

Chapter 10

Learning How to Structure Space for Language: A Crosslinguistic Perspective

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Space is an important preoccupation of young children. From birth on, infants explore the spatial properties of their environment, at first visually and proprioceptively, and then through action. With improved motor control during the second year of life, their spatial explorations become more complex, and they also begin to talk about space. Early comments on space revolve mostly around motions, with remarks about static position also beginning to appear in the second half of the second year. The following utterances from a nineteen-month-old girl learning English are typical:

- (1) a. *In*. (About to climb from the grocery compartment of a shopping cart into the child seat.)
- b. *Monies. In*. (Looking under couch cushions in search of coins she has just put down the crack between the cushions.)
- c. *Balls. Out*. (Trying to push round porthole pieces out of a foam boat puzzle.)
- d. *Books. Out. Books. Back*. (Taking tiny books out of a fitted case and putting them back in.)
- e. *Monkey up*. (After seeing a live monkey on TV jump up on a couch.)
- f. *Down. Drop!* (After a toy falls off the couch where she is sitting.)
- g. *On*. (Fingering a piece of cellophane tape that she finds stuck on the back of her highchair.)
- h. *Off*. (Pushing her mother's hand off the paper she is drawing on.)
- i. *Open mommy*. (Wants adult to straighten out a tiny flexible mommy doll whose legs are bent up).¹

Remarks like these attract little attention—the view of space they reflect is obvious to adult speakers of English. But their seeming simplicity is deceptive: on closer inspection, these little utterances raise fundamental and difficult questions about the relationship between the nonlinguistic development of spatial understanding and the acquisition of spatial language. How do children come to analyze complex events and relationships, often involving novel objects in novel configurations, into a set of

discrete spatial categories suitable for labeling? How do they decide which situations are similar enough to be referred to by the same word (e.g., the two *ins* above, and the two *outs*)? Why is their choice of spatial word occasionally odd from the adult point of view (e.g., *open* for unbending a doll)—and yet, at the same time, why is it so often appropriate?

For many years it has been widely assumed that the meanings children assign to spatial words reflect spatial concepts that arise in the infant independently of language, under the guidance of both built-in perceptual sensitivities and explorations with the spatial properties of objects (e.g., Johnston and Slobin 1979; McCune-Nicholich 1981; Slobin 1973). For example, the words *in* and *out* in the examples above might label preverbally compiled notions to do with containment, *on* and *off*, notions of contact and support; and *up* and *down*, notions of motion oriented with respect to the vertical dimension.

This view is buttressed by an impressive array of research findings with infants: for instance, toddlers clearly know a lot about spatial relationships before they begin to talk about them. It also draws support from studies that stress the existence of perceptual and environmental constraints on spatial cognition and that postulate a close correspondence between the nonlinguistic and linguistic structuring of space (e.g., Bierwisch 1967; H. H. Clark 1973; Miller and Johnson-Laird 1976; Olson and Bialystok 1983). In this view the similarity between child and adult use of spatial morphemes is not surprising: the properties of human perception and cognition mold both the meanings that languages encode and the spatial notions that speakers of all ages entertain.

I will argue that the path from a nonlinguistic understanding of spatial situations to knowledge of the meanings of spatial morphemes in any particular language is far less direct than this view suggests. The meanings spatial morphemes can express are undoubtedly constrained (e.g., Landau and Jackendoff 1993; Talmy 1983), but recent research is beginning to uncover striking differences in the way space is structured for purposes of linguistic expression (see also Levinson, chapter 4, this volume). To the extent that languages differ, nonlinguistic spatial development alone cannot be counted on to provide children with the *conceptual packaging* of space they need for their native language. Whatever form children's nonlinguistic spatial understanding may take, this understanding must be applied to the task of discovering how space is organized in the local language. Although the interaction in development between nonlinguistic and linguistic sources of spatial structuring is still poorly understood, recent crosslinguistic work suggests that the linguistic input begins to influence the child at a remarkably young age: for instance, the child whose utterances are shown above is barely more than a year and a half old, but her utterances already reflect a

profoundly language-specific spatial organization (Bowerman 1994, 1996; Choi and Bowerman 1991).

I first review studies suggesting that nonlinguistic spatial development indeed lays an important foundation for the child's acquisition of spatial words. But this is not enough: Next I discuss the problem created for learners by the existence of crosslinguistic differences in the way space is carved up into categories, and review some other aspects of spatial structuring that clearly must be *learned* on the basis of linguistic experience. After this stage setting, I describe two studies I have conducted, together with Soonja Choi, to explore how children who are learning languages that classify space in interestingly different ways arrive at the spatial categories of their language. Finally, I consider what these studies suggest about the interaction between nonlinguistic and linguistic factors in the acquisition of spatial semantic categories, and about the kinds of hypotheses children may bring to the acquisition of spatial words.

10.1 Cognitive Underpinnings of Spatial Semantic Development

If any domain has a plausible claim to strong language-independent perceptual and cognitive organization, it is space. The ability to perceive and interpret spatial relationships is clearly fundamental to human activity, and it is supported by vision and other highly structured biological systems (e.g., DeValois and DeValois 1990; von der Heydt, Peterhans, and Baumgartner 1984). Our mental representations of space are constrained not only by our biology but also by their fit to the world "out there": if we try to set an object down in midair, it falls, and if we misrepresent the location of something, we cannot find it later. Little wonder it has seemed likely to many investigators that the language of space closely mirrors the contours of nonlinguistic spatial understanding. Several kinds of empirical evidence indeed support the assumption that children know a great deal about space before they can talk about it, and that they draw on this knowledge in acquiring spatial words.

10.1.1 Prelinguistic Spatial Knowledge

10.1.1.1 Piagetian Theory: Building Spatial Representations through Action The original impetus for the modern-day hypothesis that children map spatial words onto preestablished spatial concepts came from the striking fit between Piaget's arguments about the construction of spatial knowledge in young children and the course of acquisition of spatial words.² According to Piaget and Inhelder (1956), spatial concepts do not directly reflect the perception of space but are built up on the level of

representation through the child's locomotion and actions upon objects during the first eighteen months or so of life. "The earliest spatial notions are thus closely bound to object functions such as containment or support, and to the child's concern with object permanence. Recall here the toddler's pleasure with pots and pans, towers and hiding games. In the next phase, children construct the spatial notions of proximity, separation, surrounding and order" (Johnston 1985, 969). After the emergence of these notions—often called "topological" because they do not involve perspective or measurement—projective and Euclidean spatial notions are gradually constructed.

This order is closely mirrored by the sequence in which children acquire locative morphemes such as the English prepositions. Locatives begin to come in during the second year of life, but their acquisition is a drawn-out affair. Within and across languages, they are acquired in a similar order: first come words for functional and topological notions of containment (*in*), support and contiguity (*on*), and occlusion (*under*); then for notions of proximity (*next to*, *beside*, *between*), and finally for relationships involving projective order (*in front of* and *in back of/behind*). This protracted and consistent order of acquisition of locatives, coupled with its correspondence to Piaget's claims about the course of development of spatial knowledge, has been taken as strong evidence that the learning of locatives is guided and paced by the maturation of the relevant spatial notions (Johnston 1985; Johnston and Slobin 1979; Parisi and Antinucci 1970; Slobin 1973).

10.1.1.2 Infant Spatial Perception With the explosion over the last decade of research on infant perception, the evidence for prelinguistic spatial concepts has become steadily more impressive. Challenging Piaget's emphasis on the critical role of action in the construction of spatial concepts, studies show that even very young infants are sensitive to many spatial and other physical properties of their environment. For example, habituation studies of infant perception have established that within the first few days or months of life, infants can distinguish between scenes and categorize them on the basis of spatial information such as above-below (Antell and Caron 1985; Quinn 1994), left-right (Quinn and Eimas 1986; Behl-Chadha and Eimas 1995), and different orientations of an object (Bomba 1984; Quinn and Bomba 1986; Colombo et al. 1984). Studies using the related technique of time spent looking at possible versus impossible events show that by a few months of age infants also recognize that objects continue to exist even when they are out of sight (Baillargeon 1986, 1987), that moving objects must follow a continuous trajectory and cannot pass through one another (Spelke et al. 1992), and that objects deposited in midair will fall (Needham and Baillargeon 1993).

The proper interpretation of such findings is still a matter of debate. Some researchers argue that children can represent and reason about the physical world with

core knowledge that is derived from neither action nor perception, but is inborn (e.g., Spelke et al. 1992; Spelke et al. 1994). Others argue instead for “highly constrained learning mechanisms that enable babies to quickly arrive at important generalizations about objects” (Needham and Baillargeon 1993, 145) or for powerful abilities to detect perceptual invariances in stimulus information (Gibson 1982). In any event, there can be little doubt that even babies well under a year of age command a formidable set of spatial abilities.

10.1.1.3 Temporal Priority of Nonlinguistic over Linguistic Spatial Knowledge Consistent with this, whenever children’s nonlinguistic understanding of particular aspects of space has been directly compared with their knowledge of relevant spatial words, an advantage is found for nonlinguistic understanding. For example, Levine and Carey (1982) found that children can successfully distinguish the fronts and backs of objects such as dolls, shoes, chairs, and stoves—as demonstrated, for example, by their ability to orient them appropriately to form a parade—well before they can pick out these regions in response to the words *front* and *back* (see also Johnston 1984, 1985 for a related study). Similarly, E. V. Clark (1973a) found that young children play with objects in ways that show an understanding of the notions of containment and support before they learn the words *in* and *on* (see also Freeman, Lloyd, and Sinha 1980).

10.1.2 Reliance on Nonlinguistic Spatial Knowledge in Learning New Spatial Words Not only do children show a grasp of a variety of spatial notions before they can talk about them, but they also seem to draw on this knowledge in learning new spatial words. Young children often show signs of wanting to communicate about the location of objects, and before acquiring spatial morphemes, they may do so simply by combining two nouns or a verb and a noun with what seems to be a locative intention, for example, “towel bed” for a towel *on* a bed, and “sit pool” for sitting *in* a wading pool (Bloom 1970; Bowerman 1973; Slobin 1973). The prepositions most often called for but usually missing in the speech of R. W. Brown’s (1973) three subjects were *in* and *on*. At a later stage, these were the first two prepositions to be reliably supplied. This pattern has suggested to researchers that the motor driving the acquisition of locative morphemes is the desire to communicate locative meanings that are already conceptualized (e.g., Slobin 1973).

10.1.2.1 Strategies for Interpreting Spatial Words Children’s nonlinguistic spatial notions also affect how they interpret spatial words in the speech they hear. For example, in an experiment assessing how children comply with instructions to place object A *in*, *on*, or *under* object B, E. V. Clark (1973a) found that her youngest

subjects put A 'in' if B was container-shaped, and 'on' if B had a flat, supporting surface, regardless of the preposition mentioned. This meant that they were almost always correct with *in*, correct with *on* unless B was a container, and never correct with *under*. Clark proposed that prepositions whose meanings accord with learners' nonlinguistic spatial strategies are acquired before prepositions whose meanings do not; hence, *in* is easier than *on*, which in turn is easier than *under*.

