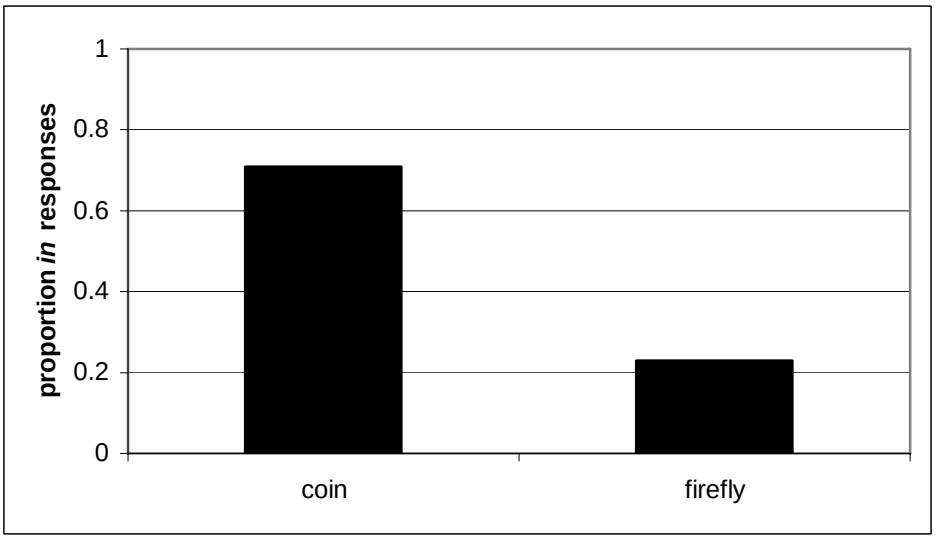

Figure 3.14 Proportion *in* responses as a function of animacy of the Figure, averaged across both Grounds

As with Experiment 2a, the pattern of results obtained in this experiment was similar to the pattern of results from Experiment 1, although the actual proportions of *in* responses differed. In the absence of pictures, participants produced a higher proportion *in* responses for the *coin* as Figure (.71 in Experiment 2b; .49 in Experiment 1), while they produced a lower proportion *in* responses for the *dish* as Ground (. 31 in Experiment 2b; .50 in Experiment 1) and for the *firefly* as Figure (.23 in Experiment 2b; .43 in Experiment 1). The proportion *in* responses for *hand* as Ground did not differ between the two experiments.

It is likely that the differences found are due to world knowledge about each of the Figures and Grounds used in this set of experiments. For

example, it is common for coins to be held in a hand or placed in a dish, while these situations are uncommon for fireflies. Thus, in the absence of visual information, a default assumption about a coin with respect to a hand or a dish might be that the coin is contained by the hand or dish, while a default assumption about a firefly with respect to a hand or a dish might be that the firefly is resting atop the hand or dish (or not in contact at all). With regard to the dish as Ground, participants in this experiment might have been picturing a flat dish, while the ambiguous dishlike-tray depicted in the stimuli from Experiment 1 was concave in two-thirds of the pictures, possibly causing them to use *in* more often in Experiment 1.

The pattern of results obtained in this experiment suggests that information gained purely from the lexical items in a sentence is used for the selection of an appropriate spatial preposition, reducing the likelihood that the results of Experiment 1 were due solely to the pictures shown. Nevertheless, the noted differences in the actual proportions of *in* responses between this experiment and Experiment 1 suggest that the pictures exerted significant influence on participants' choice between *in* and *on*.

3.2.2.4 General discussion

In Experiments 2a and 2b, I found that the usage of *in* and *on* is influenced by information gleaned from the visual scene and information communicated linguistically. Taken together, these results confirm the suggestion that the usage observed in Experiment 1 was indeed influenced by a combination of these factors. I leave to future research a closer examination of the ways in which these factors interact in speakers' decisions to choose a given spatial relational term.

3.2.3 Experiment 3

Experiment 3 was designed to examine the extent to which the effects found in the Experiment 1 may be attributed solely to functional associations derived from the nouns used to label the Ground objects. To determine this, I asked naïve participants to list functions for each of the functional Ground names used in Experiment 1; due to their afunctional nature, *rock* and *slab* were not examined in this experiment. If the meanings of spatial relational terms rely primarily on functional considerations and the English preposition *in* is used for situations in which the Ground functions as the container for

the Figure (Coventry et al., 1994), one might expect that participants would ascribe containment functions to the Ground objects approximately as often as they used *in* with those objects.

Method

Participants 23 Northwestern University undergraduates received course credit for their participation in this experiment.

Stimuli Answer sheets containing six object names: *hand*, either *dish, plate,* or *bowl*, and four distracters.

Procedure Participants were asked to write what they thought of as the functions of each of the items on the sheet. They were allowed to list as many functions as they liked.

Results and Discussion

I coded the functions listed by participants for each of the nouns under examination for whether they implied containment, which is functionally associated with *in* (Vandeloise, 1991, 1994). Example functions implying containment are listed in Table 3.1. Because the task was a free response

task, allowing participants to choose the number of functions to list, I then calculated for each of the nouns the proportion of people who chose to list at least one containment function.

Table 3.1 Example containment functions

Dish	***Plate***	***Bowl***	***Hand***
Holds plants; to contain meals	To hold food	Serves to contain something; to contain liquid foods	Holding things; basket

The proportion of people mentioning a containment function for the objects mentioned in this study was generally quite different from the proportion *in* responses to scenes involving the objects and labeled with the same nouns in Experiment 1 (r = .31) (Figure 3.15). This result suggests that knowledge about an object's function cannot be solely responsible for the pattern of responses found in Experiment 1.

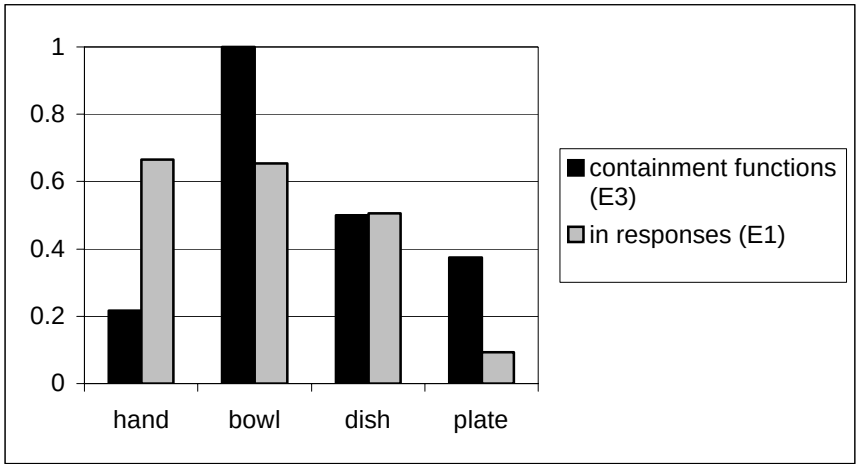

Figure 3.15 Rate of containment functions listed (Experiment 3) and *in* responses (Experiment 1) for each of the functional labels

As further evidence, Green (1971) notes that some sentences involving the preposition *in* cannot be rewritten as sentences involving the verb *contain* without a change of meaning, as shown by the examples in (1) and (2) (her example 4 a-d, p. 198).

(1) a) His eye has a cinder in it.

≠ b) His eye contains a cinder.

(2) a) This desk has three drawers in it.

≠ b) This desk contains three drawers.

Similarly, although some of the sentences describing pictures from Experiment 1 could be paraphrased using *contain*, as shown by the pair in (3), others, such as those in example (4), cannot.

(3) a) The bowl has a coin in it.

= b) The bowl contains a coin.

(4) a) The hand has a firefly in it.

≠ b) The hand contains a firefly.

If the meaning of the English preposition *in* was based on the containment function of the Ground, one would expect that any relation that could be described using *in* would equally well be described using *contain*. The fact that the two are not completely interchangeable provides additional evidence that the meanings of spatial relational terms involve attributes of spatial scenes in addition to *function*.

3.2.4 Experiment 4

As an additional control, I investigated the question of whether the results of Experiment 1 could be due solely to habits of use formed around the lexical items chosen rather than being indicative of the influence of various attributes on the use of spatial relational terms. In order to address this question, I searched the British National Corpus[19] for each of the prepositions used in Experiment 1 (*in* and *on*) in combination with each of the

[19] http://info.ox.ac.uk/bnc/index.html

nouns used to name a Ground (*hand, dish, plate, bowl, rock,* and *slab*). The British National Corpus consists of over 100 million words of spoken and written modern English. Available via the internet, the corpus can be used, as in this study, to examine the frequency with which a given pair of words occurs across a broad sample of modern English.

Participants in Experiments 1 and 2b were supplied with the noun used to label the Ground object and given a forced choice between *in* and *on* to complete each sentence. In the corpus study, I decided to look at the relative occurrence of each preposition with each noun in order to make the corpus study as similar as possible to the tasks presented in Experiments 1 and 2b. To do this, I collected instances of each noun in combination with each preposition, yielding a total number of occurrences of the noun with either of the two prepositions. The co-occurrence of each noun with *in* was then calculated as a proportion of the total number of occurrences of the noun collected. In order to compare these results with my experimental data, only those uses that I judged to be clearly spatial were tabulated[20], then the co-occurrence of each noun with *in* was recalculated.

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[20] This left a total of 246 occurrences of *hand*, 76 occurrences of *dish*, 134 occurrences of *plate*, 149 occurrences of *bowl*, 156 occurrences of *rock*, and 37 occurrences of *slab*.

Overall, the pattern of co-occurrence appears quite similar to the pattern of *in* responses found in Experiment 1 (r = .94). However, three of the nouns, *bowl, dish* and *rock*, showed a notably higher co-occurrence with *in* in the corpus than in the results of Experiment 1 (Figure 3.16). This suggests that participants' choice between *in* and *on* in Experiment 1 was not likely to be caused solely by habits of use formed around the lexical items I chose, despite high correlation between habits of use and participants' behavior in Experiment 1.

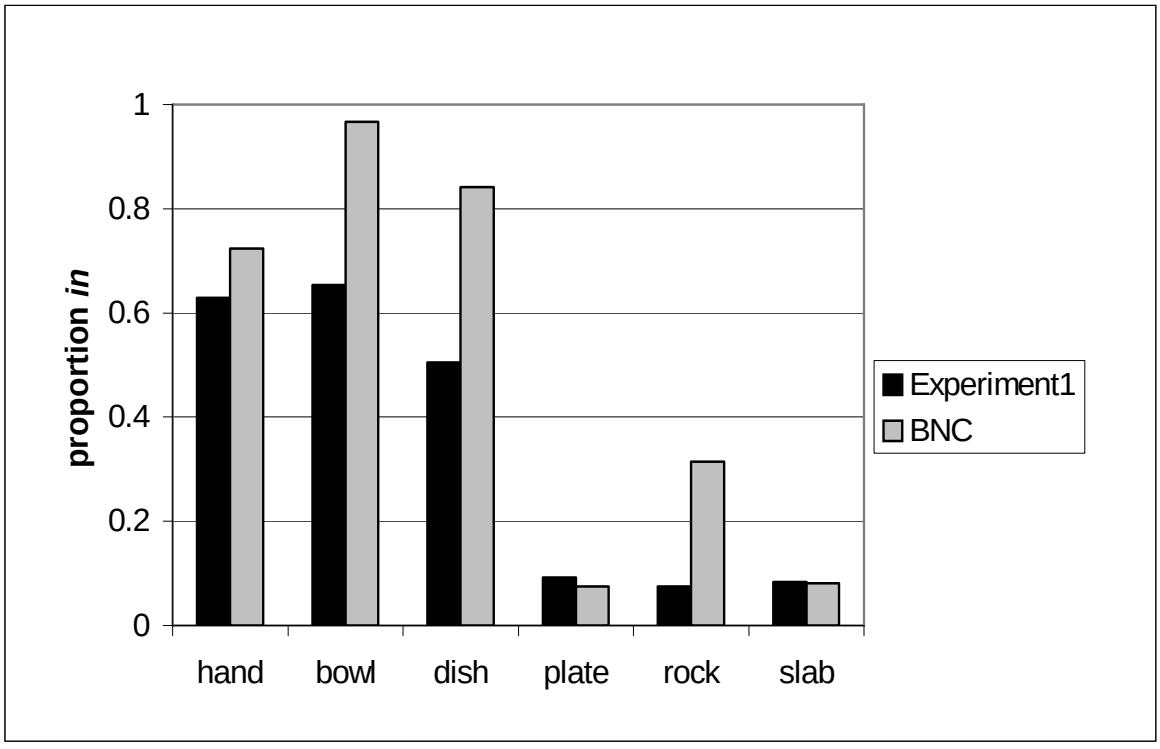

Figure 3.16 Rate of occurrence of *in* with each of the nouns in Experiment 1 and in the British National Corpus

It is also interesting to note that *dish* showed a much higher co-occurrence with *in* in the corpus than in the results of Experiment 2b, where the proportion *in* responses was lower than in Experiment 1 (see section 3.2.2.2). The reasons for this are unclear, and further research into the meaning of the word *dish* is likely necessary in order to interpret these differences.

3.3 General discussion

The results of the experiments described in this chapter suggest that the appropriate use of spatial prepositions in English is influenced by a complex set of interacting factors. Although each of these factors is able to account for the usage of the terms *in* and *on* to a point, none alone is able to fully account for the pattern of usage that I found.