10.1.2.2 Rapid Generalization of Newly Learned Spatial Words Several authors have observed that children's earliest spatial morphemes extend rapidly over a wide range of referent situations that share an abstract spatial similarity. For example, reporting that a twelve-month-old child extended *up* on the first day of use "to all vertical movement of the child himself or of objects," Nelson (1974, 281) proposed that "there is a core representation of this action concept . . . something like Vertical Movement." Similarly, Bloom (1973, 29) concluded that the use of *up* by Leopold's (1939) daughter Hildegard in connection with objects and people, including herself, "is a function of the underlying conceptual notion itself." On the basis of data from her two subjects, Gruendel (1977) concurred that "'upness' is an early-cognized or conceptualized relation" and added that *in* also "appeared from the outset to take a readily generalizable form, suggesting that meaning relations had been articulated before production began." In studying relational words in the one-word stage speech of five children, McCune-Nicholich (1981) found that *up*, *down*, *back*, and *open*, along with several other relational words, came in abruptly, generalized rapidly, and were less likely to be imitated than other words. She concluded from this that the words encode preestablished cognitive categories—specifically, operative knowledge of the late sensorimotor period.

10.1.2.3 Underextensions and Overextensions Further evidence that children draw on their nonlinguistic spatial conceptions in acquiring spatial words is that they sometimes apply the words to a range of referents that differs systematically from the adult range. For example, English-speaking children first use *behind* and *in front of* only in connection with things located behind or in front of their own body; the intended meanings seem to be "inaccessible and/or hidden" versus "visible." Later *behind* is also used when a smaller object is next to and obscured by a larger one (*under* is also sometimes inappropriately extended to these situations). Still later, *behind* and *in front of* are also produced when an object is adjacent to the back or front of a featured object such as a doll. Finally they are also used projectively to mean "second/first in the line of sight" (Johnston 1984). According to Johnston, "when we see locative meanings change over many months in a specific, predictable fashion, we are invited to assume that new spatial knowledge is prompting growth"

(p. 421). Another example of nonadultlike usage is the common overextension of the verb *open* to actions like pulling apart paper cups or Frisbees, unlacing shoes, taking a piece out of a jigsaw puzzle, and pulling a chair out from a table (Bowerman 1978; E. V. Clark 1993; see also Griffiths and Atkinson 1978). Nonadultlike uses, whether restricted or overextended relative to adult norms, have been interpreted as strong evidence for children's reliance on their own language-independent spatial notions.

The literature just reviewed establishes that infants understand a great deal about space before they acquire spatial words, that they learn spatial words in a consistent order roughly mirroring the order in which they come to understand the relationships the words encode, and that they rely on their spatial understanding in learning new words—for example, in making predictions about what these words could mean and in extending them to novel situations. There can be little doubt, then, that non-linguistic spatial development plays an important role in children's acquisition of spatial morphemes. But does the evidence establish that children map spatial words directly onto spatial concepts that are already in place? Here there is still room for doubt.

10.2 Does Language Input Play a Role in Children's Semantic Structuring of Space?

In a dissenting view, Gopnik (1980; Gopnik and Meltzoff 1986) has argued that early spatial words do not in fact express simple spatial concepts that are already thoroughly understood, but, rather, ones that are emerging and still "problematic" for children of about eighteen months. She notes that although by about twelve to fourteen months children show an interest in how objects fall and can be balanced, and in the properties of containers, there is evidence that even fifteen- to twenty-one-month-olds do not fully understand gravity and movement into and out of containers. For instance, until seventeen months Piaget's (1954) daughter Jacqueline *threw* objects to the ground rather than dropping them, and at fifteen months she was still trying to put a larger cup into a smaller one. Gopnik (1980) suggests that language may in fact help children solve spatial puzzles during the one-word stage—for example, hearing adults say "up" and "down" in connection with their experiments with gravity "may help [children] to understand that all these preliminary actions lead to the same consequence" (p. 291).

How can we reconcile Gopnik's hypothesis that eighteen-month-olds learn words for spatial concepts that are still problematic for them with evidence that much younger babies have a relatively sophisticated perceptual understanding of space? To explain the discrepancy between what infants seem able to perceive and how they act upon objects (or do not act—cf. infants' failure to search for hidden objects despite evidence they remember the existence and location of these objects; see Baillargeon

et al. 1990), some researchers have suggested that core knowledge of the physical properties of objects and their relationships is modular, and at first somewhat inaccessible to other domains of child thought and action (Spelke et al. 1994). Others point to early limitations in problem-solving skills. In order to successfully manipulate space, children not only must have spatial knowledge but also be able to devise and execute a situation-appropriate plan, and this often appears to be difficult for reasons independent of the actor's spatial understanding (Baillargeon et al. 1990).

For some spatial notions, however, there is reason to suspect that despite evidence for some early perceptual sensitivity, understanding may still be incomplete until eighteen months of age or beyond (see also Gopnik 1988). For example, by as early as six months, babies anticipate that an opening in the surface of an object allows a second, smaller object to pass through (Sitskoorn and Smitsman 1995; see also Pieraut-Le Bonniec 1987). But it is not until about seventeen to twenty months that they seem to recognize that in order to contain something, a container must have a bottom. Only at this age do they (1) look longer at an impossible event in which a bottomless cylinder seems to contain sand than at a possible event with an intact cylinder, and (2) choose with more than chance frequency an intact cup over a bottomless cup when encouraged to imitate an action of putting cubes in a cup and rattling them (Caron, Caron, and Antell 1988; see also Bower 1982, and MacLean and Schuler 1989). Similarly, although by four to six months infants recognize that an object cannot stay in midair without any support at all (Needham and Baillargeon 1993; Sitskoorn and Smitsman 1995; Spelke et al. 1992), even toddlers as old as thirty months are not surprised when a block construction stays in place after one of its two critical supporting blocks is removed (Keil 1979).

These findings are consistent with Gopnik's proposal that toddlers talk about spatial events whose properties they are still in the process of mastering, and lend some plausibility to her suggestion that linguistic input—hearing adults use the same word across a range of situations that are in some way similar—may contribute to the process of mastery. But although Gopnik stresses that language can help children to consolidate their grasp of spatial notions, she seems to assume that the form the concepts will take is ultimately determined by nonlinguistic cognition: “the cognitive concerns of all 18-month-olds are similar enough so that they will be likely to acquire the *same sorts of meanings* by the end of the one-word period” (Gopnik and Meltzoff 1986, 219, emphasis added). So linguistic input serves primarily to reinforce natural tendencies; it does not in itself introduce novel structuring principles.

As long as we restrict our attention to children learning our own native language, we have no reason to doubt that linguistic input can at most only help to reinforce spatial concepts that children will acquire in any event. This is because the spatial categories of our language seem so “natural” to us that it is easy to imagine they are

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the inevitable outcome of cognitive development. But a close look at the treatment of space in diverse languages suggests that language may play a more powerful structuring role than Gopnik suggests. For example, hearing the same word repeatedly across differing events might draw children's attention to abstract properties shared by these events that might otherwise pass unnoticed. Let us consider this possibility more closely.

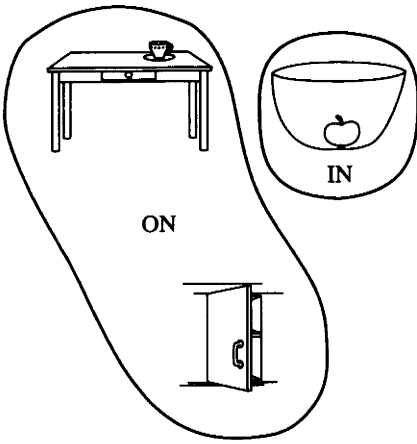
10.2.1 Crosslinguistic Perspectives on Spatial Categorization

Objectively speaking, no two objects, events, attributes, or spatial configurations are completely identical—consider two dogs, two events of falling, or two acts of kindness. But each discriminably different referent does not get its own label: one of the most basic properties of language is that it carves up the world into (often overlapping) *classes* of things that can all be referred to with the same expression, such as *dog*, *pet*, *fall*, *open*, and *kindness*. These classes, or categories, are composed of entities that can be treated as alike with respect to some equivalence metric.

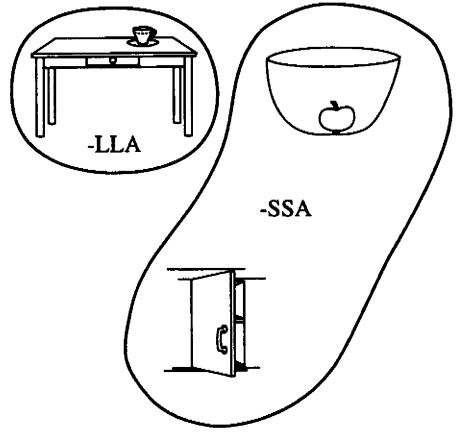
Under the hypothesis that preexisting spatial concepts provide the meanings for children's spatial words, it is assumed these concepts provide the grouping principles, or, put differently, the metric along which a word will be extended to novel situations. But what principles are these? Here it is critical to realize that there is considerable variation across languages in which similarities and differences “count” in establishing whether two spatial situations belong to the same spatial semantic category—that is, can be referred to with the same spatial morpheme.

As a simple illustration, let us consider some configurations involving the often-invoked notions of contact, support, and containment: (a) “cup on table,” (b) “apple in bowl,” and (c) “handle on cupboard door” (cf. figure 10.1). In many languages, relationships involving contact with and support by a vertical surface, such as “handle on cupboard door,” are treated as similar to relationships involving contact with and support by a more-or-less horizontal surface, such as “cup on table.” In English, for example, the spatial relationships in (a) “cup on table” and (c) “handle on cupboard door” are both routinely called *on*; a different word—*in*—is needed for “containment” relations like (b) “apple in bowl.” This grouping strategy (shown in figure 10.1a) seems to make perfect sense: after all, both “cup on table” and “handle on door,” but not “apple in bowl,” involve contact with and support by an external surface.

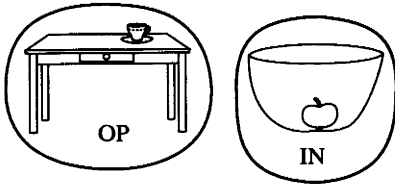
But sensible as this strategy may seem, not all languages follow it. In Finnish, for example, situations like (c) “handle on cupboard door” are grouped linguistically with those like (b) “apple in bowl” (both are encoded with the inessive case ending *-ssa*, usually translated as “in”); for (a) “cup on table” a different case ending (the adessive, *-lla*, usually translated as “on”) is needed. The motivation for this



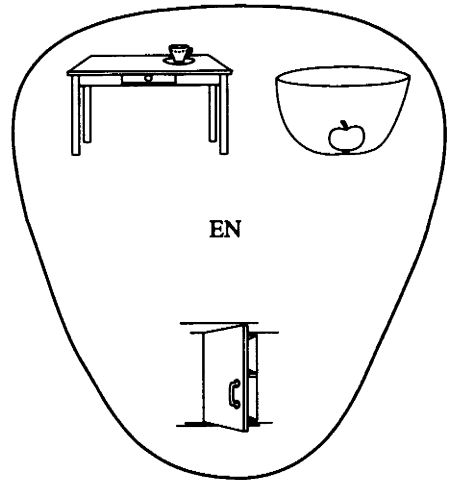
a. English



b. Finnish



c. Dutch



d. Spanish

Figure 10.1
Classification of three static spatial situations in English, Finnish, Dutch, and Spanish.

grouping—shown in figure 10.1b—may be that attachment to an external surface can be seen as similar to prototypical containment, and different from horizontal support, on a dimension of “intimacy” or “incorporation” (other surface-oriented configurations that can be encoded with the case ending *-ssa*, “in,” include “Band-aid on leg,” “ring on finger,” “coat on hook,” “sticker on cupboard,” and “glue on scissors”); Bowerman, 1996).

In still a third pattern, exemplified by Dutch, situations like (c) can be collapsed together with neither (a) (*op* ‘on₁’) nor (b) (*in* ‘in’), but are characterized with a third spatial morpheme, *aan* ‘on₂’, that is somewhat specialized to relations of hanging and other projecting attachment, (e.g., “picture on wall,” “apple on twig,” “balloon on string,” “coat on hook,” “hook on door”); Bowerman 1989, 1996); this pattern is shown in figure 10.1c. And in a fourth pattern, displayed by Spanish, it is quite unnecessary to differentiate among (a), (b), and (c)—a single preposition, *en*, can comfortably be applied to all of them! (figure 10.1d). (If desired, the situations can be distinguished by use of *encima de* ‘on top of’ for (a) and *dentro de* ‘inside of’ for (b)).³ These various classification patterns, although different, all make good sense—class membership is in each case established on the basis of an abstract constancy in certain properties, while other properties are allowed to vary.

In still other languages, the familiar notions of “contact and support” and “containment” undergo much more radical deconstruction than in the examples shown so far. For example, in Tzeltal, a Mayan language of Mexico, there is no all-purpose containment word comparable to English *in* (P. Brown 1994). Different forms are needed to indicate that

- (2) a. A man is *in* a house (*ta y-util* ‘at its-inside’)
- b. An apple is *in* a bowl (*pachal* ‘be located’, of something in a bowl-shaped container or of the container itself)
- c. Water is *in* a bottle (*waxal* ‘be located’, of something in a taller-than-wide rectangular or cylindrical object or of the object itself)
- d. An apple is *in* a bucket of water (*t’umul* ‘be located’ immersed in liquid)
- e. A bag of coffee is *in* a pot (*xojol* ‘be located’, having been inserted singly into a closely fitting container)
- f. Pencils are *in* a cup (*xijil* ‘be located’, of long/thin object, having been inserted carefully into a bounded object)
- g. A bull is *in* a corral (*tik’il* ‘be located’, having been inserted into container with a narrow opening).

Similarly, in Mixtec, an Otomanguean language also spoken in Mexico, there is no all-purpose contact-and-support word comparable to English *on*. Instead, spatial relationships between two objects are indicated by invoking a “body part” of the

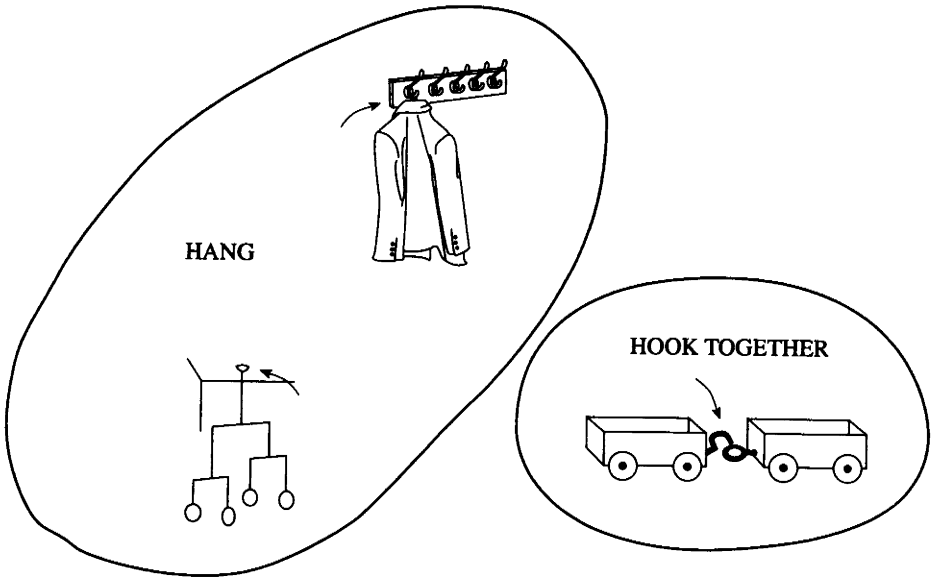
reference object in a conventionalized but completely productive way (Brugman 1983, 1984; Lakoff 1987). For example:

- (3) a. A man *on* a roof ([be.located] *sikì-βeʔe* ‘animal.back-house’)
 b. A man *on* a hill (. . . *šini-yúku* ‘head-hill’)
 c. A cat *on* mat (. . . *nũũ-yuu* ‘face-mat’)
 d. A man *on* a tree branch (. . . *ndaʔa-yúnu* ‘arm-tree’).

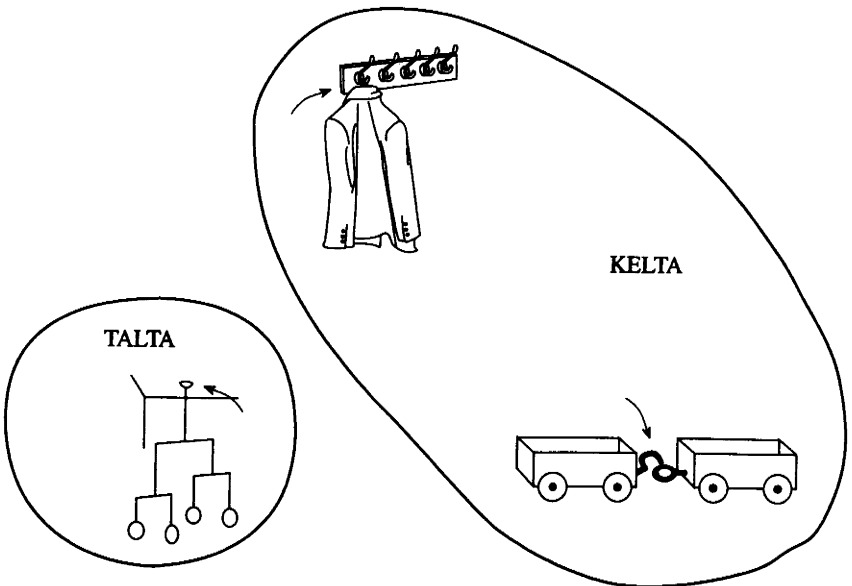
Some of these forms can also be used for an area adjacent to the named “body part” of the reference object, for example, [be.located] *šini-yúnu* ‘head-tree’ could be said of a bird either located *on* the top of a tree, or hovering *above* the tree. Comparable body part systems are also employed by Tzeltal and other Mayan languages (Levinson 1994) and many other languages of Meso-America and Africa, although details of body-part assignment vary widely (Heine 1989; MacLaury 1989).

Let us take an example from a different domain, manipulations of objects. Consider these three actions: (a) “hanging up a coat,” (b) “hanging up a mobile,” and (c) “hooking two toy train cars together.” English speakers will typically use *hang* (*up*) for both (a) and (b), conceptualizing them as similar on grounds that in both events, an entity is arranged so that it dangles downward with gravity. They will use a different expression—perhaps *hook together*—for (c), which lacks this property. This categorization pattern is shown in figure 10.2a. Korean speakers will make a different implicit grouping, using the verb *kelta* for both (a) and (c), and a different verb, *talta*, for (b). (Korean lacks the semantic category associated with English *hang*.) This pattern is shown in figure 10.2b. Why is hanging up a coat assigned to the same spatial category as hooking together two train cars? Because of the way they are attached: in both events, an entity is fixed to something by mediation of a hooking configuration (*kelta*), whereas in the “hanging a mobile” event shown in (b), the entity is attached directly (*talta*; this verb could also be used for attaching a sideways-projecting handle to a door).

Notice that both these classification strategies can achieve the same communicative effect—e.g., to call a listener’s attention to an action of hanging up a coat. But they do so in different ways. When English speakers use *hang* for hanging up a coat, they assert that the coat is arranged so that it dangles with gravity, but they say nothing about how it is attached; the listener must infer the most likely kind of attachment on the basis of his knowledge of how dangling coats are usually attached. Conversely, when speakers of Korean use *kelta* for the same action, they assert that the coat is attached by hooking, but they say nothing about dangling with gravity; again, the listener must infer on the basis of his world knowledge that when coats are hooked to something, dangling with gravity is likely to ensue. For communicative purposes, then, the expressions of the two language are equivalent: in concrete contexts, they



a. English



b. Korean

Figure 10.2
Classification of three actions in English and Korean.

can invoke the same scenes in the listener's mind. But the spatial concepts underlying the words are different, and so, consequently, are the overall sets of events they pick out.

It is clear, then, that the situations that fall together as instances of "the same spatial category" vary widely across languages in accordance with differences in the properties of situations that are conventionally used to compute similarity for purposes of selecting a word. The resulting categories cross-cut each other in complex ways. For example, the situations in (3), which are distinguished in Mixtec, all involve an object resting on a horizontal supporting surface and so are relatively prototypical for English *on*. However, Mixtec does not simply subdivide the English category of *on* more finely: recall that situations that English obligatorily distinguishes as *on* versus *above* often fall together in Mixtec—both instantiate adjacency to the named body part of the reference object.

In order to talk about space, then, it is not sufficient for children to understand that objects fall if not supported, that one object can be put above, on, below, inside, or occluding another object, and so on. A perceptual or action-based understanding of what is going on in given spatial situations is probably a necessary condition for learning to talk about space, but this knowledge alone does not buy children knowledge of how to *classify* space in their language—for example, it will not tell them whether an apple in a bowl should be seen as instantiating the same spatial relationship as a bag of coffee in a pot, or whether hanging a coat should be treated as more similar to hanging a mobile or to hooking two train cars together. To be able to make these decisions in a language-appropriate way, it is essential to discover the implicit patterning in how spatial words are distributed across contexts.⁴

10.2.2 What Else Does the Child Need to Learn?

Determining the right way to categorize spatial relations is an important problem for the language learner, but it is not the only task revealed by an examination of how different languages deal with space. A few others can be briefly summarized as follows.⁵

10.2.2.1 What Do Languages Conventionally Treat as 'Spatial Relationships' to Begin With?

In the discussion of figure 10.1, I simply assumed that all the configurations shown can be construed as "spatial"—the problem was just to identify which properties languages are sensitive to in classifying them as instances of one spatial category or another. But languages in fact differ not only in how they classify spatial configurations, but also in the likelihood that they will treat certain configurations as spatial at all.