Among the factors influencing prepositional usage, I found evidence that the geometry of the scene, general conceptual information about the Ground object, specifically functional information about the Ground, and general conceptual information about the Figure are all taken into account when choosing an appropriate preposition to apply to a scene. This suggests that a descriptively adequate account of the semantics of spatial relational

terms must incorporate the influences of multiple attributes of the scenes being described.

One puzzle that arose from the findings reported in this chapter is the status of the noun *dish*. Although *dish* was hypothesized to be a superordinate to both *plate* and *bowl*, the proportion *in* responses when the Ground was referred to as a *dish* in Experiment 1 was closer to the proportion *in* responses when the Ground was referred to as a *bowl*. Conversely, in Experiment 3, the proportion of participants listing a containment function for *dish* was closer to the proportion listing a containment function for *plate*. Finally, in the absence of pictures (Experiment 2b), the proportion *in* responses when the Ground was referred to as a *dish* was much lower than the corresponding proportion in Experiment 1, yet the co-occurrence of *dish* with *in* in the British National Corpus (Experiment 4) was much higher. It is unclear why *dish* would receive such a disparate pattern of responses; further research into the meaning of *dish* and further examination of the behavior of *in* and *on* when the Ground is labeled with a superordinate term (i.e., *furniture*) may help to resolve this issue.

The findings reported in this chapter are of necessity preliminary. My experiments made use of two physically different Grounds and two physically

different Figures in order to examine the effects of general conceptual information about the Ground and the Figure. In order to explore the generality of the effect, follow-up studies employing additional Grounds and Figures will be necessary. Similarly, my experiment used five different nouns to examine the effect of functional information conveyed by the lexical item applied to the Ground. Further work needs to examine other labels and other sources of functional information, in addition to variation in the functional information supplied about the Figure, in order to more fully understand what influence functional information has on the usage of spatial terms.

Many of the factors tested in this study figured prominently in previous theoretical work on the semantics of English spatial prepositions, although they awaited empirical evaluation. While such studies provide a fruitful ground for identifying possible factors to test, it is important not to discount those factors deemed unimportant based on studies of a single language. The languages of the world have been shown to encode a variety of different attributes of scenes in their spatial terms (Bowerman, 1996; Bowerman & Pederson, 1992, 1996; Levinson, 1996b) (see Chapter 2) which could prove relevant even in languages where they have not yet been identified to be so. As a case in point, although previous studies suggested

that the nature of the Figure does not contribute to the use of English spatial prepositions (e.g., Landau & Stecker, 1990) (see discussion in section 3.0), researchers on the Mayan language Tzeltal have shown the Figure to play a prominent role in the use of that language's spatial terms (P. Brown, 1994; Levinson, 1996b), leading me to the investigation of the role of the Figure reported in this chapter. The effect of the Figure that I found, while quite small, is suggestive of the insights that can be gleaned from broader cross-linguistic work.

Just as factors believed to influence the usage of spatial terms in other languages should be tested for their influence in English, factors that have been identified as important to the semantics of English prepositions should be tested empirically for their influence on spatial terms of other languages. By using this paradigm to investigate spatial semantics in many languages, we can further our understanding of cross-linguistic variation and linguistic universals in the semantics of space.

Chapter 4: Tying it all together: Towards a semantic theory of spatial relational terms

4.0 Introduction

In Chapter 2, I examined the ways in which the spatial relational terms of various languages can be applied to a range of scenes spanning Bowerman and Pederson's (1992, 1996) similarity gradient. I found that there are important similarities across languages in how attributes of spatial scenes are encoded by spatial relational terms, suggesting that it is viable to pursue a framework that can represent the meanings of spatial relational terms of many languages. Based on the similarities that I found, I identified a set of general patterns relating to the ways in which contact, inclusion, and a difference in vertical position are communicated by spatial relational terms. These general patterns may be robust enough to lead to implicational universals.

However, it has often been noted that languages differ in how their spatial relational terms divide up the task of describing the range of possible spatial configurations (Bowerman & Choi, in press; Bowerman & Pederson, 1992, 1996; Cienki, 1989; Gentner & Bowerman, 1996, 2000; Levinson, 1996b; Taylor, 1988) (see Chapter 1, section 1.1.4). The similarities noted in

Chapter 2 represent a set of possible constraints on the range of variation possible in the meanings of spatial relational terms.

Most attempts at characterizing the semantics of spatial relational terms have been based on an examination of an individual language and have placed primary importance on either geometric or functional information (see Chapter 1, section 1.2). These attempts have resulted in approaches that cannot account for every use of a given term, in addition to being unable to account for the meanings of spatial relational terms in languages other than the one which informed the approach. In this chapter, I will present a new approach to spatial relational meaning, based on an examination of multiple languages and incorporating the influence of both *geometry* and *function*, in addition to other abstract attributes such as *qualitative physics* (see Chapter 2, sections 2.1.4 and 2.1.5).

To begin, in section 4.1, I will discuss the repercussions of the variation found cross-linguistically on a theory of spatial relational meaning. Afterwards, in section 4.2, I will review the main classes of approaches to the semantics of spatial relational terms, taking into account the need to have a theory that accounts for both cross-linguistic similarities such as those identified in Chapter 2 and cross-linguistic variation such as that identified in Chapter 1 and in previous studies. Following that, in section 4.3, I will

outline an approach to spatial relational meaning devised with this need in mind.

4.1 Cross-linguistic variation in the description of space

As was shown in Chapter 2, the means by which people are able to describe locations of objects in space are affected by a wide variety of abstract attributes of spatial scenes. Furthermore, the influence of each of these attributes differs across the languages of the world and across the spatial relational terms of any given language, resulting in the wide variation in spatial language reviewed in Chapter 1, section 1.1.4. Often, this variation involves the presence in one language of a distinction based on one attribute of a spatial scene which does not lead to a distinction in another language. For example, the Dutch terms *op* and *aan*, discussed in Chapter 2, section 2.1.5, both are used to describe scenes in which the Figure and the Ground are in contact and the Ground supports the Figure against the force of gravity. The distinction between the terms is based on the nature of the support that the Ground supplies to the Figure (Bowerman & Pederson, 1992, 1996; Gentner & Bowerman, 1996, 2000). This distinction does not appear in the Portuguese spatial relational system, in which the preposition

em would be used to describe configurations described by either *op* or *aan* in Dutch (Bowerman & Pederson, 1992, 1996).

In order to account for the uses of the spatial relational terms of one language, a researcher must extract similarities from the instances of the use of each of the terms. In addition, it is necessary to determine how the groups of configurations described by each of the terms differ from one another. Such an analysis will lead to a characterization of each term that accounts for speakers' choices between terms to describe scenes in the world. These characterizations will include information about those attributes that are common to sets of scenes described by the same term yet are points of variation between sets of scenes described by competing terms. For example, characterizations of the spatial relational terms of Dutch will include information about the nature of the support that the Ground provides for the Figure.

Because there are attributes of spatial scenes that form the basis for a distinction in only a portion of the world's languages, no account of the uses of the spatial relational terms of one language can be cross-linguistically viable. As a case in point, a description of the uses of spatial relational terms in Portuguese will be unable to account for the distinction between *op* and *aan* found in Dutch. In order to achieve a cross-linguistically viable theory of

spatial relational meaning, it will be necessary to include all attributes that aid in the characterization of the spatial relational terms of any language.

4.2 Previous approaches to the semantics of spatial relational terms

As discussed in Chapter 1, section 1.2, there are three main classes of accounts of the semantics of spatial relational terms: those that are based on the influence of geometry alone (e.g., Bennett, 1975; Miller & Johnson-Laird, 1976; Talmy, 1983), those that are based on the influence of function alone (e.g., Coventry, Carmichael, & Garrod, 1994; Vandeloise, 1991, 1994), and those that place primary importance on the influence of geometry, yet also rely on additional knowledge, including conventions of use (e.g., Herskovits, 1986; see also Cienki, 1989). While both geometry and function are indeed quite important, as was shown by their effect on participants' use of English *in* and *on* in Chapter 3, neither of these influences alone is able to perspicuously account for the wide range of spatial relational meaning evident cross-linguistically. In addition, as each of these approaches was developed to account for the meanings of the spatial terms of a single language, no provision is included to allow for cross-linguistic phenomena such as those described in section 4.1 and in Chapter 1, section 1.1.4.

Approaches based on the influence of geometry alone represent the meaning of a spatial relational term as the geometric relation holding between the Figure and the Ground in a large proportion of the scenes described by the term (see Chapter 1, section 1.2.1), leaving scenes that do not fit the specified geometric description as exceptions. As a case in point, in many of the scenes described by the English preposition *in*, one can find the Figure located at the interior of the Ground. This generalization is reflected in Bennett's (1975) proposal for the meaning of *in*, shown in (1).

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

In many languages, however, the spatial relational term used to describe situations in which the Figure is located at the interior of the Ground is also used to describe numerous situations in which the Figure is not, strictly speaking, located at the Ground's interior, such as that depicted in Figure 4.1 or that described in (2).

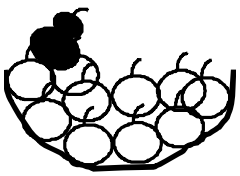

Figure 4.1 The pear is *in* the bowl

(2) A lovely ribbon is *in* her hair.

Because these situations do not conform to the geometry specified in the meaning of the spatial relational term, approaches based on the influence of geometry alone must treat them as exceptions.

Approaches based on the influence of function alone represent the meaning of a spatial relational term as the instantiation of a functional relation (see Chapter 1, section 1.2.3.2). For example, Vandeloise (1991) proposes that the meaning of the French preposition *sur* (and its converse, *sous*), which is used to describe many of the same scenes as the English preposition *on*, is that the Ground is functioning as a bearer of the Figure, a relation which he calls the *bearer/burden relation*. This definition is shown in (3).

(3) S: *a est* [=is] *sur/sous b* if its target is the second/first element of the bearer/burden relation and its landmark the first/second element of this relation.

(Vandeloise, 1991, p. 195)

In many languages, however, the spatial relational term used to describe situations in which the Ground fulfills the function of a bearer of the Figure is also used to describe situations where the existence of such a functional relation is dubious at best. For example, while example (4) would be an appropriate description of the scene in Figure 4.2, it seems odd to claim that the line is the bearer for the burden that is the circle.

(4) The circle is *on* the line.

Figure 4.2 The circle is *on* the line

Finally, the approach proposed by Herskovits (1986) places primary importance on the influence of geometry, which forms the basis for Herskovits' ideal meanings of spatial relational terms. The approach is augmented by conventions of use, stored in the lexical entries of spatial relational terms in the form of Use Types (see Chapter 1, section 1.2.3.1). Based primarily on geometry, Herskovits' theory captures significant generalizations about the use of spatial prepositions in English, as do theories based solely on geometry. In addition, through the Use Types, the theory is able to account for a wide range of actual uses of the terms. However, individual conventions of use must be stored in each term's lexical entry, much as exceptions might be in a purely geometric approach, leaving unarticulated any generalizations that are not geometric.

While approaches to spatial semantics based on geometry alone, function alone, or geometry augmented by conventions of use have all contributed significant insights into the meanings of spatial relational terms, each is left with uses of spatial relational terms that are not easily explained. In addition, as each is based on the spatial relational terms of only one

language, the frameworks proposed are not sufficiently general to account for possible meanings not occurring in the language examined once the framework is applied to additional languages.

4.3 An integrated approach

In order to address the problems associated with previous approaches to the semantics of spatial relational terms, I examined a variety of languages, allowing me to analyze a broader range of influences on speakers' choice of a spatial relational term. In Chapter 2, I found that spatial relational terms across languages tend to encode information about contact, relative vertical position, and inclusion. These relations are largely geometric and easily perceived, such that no further processing is necessary in order to determine whether or not they are found in a scene. This universal tendency to encode information about easily perceived, geometric relations is reflected in the relative importance given to the abstract attribute *geometry* in treatments of spatial relational meaning (see Chapter 1, section 1.2.1). The influence of geometry on speakers' choice of spatial relational terms shown in Chapter 3 suggests that this importance has not been misplaced.

However, as shown in Chapter 1, section 1.2.2 and in section 4.2, geometry alone is not sufficient to describe the semantics of spatial relational terms. Treatments based only on geometry necessarily are left with phenomena that cannot be explained, such as the pear in the bowl in Figure 4.1, and must be set aside as exceptions. As a solution to this problem, a geometry-based theory of spatial relational meaning could be expanded to include other explanatory means, as Herskovits' account does through the inclusion of pragmatics and conventions of use. As discussed in section 4.2, however, this account must treat a variety of common uses by listing them in the lexical entry in a manner akin to the listing of exceptions.

An alternative solution is to downplay the importance of geometry, explaining the uses of spatial terms as a result of other considerations, as Coventry and his colleagues (1994) and Vandeloise (1991, 1994) have done with function. However, this approach is also left to deal with exceptions, as discussed in section 4.2 and in Chapter 1, section 1.2.3.2. In addition, the experiments reported in Chapter 3 demonstrated that many attributes of spatial scenes work in concert to influence speakers' choice of spatial relational terms, suggesting that a theory incorporating more than one means of explanation might be descriptively superior to one with recourse to only a single attribute of spatial scenes.