Some relationships seem to be amenable to spatial characterization perhaps in all languages—for example, a cup on a table, an apple in a bowl, and a tree adjacent

to a house. But other relationships are treated more variably. In some languages, including English, part-whole relations are readily described with the same spatial expressions used for locating independent objects with respect to each other; e.g., “the handle *on* the cupboard door (is broken)” “the muscles *in* my left calf (are sore)”, and “the lid *on* this pickle jar (has a funny picture on it).” But in many languages, analogous constructions sound odd or impossible; for example, speakers of Polish consistently use genitive constructions along the lines of “the handle *of* the cupboard door,” “the muscles *of* my left calf,” and “the lid *of* the pickle jar.”

In a second example, consider entities that do not have “good Gestalt,” such as unbounded substances like glue, butter, and mud, or bounded “negative object parts” (Herskovits 1986; Landau and Jackendoff 1993) like cracks and holes. English speakers are again relatively liberal in their willingness to treat these entities as “located objects”—e.g., “Why is there butter *on* my scissors!?” (or “Why do my scissors have butter *on* them?”) and “There’s a crack *in* my favorite cup!” But speakers of many languages resist “locating” such entities with respect to another entity, preferring instead constructions comparable to “My scissors *are buttery/have butter*” and “My cup is *cracked/has a crack*.”⁶

Differences in the applicability of spatial language to entities like butter and cracks seem to reflect pervasive crosslinguistic differences in conventions about whether constructions that are typically used for *locating* objects—for example, for narrowing the search space in response to a “where” question—can be used for describing what objects look like, or how they are configured with respect to each other (cf. Wilkins and Senft 1994). Notice that when English speakers exclaim, “Why is there butter *on* my scissors?” or “There’s a crack *in* my cup!” they are not telling their listeners “where” the butter or the crack is, but rather making an observation about the condition of the cup or the scissors. Different conventions about the use of spatial language for describing what things look like also seem to lie behind the tendency of Spanish speakers to choose constructions with *tener* ‘have’ in many contexts where English speakers would use spatial language; compare “There’s a ribbon *around* the Christmas candle” with “The Christmas candle *has (tiene)* a ribbon”.

10.2.2.2 What Should Be Located with Respect to What? The difference between directing listeners to where something is versus telling them what something looks like probably also lies at the bottom of another intriguing difference between languages. Assuming a spatial characterization of the relationship between two entities, which one will be treated as the figure (located object) and which as the ground (referent object)?

As Talmy (1983) has pointed out, it is usual for speakers to treat the smaller, more mobile object as the figure and the larger, more stable object as the ground:

- (4) a. The book is on the table.
 b. ?The table is under the book.
- (5) a. The bicycle is near the church.
 b. ?The church is near the bicycle.

This principle is likely to be universal when the purpose of language is to guide the listeners' search for an entity whose location is unknown to them. But when spatial language is used for a more descriptive purpose, languages may follow different conventions. For example, when one entity completely covers the surface of another, English consistently assigns the role of figure to the "coverer" and the role of ground to that which is covered (cf. sentences 6a and 7a). Dutch, however, reverses this assignment (sentences 6b and 7b):

- (6) a. There's paint *all over* my hands.
 b. Mijn handen zitten helemaal *onder* de verf.
 'My hands sit completely *under* the paint.'
- (7) a. There's ivy *all over* the tree.
 b. De boom zit helemaal *onder* de klimop.
 'The tree sits completely *under* the ivy.'

This difference between English and Dutch might be ascribable to the lack in Dutch of an equivalent to the English expression *all over*—but we can also ask whether the absence of such an expression may not be due to a conventional assignment of figure and ground that renders it unnecessary.

10.2.2.3 How Are Objects Conventionally Conceptualized for Purposes of Spatial Description? Many crosslinguistic differences in spatial organization are due, as discussed in section 10.2.1, to variation in the makeup of spatial semantic categories—that is, in the *meaning* of spatial words. But even when morphemes have roughly similar meanings in different languages, variations in encoding may arise because of systematic differences in the way objects are conventionally *conceptualized*.

Consider, for examples, *in front of* and *behind*. In section 10.1.2.3, it was pointed out that English-speaking children initially use these words only in the context of "featured" referent objects—objects that have inherent fronts and backs. But which objects are these? People and animals are clearly featured. Trees are often mentioned as examples of objects that are not. But it turns out that this is a matter of convention. For speakers of English and familiar European languages, trees indeed do not have inherent fronts and backs. But for speakers of the African language Chamus, they do!—the front of a tree is the side toward which it leans, or, if it does not lean, the side on which it has its longest branches (Heine 1989; see also Hill 1978 for some

systematic crosslinguistic differences in the assignment of front and back regions to *nonfeatured* objects). Cienki (1989) has suggested that many differences between English, Polish, and Russian in the application of prepositions meaning “in” and “on” to concrete situations are due to differences not in the meanings of the morphemes themselves, but in whether given referent objects are conceptualized as planes or containers. Children must learn, then, not only what the spatial morphemes of their language mean, but also how the objects in their environment should be construed for purposes of their “fit” to these meanings.

10.2.2.4 How Much Information Should a Spatial Description Convey? From among all the details that could be encoded in characterizing a given situation spatially, speakers make a certain selection. Within a language, the choice between a less versus more detailed characterization of a scene (e.g., “The vase is on the cupboard” versus “the vase is on top of the cupboard”) is influenced in part by pragmatic considerations like the potential for listener misunderstanding. But holding context constant, there are striking crosslinguistic differences in conventions for how much and what kind of information to give in particular situations (see also Berman and Slobin 1994; Slobin 1987).

For example, for situations in which objects are “in” or “on” objects in a canonical way (e.g., “cup on table”, “cigarette in mouth”), speakers of many languages, such as Korean, typically use a very general locative marker and let listeners infer the exact nature of the relationship on the basis of their knowledge of the objects. English, in contrast, is relatively picky, often insisting on a distinction between *in* and *on* regardless of whether there is any potential for confusion. But English speakers are more lax when it comes to relationships that canonically involve encirclement as well as contact and support: although they can say *around*, this often seems excessive (“ring *on/around* finger,” “put your seatbelt *on/around* you”). For most Dutch speakers, in contrast, the encoding of encirclement wherever it obtains (with *om* ‘around’) is as routine as the distinction between *in* and *on* in English. This attentiveness to encirclement may in a sense be “forced” by the lack in Dutch of an equivalent to the English all-purpose *on*: both *op* ‘on₁’ and *aan* ‘on₂’ cover a narrower range of topological relationships, and neither one seems quite appropriate for most cases of “encirclement with contact and support.”

Another kind of information that is supplied much more frequently in some languages than in others is the motion that led up to a currently static spatial situation. In English and other Germanic languages, it is common to encode a static scene without reference to this event: for example, “There’s a fly *in* my cup” and “There’s a squirrel *up in* the tree!” Although a static description of such scenes is also possible in Korean, speakers typically describe them instead with a verb that explicitly

specifies the preceding event, as suggested by the English sentences "A fly has *entered* my cup" and "A squirrel has *ascended* the tree."

There are also crosslinguistic differences in the amount of information typically provided in descriptions of motion events (Berman and Slobin 1994). Speakers of languages with rich repertoires of spatial particles, like English and German, tend to characterize motion trajectories in considerable detail (e.g., "The boy and dog fell *off* the cliff *down into* the water"), while speakers of languages that express information about trajectory primarily in the verb, such as Spanish, give less information overall about trajectory (e.g., "fell *from* the cliff"/"fell *to* the water"), and often simply imply the kind of trajectory that must have been followed by providing static descriptions of the locations of landmarks (in this case: there is a cliff above, there is water below, and the boy and dog fall).

To summarize, I have argued that different languages structure space in different ways. Most basically, they partition space into disparate and often crosscutting semantic categories by using different criteria for establishing whether two spatial situations should be considered as "the same" or "different" in kind. In addition, they differ in which classes of situations can be characterized readily in spatial terms at all, in how the roles of figure and ground are assigned in certain contexts, in how objects are conventionally conceptualized for purposes of spatial description, and in how much and what kind of information spatial descriptions routinely convey. These differences mean that there is a big discrepancy between what children know about space on a nonlinguistic basis and what they need to know in order to talk about it in a language-appropriate way.

Accounts of spatial semantic development over the last twenty-five years have neglected crosslinguistic differences like these. Among students of language acquisition there has been a strong tendency to equate "semantic structure" directly with "conceptual structure"—to view the meanings of words and other morphemes to a large extent as a direct printout of the units of human thought. But although semantic structure is certainly dependent on human conceptual and perceptual abilities, it is by no means identical: the meanings of morphemes—and often of larger constructions (Goldberg 1995)—represent a highly structured and conventionalized layer of organization, different in different languages (see Bierwisch 1981; Bowerman 1985; Lakoff 1987; Langacker 1987; Levinson, in press; Pinker 1989). In failing to fully appreciate the distinction between "conceptual" and "semantic," developmentalists have overestimated the part played in spatial semantic development by children's nonlinguistic concepts, and so underestimated the magnitude of what children must learn. In consequence, we as yet have little understanding of how nonlinguistic spatial understanding and linguistic input interact in children's construction of the spatial system of their native language.

10.3 Studying Spatial Semantic Categorization Crosslinguistically

How early in life do children arrive at language-specific spatial semantic categories? If the hypothesis is correct that the structure of spatial semantic concepts is provided—at least initially—by nonlinguistic spatial cognition, we would expect language specificity to be preceded by a period of crosslinguistic uniformity (or of individual differences that are no greater between than within languages). Hypothesizing along these lines for spatial and other meanings encoded by grammatical morphemes, Slobin (1985, 1174) proposed that “children discover principles of grammatical marking according to their own categories—categories that are not yet tuned to the distinctions that are grammaticized in the parental language”; only later are they led by the language-specific uses of particular markers to “conceive of grammaticizable notions in conformity with the speech community.” This scenario predicts extensive errors at first in the use of spatial morphemes, possibly suggestive of the guiding influence of “child-style” spatial concepts that are similar across languages.

Another possibility is that although children may perceive many properties of spatial situations, they do not start out strongly biased in favor of certain grouping principles over others. In this case they might be receptive from a very early age to semantic categories introduced by the linguistic input and quickly home in on the needed principles with relatively few errors. Of course, there are many possible gradations between the two extreme scenarios sketched here—that is, early reliance on nonlinguistic concepts versus early induction of categories strictly on the basis of the linguistic input. And some domains may be more susceptible to linguistic structuring than others. For example, Gentner (1982) has argued that the mapping between verbs and other relational words onto events is less transparent—more imposed by language—than the mapping between concrete object nouns and their referents (see also note 21 on differential transparency in another domain).