Therefore, in this chapter I propose a componential representation of spatial relational meaning in which each of the abstract attributes influencing speakers' choice of spatial relational term is included as a meaning component. Included in the set of meaning components which forms this working framework for the representation of spatial relational terms are the abstract attributes *geometry*, *function*, *qualitative physics*, *animacy of the Ground*, and *animacy of the Figure*, as suggested by the work of previous scholars in addition to the results presented in Chapters 2 and 3. There may be additional abstract attributes that are components of the meanings of spatial relational terms; I leave their identification for future research. In laying out the working framework, I aim to be as explicit and specific as possible. However, it is important to bear in mind that this analysis is based on only a subset of English spatial prepositions, and it is therefore provisional.

For simplicity, I will refer to the meaning components as "attributes." The values of the attributes, which are specified in the lexical entries of spatial relational terms, are descriptions of relations between the participants in a spatial scene (e.g., contact) and of characteristics of the individual participants (e.g., the participant's typical function, if any); many of the values may correspond to complete relational descriptions. In order to determine whether a scene may appropriately be described by a given term

the values of each of the attributes for the scene are compared to the values of the attributes specified in the lexical entry for the term. Rather than being either true or untrue of a scene, the goodness of this match for many of the attributes is graded, such that the value of an attribute in a scene may approximate the value specified in the lexical entry. For example, a possible value for the attribute *geometry* is inclusion of the Figure in the Ground. Inclusion implies a very specific geometric description, yet the extent to which various scenes match this value can be shown to be graded, as in the series of scenes in Figure 4.3. In Figures 4.3c and 4.3d, the Figure is fully included in the Ground; in Figure 4.3b, it is partially included; and in Figure 4.3a, it is not included.

(a) (b) (c) (d)

Figure 4.3 Gradience of inclusion of the pear *in* the bowl

The componential approach that I have adopted has been modified to take into account such gradation. The graded nature of the goodness of the match between the attribute values in a scene and those specified in the

lexical entry of a candidate spatial relational term implies that the applicability of spatial relational terms may also be graded, as the applicability of a term is a function of the goodness of these matches. The possibility that the applicability of spatial relational terms may be graded is compatible with a prototype approach to word meaning (Coleman & Kay, 1981; Taylor, 1989). For example, the sentence in (5) could be argued to be a better description for Figures 4.3c and 4.3d than for Figure 4.3a. I leave an empirical examination of this issue to future research.

(5) The pear is *in* the bowl.

In addition, the approach has been modified to take into account the fact that theories based on only one attribute of spatial scenes are left with exceptions that cannot be explained, as the value of the attribute for the scenes that are exceptions differs from that which is proposed within the theory (see section 4.2 above). As these theories have been built around individual important attributes that explain many uses of spatial relational terms, this suggests that no one attribute defines necessary conditions for the use of a spatial relational term. Therefore, I argue that the values of the attributes influence the acceptability of spatial relational terms much like preference rules function within a preference rule system (cf. Jackendoff, 1983, 1985). Although they do not place necessary conditions on the use of a

spatial relational term, the values of the attributes represent the optimal states of affairs for application of the term.

In the rest of this section, I employ a case study of the English prepositions *in* and *on* to explain the componential approach that I have adopted, in which each of the meaning components corresponds to a weighted attribute of spatial scenes. In section 4.3.1, I discuss the rationale behind weighting the components. In section 4.3.2, I discuss the relative influence of the three most important attributes — geometry, function, and qualitative physics — leading to the relative weights hypothesized for these attributes for the lexical entries of *in* and *on*. Following that, in section 4.3.3, I address the issue of specification of the values of the attributes. Next, in section 4.4.4, I describe how scenes in the world might be compared to the lexical entries of spatial relational terms in order to determine whether a given spatial relational term can describe the scene. In order to demonstrate the way in which the approach to the meaning of spatial relational terms proposed in this dissertation accounts for the meanings of actual spatial relational terms, I apply it to uses of the English spatial prepositions *in* and *on* in sections 4.3.5 and 4.3.6. Finally, in section 4.3.7, I discuss the process of choosing a spatial relational term in a situation where information about the values of some of the attributes is missing.

4.3.1 The status of the attributes as meaning components

There are four possibilities for the way in which attributes of spatial scenes, as components of the meanings of spatial relational terms, may contribute to the meaning of spatial relational terms. The attributes may (a) form a set of necessary and sufficient conditions on the use of a term; (b) be ranked; (c) be unordered, yet differentially weighted; or (d) remain unordered and equally weighted.

As argued in section 4.2 and in Chapter 1, section 1.2, neither the geometries nor the functions proposed as the basis for the meanings of spatial relational terms are necessary for appropriate uses of the terms. For example, the relation of the pear to the bowl in Figure 4.3a can be described using *in* despite the fact that the pear is not actually included in the bowl. Similarly, although the relation of the circle to the line in Figure 4.2 can be described using *on*, it is less clear that the line could fulfill the function of a bearer. In my approach, I assume that the values specified for *geometry* and *function* in the lexical entries of *in* and *on* are those that have been proposed in previous accounts of the meanings of spatial relational terms (e.g., Bennett, 1975; Coventry et al., 1994; Herskovits, 1986; Vandeloise, 1991, 1994). Because of examples demonstrating that the terms may appropriately describe scenes that do not match these specified values, it is possible to rule out an analysis requiring that all the attributes define necessary and

sufficient conditions. Further, I propose that possibility (d) can be ruled out due to the differential effects of the various attributes reported in Chapter 3, leaving the two possibilities: (b) that the components are ranked or (c) that they are unordered, yet weighted.

If the attributes are ranked, then whenever the most highly ranked attribute applies to a scene, the acceptability of a given term is based on whether or not the scene matches the value of the most highly ranked attribute. If the most highly ranked attribute does not apply to a scene, the other attributes are considered in rank order until one is found that applies to the scene and can thereby license an appropriate use of a spatial relational term. On the other hand, if the attributes are merely weighted, then no single attribute, regardless of its weight, is able to license or rule out an appropriate use of a spatial relational term without consideration of the other attributes. Further, if the attributes are weighted rather than ranked, a complex of lower weighted attributes can conceivably overcome an insufficiency in even the highest weighted attribute, allowing an appropriate use of the term in question.

In order to provisionally decide between the options of ranked vs. weighted attributes, I will consider some uses of the English spatial preposition *in*, each of which conforms to proposed values for only one of *geometry* and *function*. The importance of *geometry* has been demonstrated

by various scholars (Bennett, 1975; Brown, 1994; Carlson-Radvansky & Regier, 1997; Herskovits, 1986; Landau & Jackendoff, 1993; Levinson, 1996b; Lindkvist, 1950; Talmy, 1983) in addition to being shown in Chapters 2 and 3. Similarly, the importance of the *function* of the Ground has also been demonstrated in previous research (Coventry et al., 1994; Vandeloise, 1991, 1994) in addition to influencing participants' choice between *in* and *on* in the experiments reported in Chapter 3. Due to the prevalence of these two attributes in previous approaches to the meanings of spatial relational terms, in addition to their influence on the use of spatial relational terms in the studies reported in Chapters 2 and 3, I assume here that they are the two best candidates for the most highly ranked attribute.

If the attributes influencing the meanings of spatial relational terms are ranked, then scenes to which the most highly ranked attribute applies, yet which fail to match a given term's value for that attribute, will be unable to be described by the term. If, on the other hand, the attributes are weighted but not ranked, than it will be possible for a term to describe scenes which do not match the value specified in the term's lexical entry for the most highly ranked attribute.

Both the scene depicted in Figure 4.4 and that depicted in Figure 4.5 can appropriately be described using English *in*. In the scene in Figure 4.4, the Ground is a container, conforming to the proposed value for the attribute

function (cf. Coventry et al., 1994; Vandeloise, 1991) for this term, but the scene fails to conform to the proposed value for the attribute *geometry*, inclusion (cf. Bennett, 1975; Herskovits, 1986). The scene in Figure 4.5, which depicts a table with its leaf in it, conforms to the proposed value for the attribute *geometry* for the use of *in*, but not to the proposed value for the attribute *function*: although the Ground does have a function, it is not that of a container.

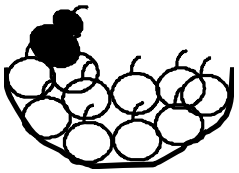

Figure 4.4 A pear *in* a bowl

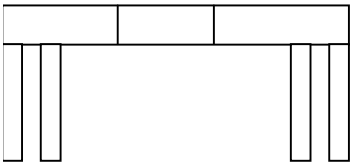

Figure 4.5 A leaf *in* a table

Both the attribute *geometry* and the attribute *function* are applicable to the scene in Figure 4.4 and to that in Figure 4.5, but each scene matches the proposed value of only one of these important attributes. Because the pear in the bowl, which fails to match the proposed value for the attribute *geometry* for the preposition *in*, is appropriately described using *in*, *geometry* cannot be the most highly ranked attribute. Similarly, because the leaf in the table,

which fails to match the proposed value for the attribute *function* for the preposition *in*, is appropriately described using *in*, *function* cannot be the most highly ranked attribute. The fact that the attributes *geometry* and *function* cannot be ranked with respect to one another suggests that the relative importance of these attributes can better be captured with a notion of differential weighting, rather than strict ranking.

4.3.2 Weighting of the attributes

Having settled on weighted attributes as a descriptive notation, in this section I will examine the relative influence of the two best candidates for the most highly weighted attribute, *geometry* and *function*[21]. In order to do this, I will investigate the applicability of *in* and *on* to situations which match the value for *function* but not *geometry*, like Figure 4.4, and to situations which match the value for *geometry* but not *function*, like Figure 4.5 (section 4.3.1 above), in addition to situations which match the values of both attributes and situations which match the value of neither. Before beginning this discussion, I need to qualify my conclusions by the fact that changes in

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[21] Although the contribution of qualitative physics is likely quite important, I assume it here to co-occur with function and I leave to future research an examination of its independent contribution.

geometry are not, strictly speaking, comparable to changes in *function*, as the values that the two attributes can take are not scalable quantities. Thus, it is not possible to equalize the extent to which a scene approximates the values specified for *geometry* and *function* in a given spatial relational term's lexical entry. However, the examples in this section, which unambiguously match or fail to match the proposed values for *geometry* and *function* for the English prepositions *in* and *on*, present a preliminary comparison of the influence of these two important attributes on the use of spatial relational terms.

Each of the examples in this section presents a Figure and a functional Ground in a particular geometric configuration. There are two ways in which a functional Ground can fail to match the value for *function* for the use of a given spatial relational term: the Ground's function[22] may differ from that specified in the spatial relational term's lexical entry, or the Ground may be unable to fulfill its function, which matches that specified in the spatial relational term's lexical entry. In this section, I will discuss examples of both types, along with examples where a Ground fulfills its function, which matches that specified in the spatial relational term's lexical entry. For each functional situation, I will look at examples where the geometry matches the

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[22] I will only be considering artifacts as Grounds in this section. The Ground's function, for the purposes of this discussion, is the function which the Ground was created to fulfill.

value for *geometry* specified in the spatial relational term's lexical entry and examples where the geometry differs from the value specified in the spatial relational term's lexical entry. I will not be considering afunctional Grounds in this section, as I hypothesize that the attribute *function* does not apply to scenes depicting afunctional Grounds (see section 4.3.4 below). Furthermore, I will not be examining the influence of the attribute *qualitative physics*, which takes values such as *support of the Figure by the Ground*, which may be important to the use of spatial relational terms (cf. Herskovits, 1986 for *on*; Vandeloise, 1991 for *sur*). Based on the scarcity of *qualitative physics* relative to *geometry* and *function* in characterizations of spatial relational terms, however, I hypothesize that the influence of *qualitative physics* is lower than that of *geometry* or *function*. I leave a detailed examination of the influence of *qualitative physics* to future research.

4.3.2.1 Function matched, geometry matched

The first class of examples that I will consider is the set of scenes which match the values specified for both *geometry* and *function* in the lexical entry of the spatial relational term in question. As will be shown, the terms in question are applicable to such situations.

For example, the scene in Figure 4.6 depicts an apple at the bottom of an upright bowl.

Figure 4.6 An apple *in* a bowl

This scene, which is appropriately described using *in,* matches the value for *function* specified for the use of *in*: the Ground, a bowl, is a container and is fulfilling its containment function. Further, the scene matches the value for *geometry*: the Figure, an apple, is included in the Ground, a bowl. The applicability of *in* can thus be explained by the fact that both the value for *function* and the value for *geometry* have been matched in this scene.

As a second example, the scene in Figure 4.7 depicts a book resting atop an upright table.

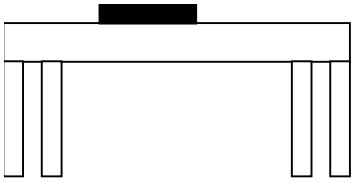

Figure 4.7 A book *on* a table

In this scene, which is appropriately described using *on*, both the value for *function* and the value for *geometry* specified for the use of *on* have been matched. The scene matches the value for *function* in that the Ground, a

table, is fulfilling the function of bearer to the Figure, a book. In addition, the scene matches the value for *geometry*: the Figure, a book, is in contact with the Ground, a table.

Both of the scenes examined in this section match the values specified for *geometry* and for *function* in the lexical entry of the spatial relational term under consideration, and in both cases the term is applicable to the scene.