The hypothesis that language can influence the formation of children’s semantic categories from the start of lexical development played an important role in earlier views of how children learn the meanings of words. For example, Roger Brown likened the process of learning word meanings to a game (“The Original Word Game”) in which the child player makes guesses about how to classify referents on the basis of the distribution of forms in adult speech, and he suggested that “a speech invariance [e.g., hearing the same word repeatedly in different contexts] is a signal to form some hypothesis about the corresponding invariance of referent” (1958, 228). But this approach to learning word meanings has been out of fashion for a number of years.

One reason for its unpopularity is that it clashes with the contemporary stress in developmental theorizing on the need for *constraints* on word learning: “an observer

who notices *everything* can learn *nothing*, for there is no end of categories known and constructable to describe a situation” (Gleitman 1990, 12; see also Keil 1990 and Markman 1989). Another reason is that the appeal to guidance by language in the construction of semantic categories is associated with the perennially controversial Whorfian hypothesis (Whorf 1956)—the proposal that the way human beings view reality is molded by the semantic and grammatical organization of their language. The Whorfian position has seemed implausible to many, especially as infant research shows ever more clearly the richness of the mental lives of babies (although see Levinson and Brown 1994; Lucy 1992; and Gumperz and Levinson 1996 for new perspectives on the Whorfian hypothesis). But in the widespread rejection of the Whorfian hypothesis, the baby has been thrown out with the bathwater. Regardless of whether the semantic categories of our language play a role in fundamental cognitive activities like perceiving, problem solving, and remembering, we must still *learn* them in order to speak our native language fluently. But how learners home in on these categories is a topic that has been little explored.⁸

In trying to evaluate the relative strength of nonlinguistic cognitive organization and the linguistic input in guiding children’s early semantic structuring of space, a useful research strategy is to compare same-age children learning languages with strikingly different spatial categories. Because we are interested in how early children can arrive at language-specific ways of structuring space, it is sensible to focus on meanings that are known in principle to be accessible to young children (thus, ‘in’ and ‘on’-type meanings are preferable to projective ‘in front of’/‘behind’-type meanings). With this in mind, I have been exploring, in projects together with various colleagues (Soonja Choi, Dedre Gentner, Lourdes de León, and Eric Pederson), how children, and languages, handle topological notions of contact, separation, inclusion, and encirclement; functional and causal notions like support, containment, attachment, and adhesion; and notions to do with vertical motion and orientation (up and down).

10.3.1 Spatial Encoding in the Spontaneous Speech of Learners of Korean and English

In one study, Soonja Choi and I compared how children talk about spontaneous and caused motion in English and Korean (Choi and Bowerman 1991; Bowerman 1994). These two languages differ typologically in their expression of directed motion. English is what Talmy (1985, 1991) calls a “satellite-framed” language. These languages—which include most Indo-European languages and also, for example, Chinese and Finnish—characteristically express path notions (movement into, out of, up, down, on, off, etc.) in a constituent that is a “satellite” to the main verb, such as a prefix or (as in the case of English) a particle/preposition. Korean, in con-

trast, is a “verb-framed” language; these languages—which include, for example, Hebrew, Turkish, and Spanish—express path in the verb itself (Korean lacks a class of spatial particles or prepositions entirely).

For present purposes, the most important difference between English and Korean is that many of their semantic categories of path are different. In general, the prepositions and particles of English identify paths that are highly abstract and schematic, whereas most of the path verbs of Korean are more specific. For example, in English, a motion along a particular path is encoded in the same way regardless of whether the motion is spontaneous or caused (cf. “Go *in* the closet” versus “Put it *in* the closet”; “Get *out* of the bathtub” versus “Take it *out* of the bathtub”). In Korean, in contrast, spontaneous versus caused motions along a particular path are typically encoded with entirely different verb roots (cf. *tule* ‘enter’ versus *nehta* ‘put loosely in (or around)’; *na* ‘exit’ versus *kkenayta* ‘take out (or take from loosely around)’).⁹ Further, English path categories are relatively indifferent to variation in the shape and identity of the figure and ground objects, whereas Korean path categories are more sensitive to this, with the result that they subdivide and crosscut the English path categories in complex ways; this is illustrated in table 10.1 (see Choi and Bowerman 1991 for more detail). The overall tendency for path categories to be larger and more schematic in English than in Korean is no doubt related to the systematic difference in how they are expressed: with *closed-class* morphemes (prepositions and particles) in English and *open-class* morphemes (verbs) in Korean (see also Landau and Jackendoff 1993 and Talmy 1983).

If the meanings that children initially associate with spatial morphemes come directly from their nonlinguistic conceptions of space, these differences in the way spatial meanings are structured in English versus Korean should have no effect on learners’ early use of spatial words—children should extend the words on the basis of their own spatial concepts, not the categories of the input language. To see whether this is so, Choi and I compared spontaneous speech samples collected longitudinally from children learning English and Korean.¹⁰

We found that both sets of children first produced spatial morphemes at about fourteen to sixteen months (particles like *up*, *down*, and *in* for the English speakers; verbs like *kkita* ‘fit tightly’ and its opposite *ppayta* ‘unfit’ for the Korean speakers; cf. table 10.1), and began to use them productively (i.e., for events involving novel configurations of objects) by sixteen to twenty months. They also talked about similar events, for example, manipulations such as putting on and taking off clothing; opening and closing containers, putting things in and taking them out, and attaching things like Lego pieces; position and posture changes such as climbing up and down from furniture and laps; and being picked up and put down. The spatial concerns of children learning quite different languages are, it seems, quite similar at this age,

Table 10.1

Relative Sensitivity of Path Categories to Variation in Properties of Figure and Ground Objects in English and Korean

English:

<i>in</i>	(e.g., put ball <i>in</i> box, earplug <i>in</i> ear, flower <i>in</i> vase, cherries <i>in</i> basket)
<i>on</i>	(e.g., put box <i>on</i> table, sticker/magnet <i>on</i> refrigerator, hat/coat/shoes/bracelet <i>on</i>)
<i>up</i>	(e.g., put a cup <i>up</i> high, pick a child <i>up</i> , sit <i>up</i> , stand <i>up</i>)

Korean:

<i>nehta</i>	'put loosely in (or around)' (e.g., ball <i>in</i> box, loose ring <i>on</i> pole)
<i>kkita</i>	'fit tightly; put tightly in/on/together/around' (e.g., earplug <i>in</i> ear, top <i>on</i> pen, two Lego pieces <i>together</i> , tight ring <i>on</i> pole)
<i>kkoc̥ta</i>	'put elongated object to base' (e.g., flower <i>in</i> vase, hairpin <i>in</i> hair, book upright <i>on</i> shelf)
<i>tamta</i>	'put multiple object in container' (e.g., cherries <i>in</i> basket)
<i>nohta</i>	'put on horizontal surface' (e.g., box <i>on</i> table)
<i>pwuchita</i>	'stick, juxtapose surfaces that are flat, or can be conceptualized as if flat' (e.g., sticker/magnet <i>on</i> refrigerator, two Lego pieces <i>together</i>)
<i>ssuta</i>	'put clothing <i>on</i> head' (e.g., hat, scarf, mask, glasses)
<i>ipta</i>	'put clothing <i>on</i> trunk' (e.g., shirt, coat, pants)
<i>sinta</i>	'put clothing <i>on</i> feet' (e.g., socks, shoes)
<i>chata</i>	'put clothing <i>on/at</i> waist or wrist' (e.g., belt, diaper, dagger, bracelet)
<i>ollita</i>	'cause to ascend' (e.g., lift a cup <i>up</i>)
<i>anta</i>	'pick up/hold in arms' (e.g., pick a child <i>up</i>)
<i>ancta</i>	'assume a sitting posture' (e.g., sit <i>up</i> , sit <i>down</i>)
<i>(ile)seta</i>	'assume a standing posture' (e.g., stand <i>up</i>)

revolving primarily around topological notions and motion up and down (see also section 10.1, and Sinha et al. 1994). But were the children's spatial *semantic categories* similar, as inferred from the range of referent events to which they extended their words? They were not. By twenty months of age, the path semantic categories of the two sets of children were quite different from each other and clearly aligned with the categories of the input language. For example:

1. The English learners used their spatial particles indiscriminately for both spontaneous and caused motion into and out of containment, up and down, and so on. In contrast, the Korean children used strictly different verbs (intransitive vs. transitive) for spontaneous and caused motion along a path. For instance, English learners said *in* both when they climbed *into* the bathtub and put magnetic letters *into* a small box; in comparable situations the Korean learners used the verbs *tule* 'enter' versus *nehta* 'put loosely in (or around)'.
2. The English learners used *up* and *down* for a wide range of events involving vertical motion, including climbing on and off furniture, posture changes (sitting and standing up, sitting and lying down), raising and lowering things, and wanting to be picked up or put down. Recall that, as reviewed in section 10.1.2.2, the rapid generalization of *up* and *down* has been interpreted as evidence that these words are coupled to non-linguistic spatial concepts. But the Korean children used no words for a comparable range of motion up or down: as is appropriate in their language, they used different words for posture changes, climbing up or down, being picked up and put down, and so forth.
3. The English learners distinguished systematically between putting things into containers of all sorts (*in*) and putting them onto surfaces (*on*), but were indifferent to whether the figure fit the container tightly or loosely, or whether it was set loosely on a horizontal surface or attached tightly to a surface in any orientation, or—in the case of clothing items—what part of the body it went onto. The Korean learners, in contrast, distinguished between tight and loose containment (*kkita* 'fit tightly' versus *nehta* 'put loosely in (or around)'), between attaching things to a surface (*kkita* again) and setting things on a surface (*nohta* 'put on horizontal surface'), and between putting clothing on the head (*ssuta*), trunk (*ipta*), and feet (*sinta*). Some examples of these differences are given in table 10.2.