4.3.2.2 Function matched, geometry not matched

The second class of examples that I will consider is the set of scenes for which the function matches that specified in a spatial relational term's lexical entry but the geometry does not. As will be shown in this section, the terms in question are applicable to these situations.

For example, the scene in Figure 4.8 depicts a pear atop a pile of apples, above the plane through the rim of the bowl that contains the fruit.

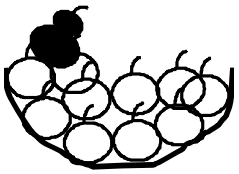

Figure 4.8 A pear *in* a bowl

This scene, which may appropriately be described using *in*, matches the value for *function* specified for the use of *in*: the Ground, a bowl, is a container and

is fulfilling its containment function. However, the scene does not match the value for *geometry*: the Figure, a pear, is not included in the Ground.

Similarly, the scene in Figure 4.9 depicts a book atop a pile of books, atop an upright table. This scene, which may appropriately be described using *on*, matches the value for *function* specified for the use of *on*: the Ground, a table, is fulfilling the function of bearer to the Figure, a book. However, the scene does not match the value for *geometry*: the Figure is not in contact with the Ground.

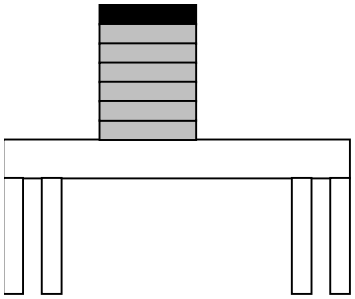

Figure 4.9 A book *on* a table

Both of the scenes discussed in this section match the value specified for *function* in the lexical entry of the spatial relational term under consideration, but neither matches the value for *geometry*. In both cases, however, the term is applicable to the scene.

4.3.2.3 Function not matched, geometry matched

As mentioned above, there are two ways in which a functional Ground can fail to match the value for *function* for the use of a given spatial relational term: the situation may prevent the Ground from fulfilling its function, which matches that specified in the term's lexical entry, or the Ground's function may differ from that specified in the term's lexical entry. As will be shown, the use of the spatial relational term in question is neither uniformly acceptable nor uniformly unacceptable in these situations.

For example, the scene in Figure 4.10 depicts an apple included in the volume of an overturned bowl. In this case, the Ground's function matches that specified in the lexical entry for the term under consideration, *in*, but the situation prevents the Ground from fulfilling its normal function.

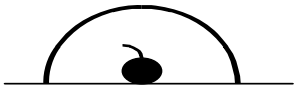

Figure 4.10 An apple not *in* a bowl

This scene matches the value for *geometry* specified for the use of *in*: the Figure, an apple, is included in the Ground, a bowl. However, the scene does not match the value for *function*: the Ground, a bowl, is a container but is not fulfilling its normal function. As Herskovits (1986) points out, it seems

wrong to say that the apple is *in* the bowl (the preference here would be for *under*).

Similarly, the scene in Figure 4.11 depicts an overturned table, upon which rests a book. As with the scene in Figure 4.10, the Ground's function matches that specified in the lexical entry for the term under consideration, *on*, but the situation prevents the Ground from fulfilling its normal function: rather than acting as bearer to the book, the overturned table acts as an obstacle preventing contact between the book and the floor, much as a rug or a pile of books might.

Figure 4.11 A book possibly *on* a table

This scene matches the value for *geometry* specified for the use of *on*: the Figure, a book, is in contact with the Ground, a table. However, the scene does not match the value for *function*: the Ground is not fulfilling its normal function. In this instance, unlike the example in Figure 4.10, the use of the spatial relational term is questionable: while *on* is not unacceptable, it does not seem to be an accurate description.

In contrast to the scenes in Figures 4.10 and 4.11, in which the Ground fails to fulfill its normal function, which matches that specified in the lexical

entry for the spatial relational term in question, in the next two examples the function of the depicted Ground differs from that specified in the lexical entry for the term in question.

Figure 4.12 shows a table which has its leaf in it, a relation appropriately described using *in*. In this scene, the Ground, a table, is functional, yet its function is not that of a container, which is the value specified for the attribute *function* in the lexical entry for *in*. The geometry of the scene, however, does match that specified in the lexical entry for *in*: the Figure is included in the Ground.

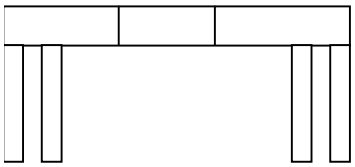

Figure 4.12 A leaf *in* a table

Similarly, Figure 4.13 depicts a scene that is appropriately described using *on*. The Ground in this instance, a bowl, does not have the normal function specified in the lexical entry for *on*; the geometry of the scene, however, does match that specified in the lexical entry for *on*: the Figure, a pencil, is in contact with the Ground, a bowl.

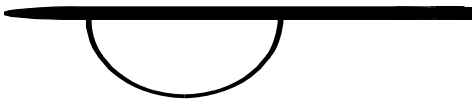

Figure 4.13 A pencil *on* a bowl

None of the scenes discussed in this section matches the value for *function* specified in the lexical entry for the spatial relational term under consideration, and all of the scenes match the value for *geometry*. Of the four scenes, two were appropriately described by the spatial relational term in question, a third exemplified a questionable use, and the fourth was unable to be described by the term.

4.3.2.4 Function not matched, geometry not matched

As will be shown in this section, the use of spatial relational terms for situations in which neither the function nor the geometry is matched, while not impossible, appears questionable.

For example, the scene in Figure 4.14 depicts a bowl filled with apples and a pear (the equivalent of the scene in Figure 4.8), then turned upside down. In this scene, which is not appropriately described using *in*, the bowl is failing to fulfill its normal function, which matches that specified in the lexical entry for *in*. Furthermore, the pear is not included in the bowl, resulting in a mismatch with the value specified for *geometry*.

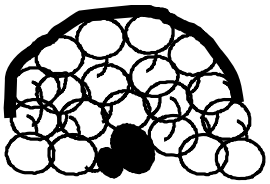

Figure 4.14 A pear not *in* the bowl

The scene in Figure 4.15 depicts a black book atop a pile of books which rests upon an overturned table. As the table is upside down, it is unable to fulfill its normal function, which matches the value for *function* specified in the lexical entry for *on*. Further, the lack of contact between the black book and the table results in a situation which fails to match the geometry specified in the lexical entry for *on*. In this situation, the use of *on* appears questionable.

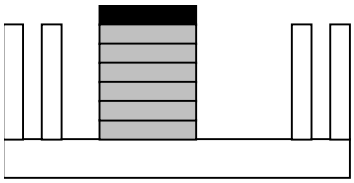

Figure 4.15 A black book that may be *on* a table

A similar pattern of acceptability emerges for scenes in which the function of the Ground does not match the value for *function* specified in the lexical entry for the term under consideration and the geometry does not match the specified value for *geometry*. The scene in Figure 4.16 depicts a table leaf resting atop a table and is not appropriately described using *in*. The Ground in this scene, a table, does not function as a container, thereby

failing to match the value for *function* specified in the lexical entry for *in*. Furthermore, the Figure, the table's leaf, is not included in the Ground, thereby failing to match the value for *geometry* specified in the lexical entry for *in*.

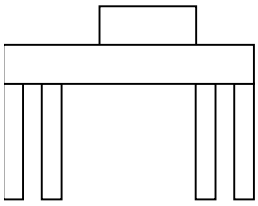

Figure 4.16 A leaf not *in* a table

The use of *on* to describe the scene in Figure 4.17, which depicts a pencil atop a pile of books atop a bowl, is questionable. The function of the Ground, a bowl, is that of a container, which does not match the value specified for *function* in the lexical entry for *on*. In addition, the Figure, a pencil, is not in contact with the Ground, resulting in a situation which does not match the value specified for *geometry* in the lexical entry for *on*.

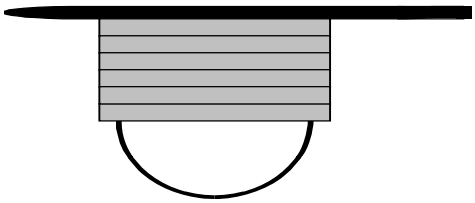

Figure 4.17 A pencil possibly *on* a bowl

None of the scenes discussed in this section matches the value for either *function* or *geometry* specified in the lexical entry for the spatial

relational term under consideration. In these cases, the use of *on* is questionable, while the use of *in* is unacceptable.

4.3.2.5 The relative weights of the attributes

In sections 4.3.2.1-4.3.2.4, I queried the acceptability of *in* and *on* to describe scenes that vary as to whether they match the values specified for *function* and for *geometry* in the lexical entries of these terms. The results of this query are summarized in Tables 4.1 and 4.2. The rows in the tables correspond to whether the value for the attribute *geometry* in the scene matches that specified in the term's lexical entry. The three columns correspond to the possibilities for matching the value specified for *function* in the term's lexical entry: (a) the value for *function* in the scene matches the value specified in the term's lexical entry ("Function matched"); (b) the scene depicts a Ground that is unable to fulfill its normal function, which matches the value for *function* specified in the term's lexical entry ("Ground fails to fulfill specified function"); or (c) the scene depicts a Ground whose normal function does not match the value for *function* specified in the term's lexical entry ("Functional mismatch"). Situations that can be appropriately described using the term are indicated with a plus; those that cannot be so described are indicated with a minus; and those for which description with

the term is questionable are marked with a question mark. An example scene for each cell is included in italics.

Table 4.1 Results for *in*

in	**Function matched**	**Ground fails to fulfill specified function**	**Functional mismatch**
Geometry matched	**+** *an apple in a bowl* *(Figure 4.6)*	**-** *an apple not in a bowl* *(Figure 4.10)*	**+** *a leaf in a table* *(Figure 4.12)*
Geometry not matched	**+** *a pear in a bowl* *(Figure 4.8)*	**-** *a pear not in a bowl* *(Figure 4.14)*	**-** *a leaf not in a table* *(Figure 4.16)*

Table 4.2 Results for *on*

on	**Function matched**	**Ground fails to fulfill specified function**	**Functional mismatch**
Geometry matched	**+** *a book on a table* *(Figure 4.7)*	**?** *a book possibly on a table* *(Figure 4.11)*	**+** *a pencil on a bowl* *(Figure 4.13)*
Geometry not matched	**+** *a book on a table* *(Figure 4.9)*	**?** *a book possibly on a table* *(Figure 4.15)*	**?** *a pencil possibly on a bowl* *(Figure 4.17)*

The tables show that if a scene matches the specified value for *function* in the lexical entry for *in* or *on*, regardless of whether or not it matches the specified value for *geometry*, it can appropriately be described using the term in question. If the scene fails to match the value for *function*, then both the

source of the functional mismatch and the status of the scene with respect to the value for *geometry* exert influence on the acceptability of the terms. As a result of this examination, I argue that the most highly weighted attribute in the set is *function*, followed by *geometry*.

I also argue that there are attributes in addition to *geometry* and *function* that influence the meanings of spatial relational terms. The influence of the qualitative physics of the scene has been demonstrated by a number of scholars (Bowerman & Choi, in press; Bowerman & Pederson, 1992, 1996; Forbus, 1983, 1984; Talmy, 1988) despite its relative scarcity in characterizations of the meanings of spatial relational terms. Due to the importance of qualitative physical characteristics such as the support provided to the Figure by the Ground, I tentatively suggest that the weight applied to the attribute *qualitative physics* is somewhat lower than that of the attribute *geometry*. Finally, I suggest that there are likely attributes of lesser importance influencing the meanings of spatial relational terms. Although many of these attributes are yet to be identified, two examples are *the animacy of the Figure*, or its capacity for self-determination, and *the animacy of the Ground*, or its capacity for self-determination (Feist & Gentner, 1997, 1998), which influenced English speakers' choice between *in* and *on* in the experiments reported in Chapter 3. I suggest that these attributes should receive lower weights than the other identified attributes in

the set, although the verification of this relative weighting requires additional research.

The set of attributes involved in the meanings of spatial relational terms is depicted in Figure 4.18. The attributes are listed according to their relative weights, with the most highly weighted at the top. There may be attributes included in the set in addition to those listed here; this possibility is represented in the figure through the use of ellipses. I leave the identification of additional attributes and the assignment of their relative weights, along with a determination of the values of the weights of the attributes, for future research.