Although the children had clearly discovered many language-specific features of spatial encoding in their input language, their command of the adult path categories was by no means perfect—there were also errors suggesting difficulties in identifying the boundaries of the adult categories, such as the use of *open* for unbending a doll (cf. last example in (1) of introduction), or the use of *kkita* 'fit tightly' for flat surface attachments involving stickers and magnets (e.g., entry 6 in table 10.2; this

Table 10.2

The Treatment of Containment and Surface Contact Relations in the Spontaneous Speech of Children Learning English and Korean

	Age (in months)	Utterance	Situation	Relation
English				
1.	18	<i>In 'gain.</i>	Trying to shove toy chair through narrow door of doll house.	Tight containment (Korean <i>kkita</i>)
2.	19	<i>In.</i>	When mother dips her foot into the washtub of water.	Loose containment (Korean <i>nehta</i>)
3.	17	<i>On.</i> <i>Horsie on.</i>	Looking for rein of rocking horse; it has come off and she wants to attach it back on to the edge of the horse's mouth.	Tight surface contact (Korean <i>kkita</i>)
4.	23	Can't wow-wow <i>on.</i>	Frustrated trying to put toy dog on a moving phonograph record.	Loose surface contact (Korean <i>nohta</i>)
Korean				
5.	17	<i>Kkita.</i>	Putting peg doll into perfectly fitting niche-seat on small horse that investigator has brought.	Tight containment (English <i>in</i>)
6.	27	<i>Kkita.</i>	Attaching a magnetic fish to magnetic beak of duck.	Tight surface contact (English <i>on</i>)
7.	20	<i>Nehta.</i>	Putting blocks into a pan.	Loose containment (English <i>in</i>)
8.	28	<i>Nohta.</i>	Putting one block on top of another.	Loose surface contact (English <i>on</i>)

The Korean examples show only citation form of the verb, not whole utterances.

should be *pwuchita* 'stick, juxtapose flat surfaces'; cf. table 10.1). These errors are important because they suggest that the language specificity of the learners' categories cannot be dismissed on grounds that the children perhaps were simply mimicking what they had heard people say in particular situations, and had no real grasp of the underlying semantic concepts. (Appropriate usage for *novel* situations, as illustrated by most of the examples in table 10.2, also argues against this interpretation.) We will come back to errors later, because they provide invaluable clues to children's relative sensitivity to different kinds of spatial semantic distinctions.

10.3.2 Spatial Encoding in Elicited Descriptions of Actions in Children Learning English, Korean, and Dutch

The examination of spontaneous speech can give a good overview of the early stages of spatial semantic development, and this approach has the advantage that, because

the utterances are freely offered, they reflect how children are conceptualizing situations for their own purposes. But a disadvantage is that the specific spatial situations that children happen to talk about vary, so comparing the distribution of forms requires matching situations that are not identical (as is done in table 10.2).

To get more control over what subjects talked about, Choi and I decided to conduct a production study in which we elicited descriptions of a standardized set of spatial actions from all subjects (Bowerman and Choi 1994). This time we focused exclusively on caused motion involving spatial manipulations of objects. To English and Korean, we added Dutch. Recall that an interesting way in which Dutch differs from English is its breakdown of spatial relations encompassed by English *on* into two subclasses, *op* 'on₁' (e.g., "cup *op* table") and *aan* 'on₂' (e.g., "handle *aan* cupboard door"); these differences are relevant to motion as well as to static spatial configuration.

The actions we used—seventy-nine in all—were selected on grounds that they are grouped and distinguished in interestingly different ways in the three languages. They were both familiar and novel, and covered a broad range of "joining" and "separating" situations such as donning and doffing clothing of different kinds (carried out with a doll), manipulations with containers and surfaces (e.g., putting a toy boat *into* a baby bathtub and taking it *out*, laying a doll *on* a towel after her bath, taking a dirty pillowcase *off* a pillow and putting a clean one *on*), *opening* and *closing* things (e.g., a suitcase, a cardboard box with flaps), putting tight- and loose-fitting rings *on* a pole and taking them *off*, buttoning and unbuttoning, hanging and "unhanging" (towel *on/off* hook), hooking (train cars *together/apart*), sticking (Band-aid *on* hand, suction hook *on/off* wall), and otherwise attaching and detaching things (e.g., magnetic train cars, Lego pieces, Popbeads, Bristle blocks). For these last-mentioned actions, we varied whether the objects were moved laterally or vertically, and whether the motions were symmetrical (e.g., one Lego piece in each hand, both hands moving together) or asymmetrical (e.g., one hand joins a Lego piece to a stack of two Legos pieces held in the other hand). (English and Dutch, but not Korean, are sensitive to these properties—compare, for example, *put on* with *put together*, and *take off* with *take apart*.)

For each language we had 40 subjects: 10 adults, and 30 children, 10 each in the age ranges 2;0–2;5, 2;6–2;11, and 3;0–3;5 years. Subjects were tested individually. We elicited spatial descriptions by showing the objects involved in each action and indicating what kind of spatial action should be performed with them, but not quite performing it, and saying things like "What should I do? Tell me what to do."¹¹ This procedure worked quite well: even in the youngest age group, 87% of the children gave a relevant verbal response, although not necessarily the same one the adults gave. Typical responses from the children learning English and Dutch were particles,

either alone (e.g., *in*, *on*) or with verbs (e.g., *put it in*); from the children learning Korean they were verbs (e.g., *kkie*, imperative form of *kkita* ‘fit tightly’).

10.3.2.1 Action Descriptions as Similarity Data The data collected can be seen as analogous to the data obtained in a sorting study. But instead of giving subjects a set of cards with, say, pictures of stimuli, and asking them to sort these into piles of stimuli that “go together,” we take each word produced by a subject as defining a category (analogous to a pile), and look to see which actions the subject applied the word to (i.e., sorted into that pile). Actions a speaker refers to with the same expression are considered more alike for that speaker than actions referred to with different expressions.¹² Seen in this way, the data can be analyzed with any technique suitable for similarity data, such as multidimensional scaling or cluster analysis.¹³

In one analysis, the data from all the subjects were subjected to a multidimensional scaling analysis that allowed us to plot the actions in two-dimensional space on the basis of how similar each action was to each other action (as determined by how often speakers across all three languages characterized both actions with the same expression). This was done separately for the set of “joining” actions and the set of “separating” actions, after earlier analyses had showed that, with rare (child) exceptions, these were distinguished by subjects of all ages and languages. The two resulting plots—somewhat modified by hand to spread out actions that were bunched very tightly together (because they were very often described with the same expression)—then serve as grids on which we can display the categorization system of any individual, or the dominant categorization of a group of individuals, by drawing in “circles” (i.e., Venn diagrams) that encompass all the actions that were described in the same way.

To see how this works, consider figures 10.3 and 10.4. Figures 10.3a and 10.3b show the dominant classification of the “joining” actions by the English-speaking adults and youngest group of English-speaking children (2;0–2;5 years); Figures 10.4a and 10.4b give the same information for the Korean subjects. The number of subjects (out of 10) who produced a given response is indicated on the grid near the label for the action.¹⁴ A quick overview of similarities and differences in how different groups of subjects classified the actions can be obtained by an eyeball comparison of the relevant figures:

- Figures 10.3a and 10.4a: *adult* speakers of *English* versus *Korean*;
- Figures 10.3b and 10.4b: *same-age child* speakers of *English* versus *Korean*;
- Figures 10.3a and 10.3b: *adult* versus *child* speakers of *English*;
- Figures 10.4a and 10.4b: *adult* versus *child* speakers of *Korean*.

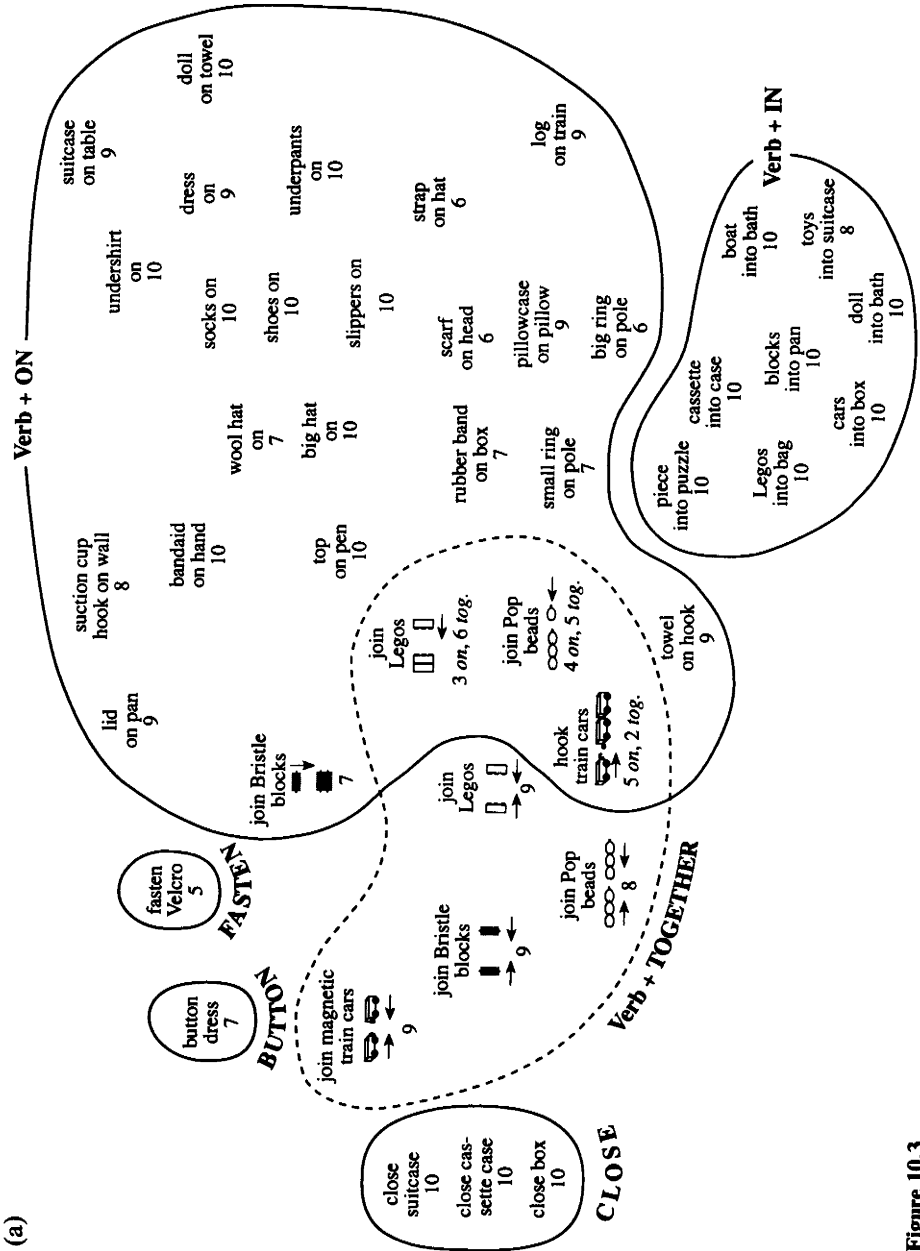


Figure 10.3
 (a) Categorization of joining actions by English-speaking adults. (b) Categorization of joining actions by English-speaking children, age 2 years to 2 years and 5 months.

These comparisons reveal both similarities and differences across subject groups. For example, in addition to agreeing that joining and separating actions should be described differently, subjects of all ages and languages agree on categorizing the “closing” actions together (to far left on grid), and also the “putting into loose container” actions (lower right). But they disagree quite dramatically on the classification of actions of “putting into a tight container,” actions of encirclement, putting on clothing, and so forth.

In general outline, the children’s classification patterns are similar to those of the adult speakers of their language, but they are simpler. The children lack some words the adults use (e.g., *together* in English; *pwuchita* ‘stick or juxtapose surfaces that are flat, or can be conceptualized as if flat,’ in Korean), and they overextend certain words relative to the adult pattern—for example, many English learners overextend *on* to “together” situations; and many Korean children overextend *kkita* ‘fit tightly’ to hooking train cars together and hanging a towel on a hook, and *nehta* ‘put loosely in (or around)’ to putting a pillowcase on a pillow.

10.3.2.2 Interpreting Children’s Categorization Patterns Comparing across the three languages, these elicited production data suggest that the way children initially classify space for language is the outcome of a complex interaction between their own nonlinguistic recognition of similarities and differences among spatial situations, on the one hand, and the way space is classified by adult speakers of their language, on the other. Overall, the influence of the input language is quite strong: statistical analysis shows that in all three languages, the youngest age group of children classified the spatial actions more similarly to *adult* speakers of their *own* language than to *same-age children* learning *other* languages.¹⁵ But obedience to the adult system was by no means perfect. Patterns of conformity with and deviation from the adult target system appear to be influenced by a mix of linguistic and nonlinguistic factors. Let us consider two examples.

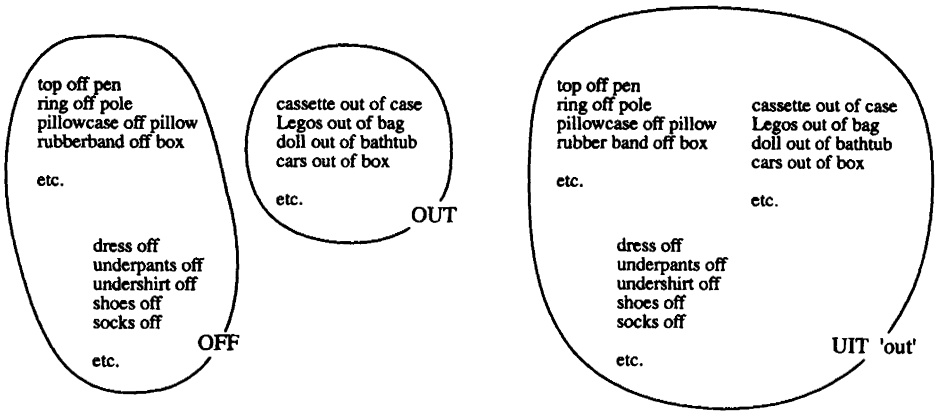
1. When children of a certain age are in principle capable of making a particular semantic distinction (as inferred from the observation that children in some language do so), the speed with which they begin to make it (if it is needed for their language) is strongly influenced by the clarity and consistency with which adult speakers mark it. For example, even the youngest age group of English speakers, like the adults, made a systematic split between “removal from containment” (*out*) and “removal from contact with an external surface” (*off*); this is illustrated in figure 10.5a with a subset of the relevant actions.¹⁶ Like English speakers, adult Dutch speakers also make a distinction between “removal from containment” (*uit* ‘out’) and “removal from contact with an external surface” (*af* ‘off’). But the youngest group of Dutch

children did not observe it—as shown in figure 10.5b, they vastly overextended *uit* ‘out’ to actions for which adults use *af* ‘off’, like taking a ring off a pole, a pillowcase off a pillow, and a rubber band off a box.

Why do the two sets of children differ in this way? Comparison of the adult systems is revealing. In English, the distribution of *out* and *off* correlates closely with removal from a concavity versus removal from a flat or convex surface (including body parts). In Dutch, the distribution of *uit* ‘out’ and *af* ‘off’ is based on the same principle, but with one important class of exceptions: whereas English uses *off* for the removal of enveloping clothing like coats, pants, shoes, and socks, Dutch uses *uit* ‘out’ (“take *out* your shoes/coat”; cf. figure 10.5c). When adult Dutch speakers are asked why they say “take out your shoes (coat, etc.),” they often seem to discover the anomaly for the first time: “It’s strange—when you take your shoe *uit* [‘out’], it’s really your foot that comes out of the shoe, isn’t it, not the shoe that comes out of your foot!” This reaction suggests that adults store this clothing use of *uit* separately from its normal use (i.e., as a separate polyseme). But this atypical use seems to be sufficiently salient to young children to obscure the distinction otherwise routinely made in Dutch between removal from surfaces and removal from containers.

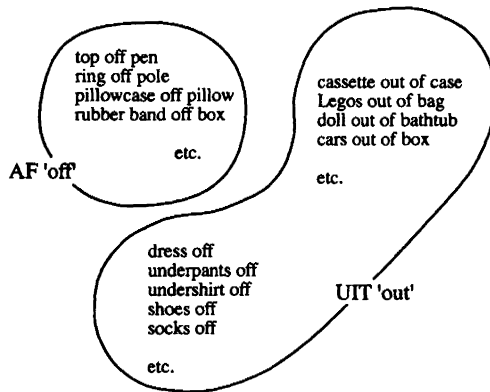
This example is intriguing because it goes squarely against a common claim about early word learning: that children at first learn and use words only in very specific contexts. According to this hypothesis, Dutch children should learn the use of *uit* for taking off clothing essentially as an independent lexical item. If so, they should proceed on the same schedule as learners of English to discover the semantic contrast between more canonical uses of *uit* ‘out’ and *af* ‘off’. But this does not happen: Dutch children appear to try to discover a coherent meaning for *uit* ‘out’ that can encompass *both* clothing- and container-oriented uses. The only meaning consistent with both uses, in that it is indifferent to the distinction between removal from a surface and removal from containment, is the notion of “removal” itself. Once children have linked this notion to *uit* ‘out’ it licenses them to use the word indiscriminately across the ‘out’/‘off’ boundary, which is exactly what they do, as shown in figure 10.5b.¹⁷

2. Children’s errors in using spatial words have often been interpreted as a direct pipeline to their nonlinguistic spatial cognition; for instance, in interpreting the somewhat different patterns of extension of the words *open* and *off* in my two daughters’ speech, I once suggested that the children had arrived at different ways of categorizing separations of various kinds on the basis of their own dealings with the physical world (Bowerman 1980). Overextensions do often seem to be conditioned by factors for which it is difficult to think of an intralinguistic explanation: for example, across all three languages in Choi’s and my study, children tended to overextend words for



a. Children learning English, age 2;0 - 2;5

b. Children learning Dutch, age 2;0 - 2;5



c. Dutch adults

Figure 10.5
Classification of actions as 'off' versus 'out' in English and Dutch.

separation more broadly than words for joining; that is, they differentiated less among actions of separation, relative to the adult pattern, than among actions of joining (and this is also true for children learning Tzotzil Mayan (Bowerman, de León, and Choi 1995). But a careful look across languages suggests that linguistic factors also play an important role in overextensions: in particular, the category structure of the input influences both *which* words get overextended and the *specific patterning* of the extensions.

If overextensions of spatial morphemes were driven purely by ways children categorize spatial events nonlinguistically, we would expect similar overextensions in different languages. And we do in fact find this to some extent: for example, similar overextensions of *open* and its translation equivalents have been reported for children learning English, French, and German (see Clark 1993 for review and sources). In Choi's and my production study, *open* (also spelled *open* in Dutch) was overextended to actions for which adults never used it about 9 times by English learners and about 21 times by Dutch learners (e.g., unbuttoning a button, taking a shoe off, separating two Lego pieces, and taking a piece out of a puzzle). But Korean children hardly make this error—it does not occur at all in the spontaneous speech data we have examined, and it occurs only once in the production study (one child used *yelda* 'open' for unhooking two train cars).

Why is there this difference in the likelihood of overgeneralizing 'open' words? A plausible explanation is that it is due to differences in the size and diversity of the 'open' categories of English and Dutch (and French and German) on the one hand, and Korean on the other. In Korean, *yelda* 'open' applies to doors, boxes, suitcases, and bags, for example, but it cannot be used for a number of other actions that are also called *open* in English and Dutch, such as opening the mouth, a clamshell, doors that slide apart (*ppellita* 'separate two parts symmetrically'), the eyes (*ttuta* 'rise'), an envelope (*ttutta* 'tear away from a base'), and a book, a hand, or a fan (*phyelchita* 'spread out a flat thing'). The breadth of the 'open' category in English and Dutch—that is, the physical diversity of the objects that can felicitously be "opened"—seems to invite children to construct a very abstract meaning; put differently, the diversity discourages children from discriminating among candidate 'opening' events on the basis of object properties that *are* in fact relevant to membership in the "open" category for adults. Conversely, the greater coherence in the physical properties of the objects to which Korean *yelda* 'open' can be applied—along with the coherence of each of the other categories encompassing events that are also called "open" in English and Dutch—may facilitate Korean children's recognition of the limits on the semantic ranges of the words.

If Korean children do not overextend *yelda* 'open', do they have another word that they overextend in the domain of separation? They do. In our production study, they

overwhelmingly used *ppayta* ‘unfit’ for virtually all the actions of separation—even including the actions for which adults usually used *yelda* ‘open’, such as opening a suitcase and a box! Like *open* in English, the category of *ppayta* ‘unfit’ is big and diverse in adult speech: out of the 36 “separation” actions in our study, 24 were labeled *ppayta* by at least one of the 10 Korean adults. (The word was used most heavily for events like separating Popbeads, Lego pieces, and Bristle blocks, and taking a piece out of a puzzle and the top off a pen, but it was also used occasionally for (e.g.) opening a cassette case, taking Legos out a bag, taking off a hat, and taking a towel off a hook.)

Do English, Dutch, and Korean children in fact use *open*, *open* ‘open’, and *ppayta* ‘unfit’ for the *same range* of events? If so, this would suggest the power of an underlying child-basic, language-independent notion. But the situations to which children extend *open* and *ppayta* ‘unfit’ differ, and the differences are related to the different meanings of the words—and their different ranges of application—in adult speech.

Korean children’s *ppayta* ‘unfit’ category seems to have its center—as in adult speech—in the notion of “separating fitted or ‘meshing’ objects with a bit of force” (e.g., pulling Popbeads and Lego pieces apart, taking the top off a pen—9 out of the 10 children used *ppayta* for these actions). It is extended from this center to taking things out of containers, and overextended, relative to patterns in the adult data, to opening containers, “unsticking” adhering and magnetized objects, and taking off clothing. In contrast, English-speaking children’s *open* category is centered on acts of separation as a means of *making something accessible* (e.g., opening a box to find something inside; opening a door to go into another room), and it is extended from this center only occasionally to pulling apart Popbeads and Legos and taking off clothing (both much more often called *off* in the elicited production study), and to taking things out of containers (much more often called *out*). English-speaking children also use *open* for actions in which something is made accessible without any separation at all, such as turning on TVs, radios, water faucets, and electric light switches (Bowerman 1978, 1980). Korean children do not overextend *ppayta* ‘unfit’ to events of this kind, probably because its use in adult speech is concentrated on acts of physical separation per se, and not on separation as a means of making something accessible.

In sum, children learning these different languages show a shared tendency, probably conditioned by nonlinguistic cognitive factors, to underdifferentiate referent events in the domain of separation—that is, they overextend words in violation of distinctions that their target language honors. But which words they “select” to overextend, and the semantic categories defined by the range of events across which they extend them, are closely related to the semantic structure of the input language.