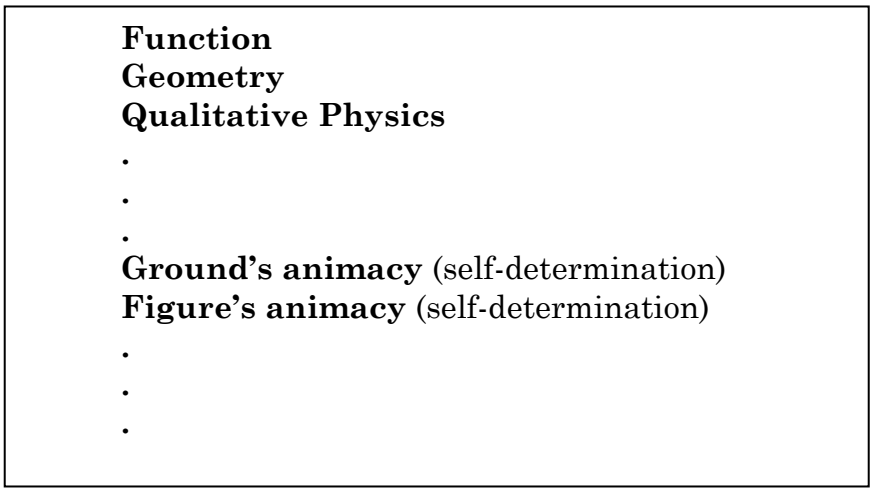

Figure 4.18 The set of weighted attributes comprising the meanings of spatial relational terms

4.3.3 Specifying the values of the attributes

The lexical entry of each spatial relational term specifies the optimal value for each attribute influencing the use of spatial relational terms. While the set of attributes is the same for all terms in all languages, the values for the attributes are specific to each term. Many of the attributes have values which refer to relations between the objects in the scene and may be based upon qualitative schemas (cf. Talmy, 1983), which result from "a process that involves the systematic selection of certain aspects of a referent scene to represent the whole, while disregarding the remaining aspects" (p. 1). Because the meanings of all spatial relational terms are built from the same set of weighted attributes, it is to be expected that these meanings will display significant similarities, such as the cross-linguistic similarities noted in Chapter 2. Variation in the meanings of the terms, such as those noted in Chapter 1, section 1.1.4, arises from individual specification of the values. I further hypothesize that variation among terms that describe similar ranges of scenes will tend to arise with respect to the less important attributes. The general tendencies in the lexicalization of *contact, support, relative vertical position*, and *inclusion* found in Chapter 2 present preliminary support for this hypothesis, as these are possible values of the highly ranked attributes *geometry* and *qualitative physics*, but further experimental work on this issue is necessary.

The specification of the values for each of the attributes raises yet another question: that of level of detail of the specification. As discussed in Chapter 2, section 2.2.1, not every attribute of a spatial scene is relevant to every term in every language. As a case in point, while a possible value for the attribute *qualitative physics*, support of the Figure by the Ground, is important to many uses of the English term *on* (see Chapter 2, section 2.1.4), there are various means by which the Ground can support the Figure, including supporting the Figure from below, as in (6a); by means of attachment at a single point from the side, as in (6b); by means of attachment at a number of points from the side, as in (6c); or by being inserted through the Figure, as in (6d) (see discussion of the influence of the nature of the support, Chapter 2, section 2.1.5).

(6) a) The cup is *on* the table.

b) The picture is *on* the wall.

c) The magnet is *on* the refrigerator.

d) The ring is *on* his finger.

In a theory of spatial relational meaning, the lexical entry for *on* could be constructed as fully specified for each of these means of support (among others), underspecified (perhaps only specifying that support of some kind is afforded the Figure by the Ground), or unspecified (leaving support out of the meaning of *on*). Full specification would likely result in four separate

meanings for *on* whereas both underspecification and lack of specification are compatible with the possibility that *on* has one unified meaning.

To begin to determine the level of specification, one can apply the syntactic test of *conjunction reduction* (Zwicky & Sadock, 1975) to determine whether *on* is unspecified or ambiguous (and therefore either fully specified or underspecified) regarding the nature of the support[23]. It is possible to reduce two sentences by conjoining them just in case the material to be deleted is identical for the two sentences (Zwicky & Sadock, 1975), as in (7). (7a) and (7b) both contain the verb phrase *are walking to the store*. In (7c), the two sentences have been combined, forming a new sentence in which *are walking to the store* is predicated of the subjects of both (7a) and (7b). This reduction, called *conjunction reduction*, is possible because the verb phrases of (7a) and (7b) are identical.

(7) a) The boys *are walking to the store*.

b) The girls *are walking to the store*.

c) The boys and the girls *are walking to the store*.

To test whether the nature of the *support* in the lexical entry of *on* is unspecified, I have applied the conjunction reduction test as follows. Since *on*

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[23] The argument to follow could be updated in terms of current theories of coordination that are formulated in terms of predication instead of VP deletion; as the structure and force of the argument remain essentially the same, I have chosen to present the argument in the form I do so that it is closer to those in the literature on ambiguity tests.

can express a situation involving any of the four means of support described above, if it is ambiguous (and therefore either underspecified or fully specified) it is to be expected that the sentences in (8) and (9) are both four-way ambiguous as to the nature of the support afforded by the box[24].

(8) The label is on the box.

(9) The stamp is on the box.

When the sentences are conjoined, repetition of the verb phrase *is on the box* is deleted, resulting in the sentence in (10).

(10) The label and the stamp are on the box.

In order for conjunction reduction to be acceptable, the deleted material must be identical for the two sentences. The necessary identity of meaning affects the level of specification that can be posited for *support* in the lexical entry for *on* in that the nature of the support afforded by the Ground must be identical in the two phrases at the level of specification in the lexical entry. If the nature of the support is unspecified, the reduced sentence in (10) should have sixteen understandings corresponding to all of the permutations of support for the label and support for the stamp. All sixteen understandings would be available because no particular means of support

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[24] Although world knowledge can eliminate support by the Ground being inserted through the Figure, the other three means of support are equally possible, leaving at least three-way ambiguity for the nature of the support afforded by the box.

would be encoded in the lexical entry for *on*. Thus, for example, sentence (10) should be able to describe a situation in which the label is affixed to the side of the box and the stamp is resting on top of the box.

If some specification of the nature of the support is encoded in the lexical entry for *on*, then the only available understandings for (10) should be those in which the nature of the support afforded the label is the same as that afforded the stamp. The possible understandings for the case that some specification is encoded are listed in (11).

(11) a) The label and the stamp are affixed to the box.

b) The label and the stamp are resting atop the box.

c) The label and the stamp are tacked to the box.

d) The label and the stamp are impaled on the box.

However, it appears that (10) lacks crossed understandings, as the situation in which the label is affixed to the box, atop of which rests the stamp, is odd as an interpretation of (10). The lack of crossed understandings for (10) allows the conclusion that there is some amount of specification as to the nature of the support afforded the Figure by the Ground in the lexical entry for *on*. As further evidence, as was discussed in Chapter 2, section 2.1.5, there are spatial relational terms in both English (e.g*., around*) and Dutch (e.g*., op*) whose applicability is dependent on specifics of the nature of

the support afforded the Figure, suggesting that such information is specified in their lexical entries.

Having ruled out a lack of specification, the remaining options are underspecification and full specification. In order to decide between underspecification and full specification, it is instructive to explore what each level of specification might entail. If the lexical entry is underspecified, the context of the utterance and knowledge about the Figure and the Ground supply the missing information such that an unambiguous understanding can be reached. If the lexical entry is fully specified, neither the context nor knowledge about the objects is necessary in order to reach an unambiguous understanding. Evidence that knowledge about the objects in the scene is important to the use of spatial relational terms comes from the experiments reported in Chapter 3. These experiments showed that the choice between the prepositions *in* and *on* is influenced by the label applied to an ambiguous Ground. Because preposition use is influenced by knowledge about the Ground, I would hypothesize that comprehension is similarly influenced, although further empirical work is necessary to establish this. Thus, I provisionally propose that the values for the attributes are underspecified in the lexical entries of spatial relational terms, requiring knowledge about the objects in the scene and the context of the utterance to reach an unambiguous understanding.

4.3.4 Comparing scenes to lexical entries

If it is the case that the lexical entries for spatial relational terms are built as suggested above, the next question to be considered here is how a speaker determines whether a scene can appropriately be described by a given term. In order to make this determination, a speaker would first need to determine which attributes apply to the scene. It is hypothesized that there will be scenes to which certain attributes will be inapplicable. For example, if a scene involves a Ground which has no conventional function (such as a square or other two-dimensional geometric figure, or a natural object such as a rock or tree), then the attribute *function* is inapplicable to the scene. Similarly, if a scene involves two-dimensional figures which cannot be moved and upon which gravity exerts no force, then the attribute *qualitative physics* is inapplicable to the scene.

After determining which attributes apply to a scene, a speaker would assess the value of each of the applicable attributes and compare them to the values stored in the lexical entry of the spatial relational term. The appropriateness of a term to a given scene is hypothesized to be a function of the extent to which the values of the attributes for the scene match the values of the attributes listed for the term.

In order to accomplish this comparison, there must be some way to determine the values of the attributes for the scenes. I propose that the

value for *geometry* is determined through visual perception of the scene, with one important exception: *inclusion*. It has been noted in the literature that the task of determining what counts as *inclusion* is often problematic (Herskovits, 1986; Vandeloise, 1991), particularly when the Ground is an open container. For example, Vandeloise (1991, p. 213) discusses the case of a fly located in the volume of containment delimited by the inner surface of a glass (Figure 4.19), which can appropriately be described as being *in* the glass.

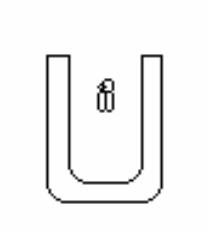

Figure 4.19 A fly *in* a glass

Because the fly is not within the material part of the glass, nor even in contact with the glass, categorization of this as an instance of *inclusion* runs counter to the geometric notion. The solution proposed by both Vandeloise (as cited in Vandeloise, 1991) and Herskovits (as cited in Vandeloise, 1991) involves an idealization in which the glass is closed with a dotted line through the rim. An alternative solution can be found in Pustejovsky's (1991) proposal that "[k]nowledge of an object includes not just being able to identify or refer, but more specifically, being able to explain how an artifact comes

into being, as well as what it is used for" (p. 422). According to Pustejovsky, this knowledge is stored in the lexicon in the noun's Qualia Structure, which is made up of "notions such as container, space, surface, figure, artifact, and so on" (p. 426). The Qualia Structure encompasses four roles: the Constitutive Role, which specifies information about what the object is made of; the Formal Role, which specifies information about the object's size, shape, position, color and orientation; the Telic Role, which specifies information about the object's purpose and function; and the Agentive Role, which specifies information about how the object came to be. What is important for our purposes is the Telic Role, because by knowing what an object is called, a perceiver would have access to information from the Telic Role in the lexical entry for the noun naming the object about whether the object is a container. The perceiver could then use this information to reason about whether or how something could be included in the object. Experiment 1, reported in Chapter 3, provides some evidence that information in a noun's lexical entry may affect spatial relational term use: participants were more likely to choose *in* if the label given to the Ground object referred to a container.

In a similar manner, a speaker might access the lexical entries for the nouns which they choose to refer to the participants in a scene in order to compare the values of the attributes for the scene to the values in the lexical entries of spatial relational terms for attributes other than *geometry*, such as

function, *qualitative physics*, or the *animacy* of the Ground and of the Figure. A speaker would need to reason about any information that is neither directly gained through perception nor obtainable from the Qualia Structures of the nouns referring to the objects in the scenes (e.g., by recourse to additional world knowledge).

While the values of the attributes for some scenes will exactly match the values of all the attributes for a given term, this situation is not expected to be common, in part due to the small inventories of spatial relational terms in all languages relative to the possible configurations of a Figure and a Ground (see, for example, Landau & Jackendoff, 1993, on the small number of spatial relational terms found in language). Further, it is possible that there are exceptions to the values of all of the attributes contributing to the meaning of spatial relational terms. As was shown in Chapter 1, section 1.2 (reviewed in section 4.2 above), characterizations of spatial relational terms have been proposed based on various individual attributes of spatial scenes. While these characterizations describe a wide range of uses of the terms, none have been without exceptions, providing evidence for this possibility. For example, the use of *in* to describe the relation of the pear to the bowl in Figure 4.20 (discussed in section 4.3.1 above) demonstrates that it is not necessary to match the specified value for *geometry*; the use of *in* to describe the relation of the leaf to the table in Figure 4.21 (discussed in section 4.3.1

above) demonstrates that it is not necessary to match the specified value for *function*.

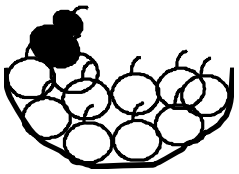

Figure 4.20 A pear *in* a bowl

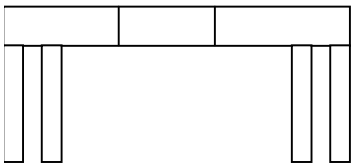

Figure 4.21 A leaf *in* a table

Herskovits (1986) mentions the use of *on* to describe the relation between a lock of hair and a forehead in the sentence in (12) (see Chapter 1, section 1.2.3.1), yet the Ground in this example, the forehead, does not support the Figure, the lock of hair, against gravity. Therefore, the situation does not match the value for the attribute *qualitative physics* specified in the lexical entry for *on* (see section 4.3.6 below). The applicability of *on* in this situation demonstrates that it is not necessary to match the value for *qualitative physics* for a term to be applicable.

(12) There is a lock of hair *on* her forehead.

Finally, the fact that both *in* and *on* can be used to describe scenes depicting either animate or inanimate Figures and Grounds, as exemplified

in (13), demonstrates that it is not necessary to match the values for these attributes, either.

(13) a) The firefly is *in* the dish.

b) The firefly is *in* the hand.

c) The coin is *in* the dish.

d) The coin is *in* the hand.

e) The firefly is *on* the dish.

f) The firefly is *on* the hand.

g) The coin is *on* the dish.

g) The coin is *on* the hand.

Given that no attribute imposes necessary conditions on the use of a term, it is necessary to decide how different the values of the attributes for a scene can be from the values of the attributes specified in the lexical entry of a candidate spatial relational terms before it becomes inappropriate to apply the term to the scene. It is here that the relative weights of the attributes become important; I hypothesize that the values of less important attributes will be able to differ relatively more than the values of more important attributes without adversely affecting the appropriateness of the term. In order for a scene for which the value of a more important attribute differs significantly from that specified in the lexical entry of a spatial relational term to still be appropriately described by the term, the values of the other

attributes would have to match quite well. As a result, a complex of lower weighted attributes may override an insufficient match for a more highly weighted attribute to create an environment in which the use of a term remains appropriate. Thus, a scene can appropriately be described by a spatial relational term if (a) the values of enough of the highly weighted attributes match, or (b) the values of a sufficient complex of lower weighted attributes match in order to override the failure to match one or more highly weighted attributes. This system is not unlike Jackendoff's (1983) preference rules, a set of non-necessary conditions pertaining to the application of a word in a given context. As the name suggests, preference rules represent preferences rather than requirements for the appropriate use of a word. Although the preference rules specify the optimal states of affairs for application of the word, no single rule need be satisfied in order for the word to be appropriate. Similarly, the specified values for the attributes correspond to the optimal states of affairs for the use of a given spatial relational term, yet no single attribute imposes necessary conditions on the use of any term.

Furthermore, the principles underlying preference rules represent conditions that are graded rather than all-or-none, as are the values that the attributes can take (see the beginning of section 4.3 above). As the values of the attributes for scenes in the world more closely approximate the values of

the attributes specified in a term's lexical entry, the applicability of the term improves. Deviations along the dimension defined by one attribute of a scene will best be allowed if the values of the attributes for the scene match the values of the other attributes in the lexical entry. This accounts for examples like those that Herskovits (1986) explained through her principle of tolerance (see Chapter 1, section 1.2.3.1), such as the conceptualization of a man as a point in order to be able to say that he is *in* a two-dimensional field. The current approach explains deviations from the ideal without recourse to additional principles by presenting the values of the attributes as preferences rather than requirements for an appropriate use.

4.3.5 English in

As discussed above, I propose that a set of weighted abstract attributes forms the basis of the lexical entries of spatial relational terms. Specifying the value of each of the attributes results in a representation of the meaning of an individual spatial relational term.

For example, the value for the attribute *function* in the lexical entry for *in* would be that the Ground functions as a container (Coventry et al., 1994; Vandeloise, 1991, 1994). The value for the attribute *geometry* would be inclusion of the Figure in the Ground (Bennett, 1975; Bowerman & Pederson,

1992, 1996; Herskovits, 1986; Miller & Johnson-Laird, 1976; Vandeloise, 1991). The value for the attribute *qualitative physics* would be that the Ground limits the position and movement of the Figure (c.f. Coventry et al., 1994; Vandeloise, 1991). Finally, the value for the attribute *animacy of the Ground* would be that the Ground is animate and self-determining, or able to exert control over its own position, while the value for the attribute *animacy of the Figure* would be that the Figure is inanimate and non-self-determining, or unable to exert such control, based on the results reported in Chapter 3. The resulting lexical entry for *in* is depicted in Figure 4.22.

in
Function: Ground as container
Geometry: inclusion
Qualitative Physics: Ground limits position and movement of Figure
.
.
.
Ground's animacy (self-determination): animate (self-determining)
Figure's animacy (self-determination): inanimate (non-self-determining)
.
.
.

Figure 4.22 The lexical entry for *in*

In the remainder of this section, I demonstrate the application of my approach to the meanings of spatial relational terms to a few canonical and non-canonical uses of English *in*.

4.3.5.1 An apple in a bowl

A common example of an appropriate use of *in* cited in the literature is a scene depicting one apple located at the bottom of a right side up, otherwise empty bowl (Figure 4.23) (see also section 4.3.2.1). Why is this such a good example of *in*?

Figure 4.23 The apple is *in* the bowl.

In order to know whether *in* is an appropriate term to describe the spatial relation depicted in this scene, one must compare the values of the attributes for the scene with the values of the attributes specified in the lexical entry for *in*. The value for the attribute *function* in the scene matches that specified in the proposed lexical entry for *in*: an examination of the Telic Role in the Qualia Structure for the Ground, *bowl,* reveals that the Ground is a container. Additionally, the scene matches the value for *geometry*: the apple

is fully included in the volume demarcated by the bowl. Furthermore, the scene matches the value for *qualitative physics*: the Ground limits the position and movement of the Figure. Finally, the Figure is inanimate and non-self-determining, matching yet another of the attribute values. The canonical nature of this scene as an example of the use of English *in* can be explained by the fact that so many of the attribute values are matched. The results of comparing the values of the attributes for the scene in Figure 4.23 to the values specified in the proposed lexical entry for *in* are presented in Table 4.3. In this table and the tables that follow, the attributes are given in the first column, with the highest-weighted attributes listed first. The overall applicability of the term is determined by combining the goodness of fit for all the attributes, each contributing according to its weight. If this combined goodness of fit exceeds some threshold of applicability (which might vary with context) then the term can be applied.

Table 4.3 Why the apple is *in* the bowl

Attribute	**Value in lexical entry for *in***	**Value in scene**	**Comparison of values**
Function	Ground as container	Ground as container	Match
Geometry	Inclusion	Inclusion	Match
Qualitative physics	Ground limits position and movement of Figure	Ground limits position and movement of Figure	Match
Ground's animacy	Animate	Inanimate	Mismatch
Figure's animacy	Inanimate	Inanimate	Match

4.3.5.2 Unmatched attribute values

In the example of the apple in the bowl, four out of five of the values of the attributes specified in the lexical entry for *in* were matched in the scene. Especially important is the fact that the values for both of the highest weighted attributes, *function* and *geometry*, were matched. In this subsection, I will probe the descriptive adequacy of the current approach with respect to situations for which the value for *geometry* or *function* is not matched (see also section 4.3.2 above).

One problem case mentioned in the literature is Herskovits' (1986, p.16) example of an overturned bowl, with a potato placed such that it is at

the bowl's interior, though under it and not in contact with it (Figure 4.24) (see also section 4.3.2.3 above).

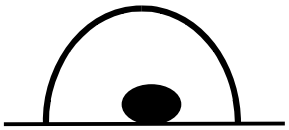

Figure 4.24 The potato is not *in* the bowl

Despite the fact that the potato is at the bowl's interior, as Herskovits points out, it seems wrong to say that the potato is *in* the bowl. Comparing the values for the attributes in this scene to the values specified in the proposed lexical entry for *in* can help explain why *in* is not considered appropriate for this scene. The scene matches the value for *geometry*, as the potato is fully included in the volume demarcated by the bowl. In addition, the scene matches the value for *qualitative physics*: the Ground limits the position and motion of the Figure. Finally, the Figure is inanimate and non-self-determining, matching another attribute value. However, the scene fails to match the value specified for *function*. Despite the fact that an examination of the Qualia Structure for *bowl* would reveal that the Ground is a container, as noted above, it would also contain information about orientation as part of the Formal Role (Pustejovsky, 1991), to which the bowl in this case certainly fails to conform. Thus, one would deduce from knowledge gleaned from the lexical entry for *bowl* that an overturned bowl is failing to fulfill its normal

function of a container. The results of comparing the values of the attributes for the scene in Figure 4.24 to the values specified in the proposed lexical entry for *in* are presented in Table 4.4.

Table 4.4 Why the potato is not *in* the bowl

Attribute	**Value in lexical entry for *in***	**Value in scene**	**Comparison of values**
Function	Ground as container	Ground not functioning as container	Mismatch
Geometry	Inclusion	Inclusion	Match
Qualitative physics	Ground limits position and movement of Figure	Ground limits position and movement of Figure	Match
Ground's animacy	Animate	Inanimate	Mismatch
Figure's animacy	Inanimate	Inanimate	Match

Unlike the example in Figure 4.24, there are some scenes for which the value for the attribute *function* fails to match that specified in the lexical entry for *in*, yet which nonetheless are appropriately described by *in*. For example, as noted in Chapter 1, section 1.2.3.2, the scene in Figure 4.25 can be appropriately described by example (14), despite the fact that it would be odd to say that the square functions as the container for the circle.

(14) The circle is *in* the square.

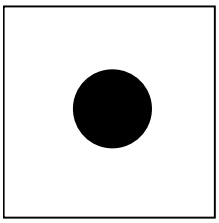

Figure 4.25 A circle *in* a square

In this situation, the only attributes whose values are matched in the scene are *geometry* and the *animacy of the Figure*. However, unlike the Ground in Figure 4.24, the Ground in Figure 4.25 is afunctional. As I argued in section 4.3.4 above, the attribute *function* is not applicable to a scene involving an afunctional Ground. Furthermore, as I also argued in section 4.3.4, the attribute *qualitative physics* is inapplicable to scenes depicting two-dimensional objects which are not subject to forces in a three-dimensional world. Thus, the scene matches the values for two of the three applicable attributes, including the most highly weighted of the three, as shown in Table 4.5 (the columns "value in scene" and "comparison of values" have been left blank for inapplicable attributes).

Table 4.5 Why the circle is *in* the square

Attribute	**Value in lexical entry for *in***	**Value in scene**	**Comparison of values**
Function	Ground as container		
Geometry	Inclusion	Inclusion	Match
Qualitative physics	Ground limits position and movement of Figure		
Ground's animacy	Animate	Inanimate	Mismatch
Figure's animacy	Inanimate	Inanimate	Match

Similarly, as discussed in section 4.3.2.3 above, the scene in Figure 4.26 is appropriately described by example 15, despite the fact that the Ground has a typical function, allowing the attribute *function* to be applicable to the scene, and the value for the attribute *function* in the scene does not match that specified in the proposed lexical entry for *in*.

(15) The leaf is *in* the table.

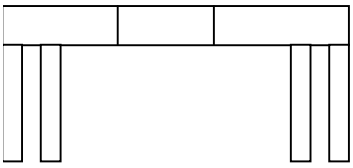

Figure 4.26 The leaf is *in* the table

In this case, the value for *geometry* is matched: the leaf is included in the table. Similarly, the value for *qualitative physics* is matched: the table

limits the position and movement of the leaf. Finally, the value for the *animacy of the Figure* is matched: the Figure is inanimate and non-self-determining. The fact that these three attribute values are matched, as shown in Table 4.6, coupled with the fact that the failure to match the value for *function* is due to functional mismatch, rather than a failure on the part of the Ground to fulfill its typical function (see section 4.3.2.5 above), results in an appropriate use of *in*.

Table 4.6 Why the leaf is *in* the table

Attribute	**Value in lexical entry for *in***	**Value in scene**	**Comparison of values**
Function	Ground as container	Ground is bearer	Mismatch
Geometry	Inclusion	Inclusion	Match
Qualitative physics	Ground limits position and movement of Figure	Ground limits position and movement of Figure	Match
Ground's animacy	Animate	Inanimate	Mismatch
Figure's animacy	Inanimate	Inanimate	Match

Finally, as discussed in section 4.3.2.2 above, the scene in Figure 4.27 is appropriately described by example 16, despite the fact that the scene does not match the specified value for *geometry*.

(16) The pear is *in* the bowl.

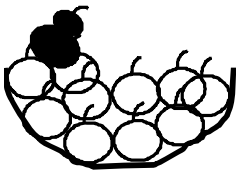

Figure 4.27 A pear *in* a bowl

Comparing the values of the attributes for the scene with the values of the attributes specified in the proposed lexical entry for *in* provides an explanation for *in*'s applicability. The scene matches the value for *function*: the Ground is a container and is fulfilling its containment function. In addition, the scene matches the value for *qualitative physics*: the Ground limits the position and movement of the Figure. Finally, the scene matches the value for the *animacy of the Figure*: it is inanimate and non-self-determining. The results of comparing the values of the attributes for the scene in Figure 4.27 to the specified values in the proposed lexical entry for *in* are presented in Table 4.7.

Table 4.7 Why the pear is *in* the bowl

Attribute	**Value in lexical entry for *in***	**Value in scene**	**Comparison of values**
Function	Ground as container	Ground as container	Match
Geometry	Inclusion	Figure not included	Mismatch
Qualitative physics	Ground limits position and movement of Figure	Ground limits position and movement of Figure	Match
Ground's animacy	Animate	Inanimate	Mismatch
Figure's animacy	Inanimate	Inanimate	Match

As demonstrated by the examples discussed in this section, the approach to the semantics of spatial relational terms proposed in this dissertation is able to account not only for uses that are considered canonical, but also for uses that must appear as exceptions in previous approaches. As will be shown in the next subsection, this situation is not idiosyncratic to the English preposition *in*.

4.3.6 English on

As with *in*, it is possible to specify the values of the attributes for the lexical entry for *on*. The value for the attribute *function* would be that the Ground functions as a bearer of the burden that is the Figure (Vandeloise,

1991). The value for the attribute *geometry* is hypothesized to be contact between the Figure and the Ground (Bowerman & Pederson, 1992, 1996; Herskovits, 1986; Miller & Johnson-Laird, 1976). The value for the attribute *qualitative physics* is that the Ground supports the Figure against gravity (Bowerman & Pederson, 1992, 1996; Herskovits, 1986), with no specific requirements as to the nature of the support. Finally, the value for the attribute *animacy of the Ground* would be that the Ground is inanimate and non-self-determining, while the value for the attribute *animacy of the Figure* is left unspecified (Chapter 3). These values are shown in the lexical entry for *on* in Figure 4.28.

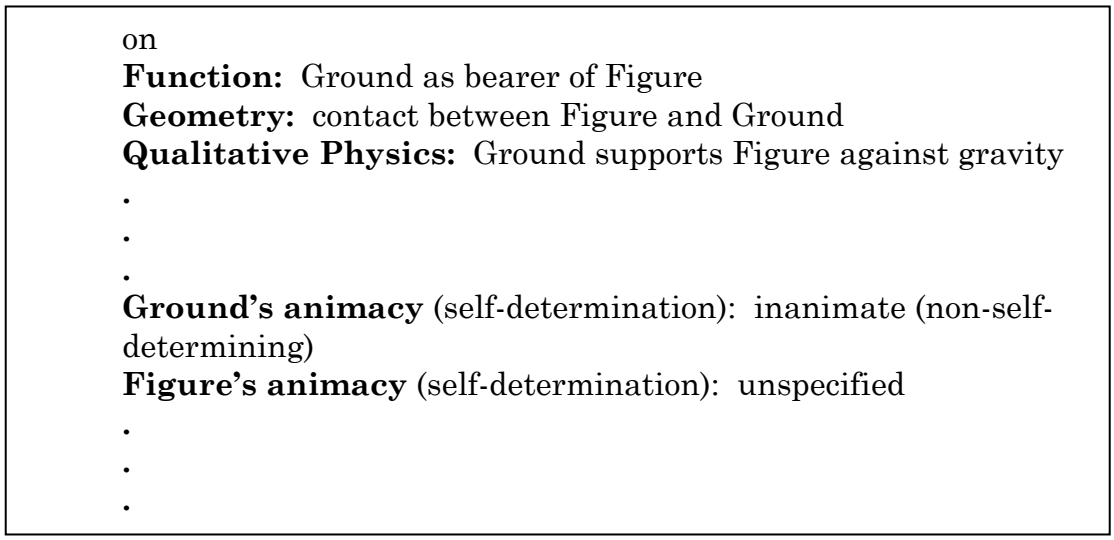

Figure 4.28 The lexical entry for *on*

In the remainder of this section, I demonstrate the application of my approach to the meanings of spatial relational terms to a few canonical and non-canonical uses of English *on*.

4.3.6.1 A book on a table

A common example of an appropriate use of *on* is to describe a scene depicting a book lying atop a table (Figure 4.29).

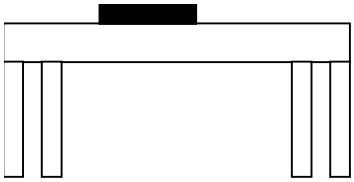

Figure 4.29 The black book is *on* the table

Comparing the values of the attributes for this scene with the attribute values specified in the proposed lexical entry for *on* provides an explanation for why this is a canonical example of *on*. First, the Ground, a table, is fulfilling the preferred function of bearer of the Figure, a book. The scene matches the value for *geometry*: the Figure is in contact with the Ground. In addition, the scene matches the value for *qualitative physics*: the Ground supports the Figure against gravity; and the scene matches the value for *animacy of the Ground*, as the Ground is inanimate. The results of

comparing the scene in Figure 4.29 to the values specified in the proposed lexical entry for *on* are presented in Table 4.8[25].

Table 4.8 Why the book is on the table

Attribute	**Value in lexical entry for *on***	**Value in scene**	**Comparison of values**
Function	Ground as bearer of Figure	Ground as bearer of Figure	Match
Geometry	Contact	Contact	Match
Qualitative physics	Ground supports Figure	Ground supports Figure	Match
Ground's animacy	Inanimate	Inanimate	Match

4.3.6.2 Unmatched attribute values

As a second example, Herskovits (1986) mentions the appropriate use of *on* in the sentence in (17) despite conditions in which the book is separated from the table by other objects rather than being in direct contact with the table (Figure 4.30; see also section 4.3.2.2).

(17) The book is *on* the table.

[25] As the animacy of the Figure is hypothesized to be unspecified in the lexical entry for *on*, it has been left off of this and subsequent tables relating to the use of *on*.

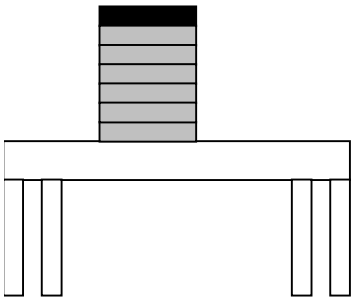

Figure 4.30 The black book is *on* the table

In this case, although the scene does not match the value for *geometry*, it does match the values for *function, qualitative physics*, and *the Ground's animacy*, as in the above canonical example, as shown in Table 4.9.

Table 4.9 Why the black book is *on* the table

Attribute	**Value in lexical entry for *on***	**Value in scene**	**Comparison of values**
Function	Ground as bearer of Figure	Ground as bearer of Figure	Match
Geometry	Contact	No contact	Mismatch
Qualitative physics	Ground supports Figure	Ground supports Figure	Match
Ground's animacy	Inanimate	Inanimate	Match

Similarly, as discussed in section 4.3.2.3, there are allowable uses of *on* to describe scenes which fail to match the value for *function*, including the scene in Figure 4.31, which can be described using example (18).

(18) The circle is *on* the line.

Figure 4.31 A circle *on* a line

The only attributes with values that this scene matches are *geometry* and the *animacy of the Ground* (Table 4.10). As in the case of the square in the circle, however, the Ground is afunctional and both the Figure and the Ground are two-dimensional objects which are not subject to forces such as gravity. As argued in section 4.3.4, the attribute *function* is inapplicable to a scene depicting an afunctional Ground and the attribute *qualitative physics* is inapplicable to a scene depicting two-dimensional objects not subject to the forces of a three-dimensional world (as in Table 4.5, the columns "value in scene" and "comparison of values" have been left blank for inapplicable attributes). Thus, matching only the values of *geometry* and the *animacy of the Ground* is in this case sufficient for an appropriate use of the English preposition *on*. It is helpful to also note that this scene is visually parallel to a two-dimensional projection of a three-dimensional scene such as the book on the table depicted in Figure 4.29, which is canonically described using *on*, further explaining *on*'s applicability.

Table 4.10 Why the circle is *on* the line

Attribute	**Value in lexical entry for *on***	**Value in scene**	**Comparison of values**
Function	Ground as bearer of Figure		
Geometry	Contact	Contact	Match
Qualitative physics	Ground supports Figure		
Ground's animacy	Inanimate	Inanimate	Match

As with *in*, *on* can appropriately describe scenes which fail to match the value specified for the most highly weighted attribute, *function*. An example is the scene depicted in Figure 4.32, which can be described by example (19).

(19) The pencil is *on* the bowl.

Figure 4.32 A pencil *on* a bowl

On's applicability to this scene is evident from a comparison of the values of the attributes for the scene with those specified in the lexical entry for *on* (Table 4.11). The scene matches the value for *geometry*: the Figure is in contact with the Ground. Furthermore, it matches the value for *qualitative physics*: the Ground supports the Figure against gravity. Finally,

it matches the value for the *animacy of the Ground*: the Ground is inanimate and non-self-determining.

Table 4.11 Why the pencil is *on* the bowl

Attribute	**Value in lexical entry for *on***	**Value in scene**	**Comparison of values**
Function	Ground as bearer of Figure	Ground is container	Mismatch
Geometry	Contact	Contact	Match
Qualitative physics	Ground supports Figure	Ground supports Figure	Match
Ground's animacy	Inanimate	Inanimate	Match

Finally, as discussed in section 4.3.2.3, the use of *on* is questionable for scenes depicting a Ground with a function matching that specified in the lexical entry for *on* but unable to fulfill its function, such as the scene in Figure 4.33.

Figure 4.33 A book possibly *on* the table

In this example, as in the example in Figure 4.24 (section 4.3.5.2), the Ground is unable to fulfill its normal function, resulting in a situation which does not match the value specified for the attribute *function* in the proposed lexical entry for *on*. The scene does match the values for *geometry*,

qualitative physics, and the *animacy of the Ground*, however, as shown in Table 4.12.

Table 4.12 Why the book may be *on* the table

Attribute	**Value in lexical entry for *on***	**Value in scene**	**Comparison of values**
Function	Ground as bearer of Figure	Ground not configured to be bearer	Mismatch
Geometry	Contact	Contact	Match
Qualitative physics	Ground supports Figure	Ground supports Figure	Match
Ground's animacy	Inanimate	Inanimate	Match

Unlike the apple and the upside-down bowl in section 4.3.5.2, which could not be described using *in* despite matching the values of three of the five attributes in the lexical entry for *in*, the scene in Figure 4.33, which matched the values of a comparable three attributes in the lexical entry for *on,* exemplified a questionable use of the term. It is possible that this difference between *in* and *on* may indicate that, in addition to individually specifying the values of the attributes, spatial relational terms individually specify the values of the weights of the attributes. I leave the resolution of this issue to future research.

4.3.7 Dealing with missing information

Sometimes information about an attribute is unavailable, as in Experiments 2a and 2b of Chapter 3. In the case of Experiment 2a, in which nouns were not provided to label the Figure and the Ground, participants lacked functional information about the inanimate Ground. In spite of this, they were able to complete the sentences like the one in (20) based on the pictures. The pictures depicted scenes in which either a firefly or a coin was placed in the center of either a hand or an ambiguous dishlike tray, providing information about the attributes *geometry*, *qualitative physics*, *animacy of the Ground,* and *animacy of the Figure*.

(20) A is IN/ON B.

Similarly, in Experiment 2b, participants were asked to choose between *in* and *on* to complete the sentences in (21) in the absence of pictures.

(21) a) The firefly is IN/ON the hand.

b) The firefly is IN/ON the dish.

c) The coin is IN/ON the hand.

d) The coin is IN/ON the dish.

The lack of pictures meant that participants had to make this choice without access to information about the values of the attributes *geometry* and *qualitative physics* for the scenes they might be describing; despite this, the participants were capable of completing the task (there were no complaints

from participants that the task was impossible, and the task was quickly completed by all participants). In this particular task, people had access to information about the Ground's function, the Ground's animacy, and the Figure's animacy through the nouns used to refer to the Ground and the Figure; from information in the Qualia Structure in the lexical entries for the nouns, one can fill in the values for these attributes. Had I presented participants with similar sentences using novel nouns, as in example (22), the task would likely have been impossible, since participants would lack information available in the Qualia Structure of the nouns.

(22) The blick is IN/ON the dax.

Based on the evidence presented in Chapter 3, speakers seem able to easily adjust to a lack of information about a portion of the attributes as long as sufficient evidence can be gathered about the others, providing evidence that a given term may be used if enough of the information about the described scene matches the values of the attributes specified in the lexical entry for the term. I leave to future research the questions of how much missing information speakers can overcome, and how speakers' ability to adjust to a lack of information interacts with the relative weights of the attributes.

I hypothesize that missing information is left unspecified when comparing the values of the attributes for a situation in the world to the values of the attributes stored in the lexical entry for a spatial term. The

information available is tabulated, and if the values of the attributes for the scene match enough of the attribute values in the lexical entry, the term will be applied. In the case that the scene matches few attribute values, it will be most likely that the term will apply if the matched values are those of heavily weighted attributes.

4.4 Conclusions

Previous work on the semantics of spatial relational terms has demonstrated the importance of both the geometry of a described scene and the function of the Ground to the application of the terms. However, neither of these attributes alone is able to account for all uses of a given spatial relational term, as demonstrated in Chapter 1, section 1.2 and in section 4.2 above. Furthermore, the results of the set of experiments reported in Chapter 3 suggest that the meanings of spatial relational terms are dependent on a complex set of interacting factors rather than on *geometry* or *function* alone. In addition, the results presented in Chapter 3 and the cross-linguistic similarities presented in Chapter 2 suggest that the influence of the various attributes is unequal. In keeping with these findings, I proposed that the meanings of spatial relational terms are built upon a set of weighted attributes of spatial scenes.

This proposal can account for various uses of spatial relational terms, as suggested by the examples in sections 4.3.5 and 4.3.6 above. In addition, this approach would predict that speakers' choice between competing spatial relational terms would vary according to the extent to which the values of the attributes for a scene approximate the values specified in the lexical entries of the terms in question, a prediction that is borne out by the use of the prepositions *in* and *on* in the experiments reported in Chapter 3.

Through its recognition of the complex set of interacting attributes that influence the use of spatial relational terms, this approach provides a means of representing the meanings of a wide variety of spatial relational terms in multiple languages. By making explicit the ways in which attributes of scenes in the world influence the meanings of the terms used to describe them, this approach may add to our understanding of how spatial terms behave across languages.

Chapter 5: Conclusions

5.1 Summary of the main points

In this dissertation, I presented an approach to the semantics of spatial relational terms motivated by the dual need to allow for universals in how humans talk about space and to account for the variation noted in how different languages encode spatial relations. Unlike previous approaches to the semantics of spatial relational terms (discussed in Chapter 1, section 1.2), which resulted from the examination of the terms of one language, the approach proposed in this dissertation resulted from the examination of the terms used to describe a small set of scenes in a variety of languages. In addition, previous approaches to the semantics of spatial relational terms focussed on one attribute of spatial scenes as the determinant of spatial relational meaning. In contrast, I found that a variety of attributes of spatial scenes influence the meanings of spatial relational terms.

In order to elicit comparable terms in multiple languages, I presented a set of scenes that would be described in English using the prepositions *in* and *on* to speakers of a variety of languages (Chapter 2). I then examined the groups of scenes described by each of the elicited terms in search of the attribute or attributes uniting the group. Comparison between the groups

described by the elicited terms led to the identification of the set of general tendencies listed in (1).

(1) a) Terms encode the presence of *contact* or the presence of a difference in *relative vertical position* of the Figure and the Ground.

b) Terms are unlikely to encode both the presence of *contact* and the presence of a difference in *relative vertical position* of the Figure and Ground.

c) If a term encodes *inclusion* of the Figure in the Ground, it is likely to be acceptable for both full and partial inclusion.

These general tendencies show that there exist important similarities in how the languages of the world lexicalize spatial relational meaning, suggesting that it may be viable to pursue a framework for representing the meanings of spatial relational terms that can be extended to the terms of many languages. In addition, as each of these tendencies relates to values of the attribute *geometry*, they demonstrate the importance of *geometry* to the meanings of spatial relational terms.

In order to closely examine the influence of a few attributes of spatial scenes on the use of spatial relational terms, I adapted Labov's (1973) method for studying complex interacting factors in the use of English nouns (Chapter

3). I presented English speakers with a set of scenes varying with respect to the geometry of the Ground, general conceptual information about the Ground, specifically functional information about the Ground, and general conceptual information about the Figure. For each scene, I asked participants to choose between *in* and *on* to complete the description. I found that each of these manipulations influenced preposition choice, but that the influences were unequal. This led to the characterization that spatial relational terms, like English nouns, are influenced by a set of complex interacting factors.

Incorporating the findings of the two studies described in this dissertation, I proposed that the meanings of spatial relational terms are based on multiple attributes of spatial scenes exhibiting unequal influence (Chapter 4). These attributes, none of which is necessary for the appropriate use of any spatial relational term, comprise a set of weighted attributes upon which the meanings of all spatial relational terms are based. Each term fills in the value for each of the attributes for the term to apply to a scene. The most heavily weighted of the attributes is the attribute *function* (Coventry, Carmichael, & Garrod, 1994; Vandeloise, 1991, 1994). The attribute *geometry*, the influence of which was found to be quite widespread (Bennett, 1975; P. Brown, 1994; Carlson-Radvansky & Regier, 1997; Cienki, 1989;

Herskovits, 1986; Landau & Jackendoff, 1993; Levinson, 1996b; Lindkvist, 1950; Talmy, 1983), has a slightly lower weight than does *function*, followed by *qualitative physical properties* (Bowerman & Choi, in press; Bowerman & Pederson, 1992, 1996; Forbus, 1983, 1984; Talmy, 1988), and attributes relating to the nature of the Figure and the Ground, such as animacy (Feist & Gentner, 1997, 1998). Acceptable uses of spatial relational terms are those describing scenes in the world that sufficiently match the values of the attributes specified in the lexical entries of the terms. As shown in Chapter 4, sections 4.3.5 and 4.3.6, this approach is able to explain both the acceptability of appropriate uses of spatial relational terms and the unacceptability of inappropriate uses.

5.2 Future research

In the future, I plan to expand the explanatory power of the theory proposed in this dissertation in a number of ways. First, I plan to continue my examination of spatial terms used to describe scenes instantiating relations along Bowerman and Pederson's (1992, 1996) similarity gradient, discussed in Chapter 2, section 2.2.2. Through this examination, I aim to identify additional attributes of scenes in the world that are components of the meanings of spatial relational terms. I will accomplish this in two ways:

by expanding the cross-linguistic elicitation study to include a wider range of languages and by using the methods and stimuli developed for the psychological experimentation to conduct experiments such as Experiment 1 (Chapter 3) in languages other than English.

In addition to continuing my examination of the terms used for the relations along Bowerman and Pederson's similarity gradient, I plan to use the methods applied in this research to expand the range of spatial terms under study. The first set of terms that I plan to include is the set of terms used to describe scenes that English describes using the preposition *over*, as these terms may overlap in their range of application with the terms examined in this dissertation (Bowerman & Pederson, 1992, 1996). In order to adapt the psycholinguistic experiment described in this dissertation to the study of additional terms, I plan to create stimuli addressing contrasts other than the *in-on* contrast described in this dissertation. It is expected that this line of research, like the expansion of the cross-linguistic elicitation study mentioned above, will suggest additional attributes to incorporate into the set.

In addition to expanding the descriptive adequacy of the approach to spatial semantics proposed in this dissertation, I plan to further my exploration into the semantics of spatial relational terms by examining the

nature of the categories named by these terms. As mentioned in Chapter 4, section 4.3, my approach is compatible with a prototype approach to word meaning (Coleman & Kay, 1981; Taylor, 1989). In order to determine whether spatial relational terms do, in fact, name prototype categories, I plan to conduct experiments modeled on those of Rosch (1973, 1975), Berlin and Kay (1969), and Coleman and Kay (1981). Through these experiments I will endeavor to determine whether the categories named by spatial relational terms have focal members, with a statistically reliable graded membership amongst a wide variety of scenes that can be named by the term.

Finally, the approach described in this dissertation related solely to the encoding of spatial relations in language. However, a full understanding of the meanings of spatial relational terms would necessarily address the issue of what a listener expects of a scene upon hearing a particular spatial relational term. In order to determine the influences present when language is decoded, I intend to adapt the methodologies developed in this dissertation to create a set of comprehension tasks.

5.3 Implications

The representation of the semantics of spatial relational terms proposed in this dissertation may have useful applications for a number of

fields. Firstly, this approach may simplify the teaching of second languages, in which students often feel that the spatial relational terms are very difficult to acquire[26]. If students are introduced to the set of weighted attributes in reference to the spatial relational terms of their native language, it will be easier for them to understand how different attributes of scenes in the world influence the appropriate use of spatial relational terms in general. Terms in the target language could then be taught via the set of attributes, so that students can learn to use them by assessing whether the scene being described matches the values of the attributes specified in the lexical entry of the term being considered.

Similarly, this approach may benefit the field of machine translation. Having specified the meanings of spatial relational terms in terms of a set of attributes such as the one I have proposed, entries for candidate translation equivalents can be compared. In the event that the scene being described is unavailable, the discourse will help fill in the actual values for the scene, as described in Chapter 4, section 4.3.3, before the system performs the comparison. Based on this comparison, an appropriate term can be chosen in the target language, thus simplifying the task of translation.

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[26] I found this to be true both of the students to whom I taught English as a Second Language at Northwestern University and of individuals whom I interviewed for a research paper written while I was an undergraduate living in Spain.

Finally, this view of the semantics of spatial relational terms has implications for the endeavor of natural language generation. Using data collected on how various scenes are described in a range of languages, the values of the weights for each of the attributes in the set may be specified, allowing the incorporation of the set into a natural language generation system. The system can compare the values of the attributes for a scene in the world with the stored preferences in the lexical entries of spatial relational terms and thus choose the best term to describe the scene.

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APPENDIX: ELICITATION DATA FROM PARTICIPANTS RAISED SPEAKING ONLY ONE LANGUAGE

Pictures	**Polish**	**Russian**	**Russian**	**Italian**	**French**	**French**
lamp over table	ponad	[nad]	[nad]	sopra	au-dessus	au dessus de
cloud over mountain	ponad	[nad]	[nad]	sopra	au-dessus	au dessus de
cup on table	na	[na]	[na]	sopra	sur	sur
book on shelf	na	[na]	[na]	su	sur	sur
cat on mat	na	[na]	[na]	su	sur	sur
face on stamp	na	[na]	[na]	"in the middle"	au centre de	sur
address on envelope	na	N/A	[na]	su	sur	sur
stamp on envelope	na	[na]	[na]	sopra	sur	sur
butter on knife	na	[na]	[na]	su	le long de	sur
bandaid on leg	na	[na]	[na]	su	sur	à
jacket on hook	na	[na]	[na]	a	à la gauche	à, sur
picture on wall	na	[na]	[na]	a	à	à, sur
phone on wall	na	[na]	[na]	a	à	à, sur
handle on door	na	[na]	[na]	su	sur	sur
balloon on stick	na	[na]	[na]	N/A	N/A	N/A
apple on branch	na	[na]	[na]	sotto	sous	sur
laundry on clothesline	na	[na]	[na]	sotto	à	sur
ribbon on candle	[naɬkowo]	[na]	[va kruk]	attorno	autours de	au milieu de
ring on finger	na	[na]	[na]	a	à, (sur)	à
papers on spindle	na	[na]	[na]	nel	sur	percés par
apple on stick	na	[na]	[na]	"crossed by"	"crossed by"	?
arrow in apple	"pierced"	[v]	[v]	attraverso	"goes through"	traverse
earring in ear	w	[v]	[v]	"hangs from"	dans	à
box in purse	w	[v]	[v]	nel	dans	dans
dog in dogbed	na	[v]	[na]	N/A	N/A	N/A
cork in bottle	na	[v]	[v]	su	dans	sur
flowers in vase	w	N/A	[v]	"coming out"	dans	dans
apple in bowl	w	[v]	[v]	dentro	dans	au fond de
owl in tree	"looks out from"	[v]	[v]	nel	dans	dans

Pictures	Hebrew	Hebrew	Hungarian	Cantonese	German	German
lamp over table	[mɫʌcn_	[mɫʌcn_	felett	[hai...s–ɒdkɒ]	über	über
cloud over mountain	[mɫʌcn_	[mɫʌcn_	felett	[hai...s–ɒdkɒ]	über	über
cup on table	[al]	[al]	-on	[hai...s–ɒdkɒ]	auf	auf
book on shelf	[al]	[al]	-on	[hai...s–ɒdkɒ]	auf	auf
cat on mat	[al]	[al]	-en	[hai]	auf	auf
face on stamp	[al]	[al]	-en	[hai...s–ɒdkɒ]	auf	auf
address on envelope	N/A	[al]	-on	N/A	N/A	auf
stamp on envelope	"pasted to"	[al]	-on	[hai]	auf	auf
butter on knife	[al]	[al]	N/A	[hai]	an, auf	an
bandaid on leg	[al]	[al]	-on	[hai]	an, (auf)	an
jacket on hook	[al]	[al]	-on	[hai]	an	an
picture on wall	[al]	[al]	-on	[hai]	an	an
phone on wall	[al]	[al]	-on	[hai]	an	an
handle on door	"connected to"	[al]	-ra, -ón	[hai...tʊɫdkɒ_	an	an
balloon on stick	"tied to"	"connected to"	N/A	[hai]	an	N/A
apple on branch	"connected to"	[al]	-on	[hai]	an	an
laundry on clothesline	[al]	[al]	-en	[hai]	an, (auf)	an
ribbon on candle	[misaviv]	[misaviv]	körül	[hai...s–ɒdkɒ]	um	um
ring on finger	[al]	[al]	-on	[hai]	an	an
papers on spindle	[al]	[bɫtox]	-ra	[hai]	auf	auf
apple on stick	[al]	[bɫtox]	-ra	[hai...n–ɟdk]	auf	auf
arrow in apple	"crosses"	[bɫtox]	-ban	"punctures"	in, durch	durch
earring in ear	[bɫ_	[b], *[bɫtox]	-ben, (-an)	[hai]	an, in	in
box in purse	[bɫvqz_	[bɫtox]	-ben	[hai...n–ɟdk]	in	in
dog in dogbed	[bɫvqz_	[bɫtox]	(-ban)	[hai]	in	N/A
cork in bottle	[bɫvqz_	[bɫtox]	-ban	[hai]	in	in (auf possible but worse)
flowers in vase	N/A	[b]	-ban	N/A	N/A	in
apple in bowl	[bɫvqz_	[bɫtox]	-ban	[hai...n–ɟdk]	in	in
owl in tree	[bɫvqz_	[bɫtox]	-ban	[hai...n–ɟdk]	in	in

Pictures	Turkish	Korean	Japanese
lamp over table	tepesinde	[viG]	ue
cloud over mountain	üzerinde	[viG]	ue
cup on table	üzerinde	[viG]	ue
book on shelf	-ta (loc) (üzerinde)	[viG]	ue
cat on mat	üzerinde	[G], [viG]	ue
face on stamp	üzerinde	[G]	naka
address on envelope	üzerinde	N/A	ni
stamp on envelope	üzerinde	[G]	no
butter on knife	üzerinde	[G]	ni
bandaid on leg	-da (loc)	[G]	ni
jacket on hook	-da	[G]	ni
picture on wall	-da	[G]	ni
phone on wall	-da	[G]	ni
handle on door	üzerinde	[G]	no
balloon on stick	N/A	[G]	N/A
apple on branch	-ta	[G]	ni, no
laundry on clothesline	-da	[G]	ni
ribbon on candle	etrafinda	[G]	ni
ring on finger	-da	[G]	ni
papers on spindle	"stuck to"	[G]	ni
apple on stick	"stuck to"	[G]	ni
arrow in apple	iqinden	"skewered"	ni
earring in ear	-da	[G]	ni
box in purse	iqinde	[ane]	naka
dog in dogbed	N/A	[G]	N/A
cork in bottle	"at the mouth of"	[G]	no
flowers in vase	-da	N/A	no
apple in bowl	iqinde	[ane]	naka
owl in tree	-da	[ane]	naka