10.4 How Do Children Construct the Spatial Semantic System of Their Language?

We have seen that language learners are influenced by the semantic categorization of space in their input language from a remarkably young age. This does not mean, of course, that they simply passively register the patterns displayed in the input—they do make errors, and these suggest that learners find some distinctions and grouping principles employed by the input language either difficult or unclear (or both). There is, then, an intricate interaction between nonlinguistic and linguistic factors in the process of spatial semantic development. In this final section, let us speculate about how this interaction takes place.

10.4.1 Is the Hypothesis That Children Map Spatial Morphemes onto Prelinguistically Compiled Spatial Concepts Still Viable?

The evidence for early language specificity in semantic categorization presented in section 10.3 might seem to argue strongly against the hypothesis that children start out by mapping spatial words onto prepackaged notions of space. But Mandler (1992 and chapter 9, this volume) suggests that the two can, after all, be reconciled.

Inspired by the work of cognitively minded linguists such as Langacker (1987), Lakoff (1987), and Talmy (1983, 1985), Mandler hypothesizes that an important step in the prelinguistic development of infants is the “redescription” of perceptual information into “image-schemas”—representations that abstract away from perceptual details to present information in a more schematic form. Preverbal image schemas would play a number of roles in infant mental life, but of special relevance for us is Mandler’s (1992, 598) suggestion that they “would seem to be particularly useful in the acquisition of various relational categories in language.” In particular, Mandler suggests that words meaning ‘in’ and ‘on’ are mapped to the image-schemas of *containment* (and the related notions of *going in* and *going out*) and *support*:

(8) Containment:  Going in:  Going out: 

(9) Support: 

In considering evidence that languages partition spatial situations in different ways, as discussed in Bowerman (1989) and Choi and Bowerman (1991), Mandler (1992, 599) suggests that “however the cuts are made, they will be interpreted [by the learner] within the framework of the underlying meanings represented by nonverbal image-schemas.” This means that children “do not have to consider countless variations in meaning suggested by the infinite variety of perceptual displays with which they are confronted; meaningful partitions have already taken place” (p. 599). Reliance on the preorganization provided by the nonverbal image-schemas for containment and support will make some distinctions harder to learn than others; for

example, Mandler suggests that children acquiring Dutch will have to learn how to break down the support schema into two subtypes of support (*op* 'on₁' and *aan* 'on₂'; cf. section 10.2.1), and this might well take some time (which is in fact true; see Bowerman 1993). On the other hand, Mandler predicts no difficulty for Spanish-speaking children in learning *en* 'in, on' (this seems also to be true) because this involves only collapsing the distinction between containment and support.

But what about the 'tight fit' category of the Korean verb *kkita*, which crosscuts the categories of both *in* and *on* in English, and, as Choi and Bowerman (1991) showed (cf. section 10.3.1), is acquired very early? Mandler (1992, 599) suggests that the early mapping of *kkita* onto the 'tight fit' meaning "is only a puzzle if one assumes that *in* and *on* are the only kinds of spatial analyses of containment and support that have been carried out." But 'tight fit' may well be an additional meaning that is prelinguistically analyzed, and thus is available for mapping to a word. Mandler acknowledges that we do not yet have independent evidence for this concept in prelinguistic infants, as we do for containment and support, and adds that "until such research is carried out it will not be possible to determine whether a given language merely tells the child how to categorize [i.e., subdivide or lump] a set of meanings the child has already analyzed or whether the language tells the child it is time to carry out new perceptual analyses" (pp. 599–600).

Mandler's hypothesis is by no means implausible, but it comes at a price. Suppose we discover that, from a very young age, toddlers learning a newly researched language, *L*, extend a word across a range of referents that breaks down or crosscuts the spatial semantic categories we already know children are sensitive to, like the categories defined by the putative image-schemas of containment, support, and tight fit. This means, by the logic of Mandler's argument, that there is yet another universal preverbal image-schema out there that we were not aware of before, and we must assume that all children everywhere have it, regardless of whether they will ever need it for the language they are learning.

This price may be acceptable as long as the putative preverbal image schemas uncovered by future research are not too numerous, and do not overlap each other in complex and subtle ways. But this seems doubtful, even on the basis of the limited data that is currently available. For example, the categories picked out by *open* and *ppayta* 'unfit' in the early speech of children learning English versus Korean overlap extensively. This might suggest that both words are mapped to the same preverbal image schema, but, as argued earlier, the overall range of the two categories in fact differs, each one being centered on core uses of the relevant word in adult speech.¹⁸

Mandler points out (personal communication) that her hypothesis is designed to account only for the very first stage of acquiring spatial morphemes; differing

extension patterns such as those just discussed may represent developments beyond this point. This is possible. But in this case the spatial image-schemas are doing little of the work that has often motivated the postulation that children map words to prelinguistically established concepts—namely, to provide a principled basis on which children can extend their morphemes beyond the situations in which they have frequently heard them. Regardless of whether image-schemas serve as the starting points, then, it seems we cannot rely on them to account for productivity in children's uses of spatial morphemes. For this, we will have to appeal to a process of learning in which children *build* spatial semantic categories in response to the distribution of spatial morphemes across contexts in the language they hear.

10.4.2 Semantic Primitives and Domain-specific Constraints

If semantic categories are constructed, they must be constructed out of something, and an important question is what this something is. Here we come squarely up against one of the oldest and most difficult problems for theorists interested in the structure of mind: identifying the ultimate stuff of which meaning is made.

Among students of language, a time-honored approach to this problem has been to invoke a set of semantic primitives—privileged meaning components that are available to speakers of all languages, but that can be combined in different ways to make up different word meanings.¹⁹ In searching for the ultimate elements from which the meanings of closed-class spatial words such as the set of English prepositions are composed, researchers have been struck by the relative sparseness of what can be important. Among the things that can play a role are notions like verticality, horizontality, place, region, inclusion, contact, support, gravity, attachment, dimensionality (point, line, plane, or volume), distance, movement, and path (cf. Bierwisch 1967; H. H. Clark 1973; Landau and Jackendoff 1993; Miller and Johnson-Laird 1976; Olson and Bialystok 1983; Talmy 1983; Wierzbicka 1972). Among things that never seem to play a role are, for example, the color, exact size or shape, or smell of the figure and ground objects (although see also Brown 1994).

10.4.2.1 Domain-specific Learning? If the meanings of closed-class spatial morphemes are so restricted—and restricted in similar ways across languages—children might take advantage of this in trying to figure out the meanings of new spatial forms. That is, they might approach the task of learning spatial morphemes with a *constrained hypothesis space*, entertaining only elements of meaning that are likely to be relevant for words in this domain.

Reasoning in this way, Landau and Stecker (1990) hypothesized that although children should be prepared to take shape into account in learning new words for objects, they should attend to shape only minimally in hypothesizing meanings for new spatial

words. To test this hypothesis, they showed three- and five-year-old learners of English a novel object on the top front corner of a box, and told them either “This is *a corp*” (count noun condition) or “This is *acorp* my box” (preposition condition). Subjects in the count noun condition generalized the new word to objects of the same shape, ignoring the object’s location, whereas subjects in the preposition condition generalized it to objects of any shape, as long as they were in approximately the same location as the original (the top region of the box).²⁰

While these findings are compatible with the claim that children’s hypotheses about the meaning of a new preposition are constrained by their obedience to domain-specific restrictions on what can be relevant to a closed-class spatial word, they are not compelling evidence. The subjects had, after all, already learned a number of English prepositions for which the shape of the figure is unimportant, so they may have been influenced by a *learned* language-specific bias to disregard shape in hypothesizing a meaning for a new preposition.²¹ Whether the claimed biases exist prior to linguistic experience is, then, still uncertain.²²

In hypothesizing about constraints on the meanings of spatial morphemes, and constraints on children in learning them, researchers have concentrated on closed-class spatial words—it is agreed that spatial *verbs*, as open-class items, can incorporate a wide range of information about the shape, properties, position, and even identity of figure and ground objects, and about the manner of motion (Landau and Jackendoff 1993, 235–236; Talmy 1983, 273). Following the logic of “constraints” argumentation, children’s hypothesis space about closed-class spatial morphemes should therefore be more constrained than their hypothesis space about spatial verbs, since spatial verbs—especially in languages that rely heavily on them, like Korean—are sensitive to the same things that spatial prepositions are sensitive to, and a lot more besides.²³ Because the advantage of built-in constraints is supposed to be that they enable learners to quickly home in on a word’s meaning without having to sift endlessly through all the things that could conceivably be relevant, it seems that children should have an easier time arriving at the meanings of closed-class spatial morphemes (more constrained) than of spatial verbs (more open).

This is an empirical question, and one that can be examined by comparing, for example, whether children acquiring English learn the meanings of spatial particles more quickly than children acquiring Korean learn the meanings of roughly comparable spatial verbs. But in Choi’s and my studies, children learning Korean were just as fast at approximating the adult meanings of common spatial verbs used to encode actions of joining and separation as children learning English were at approximating the adult meanings of English particles used to encode the same actions (cf. figures 10.3 and 10.4). And this is true even though a number of the Korean children’s early verbs incorporated shape or object-related information such

as “figure is a clothing item,” “ground is the head/the trunk/the feet” (Choi and Bowerman 1991, 116).

It was, then, apparently no harder for children to figure out the meanings of putatively less constrained spatial verbs than of more constrained closed-class spatial morphemes. This outcome casts doubt on what these domain-specific constraints are buying for the child, and whether they are really needed in our theory of acquisition.

10.4.2.2 Does Learning Spatial Words Involve Bundling Semantic Primitives? Regardless of whether children acquiring closed-class spatial morphemes are assisted by domain-specific constraints, we can still ask whether the task of formulating the meanings of spatial words is correctly seen as a process of assembling semantic primitives into the right configurations. The appeal to semantic primitives has a long history in the study of language acquisition—a particularly influential statement of this position was E. V. Clark’s (1973b) Semantic Features Hypothesis, which held that the development of a word’s meaning is a process of adding semantic components one by one until the adult meaning of the word has been reached. Clark’s approach was discarded after extensive testing and analysis, even by Clark herself (1983), and for good reason—various predictions made by the theory were simply not met (see Richards 1979 and Carey 1982 for reviews and discussions).

In an analysis of what went wrong, Carey (1982, 367) makes an important point for our purposes: many candidate semantic features are “theory-laden”—they “represent a systematization of knowledge, the linguistic community’s theory building. As such, they depend upon knowledge unavailable to the young child, and they are therefore not likely candidates for developmental primitives” (see also Gopnik 1988 and Murphy and Medin 1985 for related arguments).

Illustrating with an example from the domain of space, Carey points out that the component [tertiary (extent)]—proposed by Bierwisch (1967) as one of a set of semantic features (along with [primary] and [secondary]) needed to distinguish *long*, *tall*, *wide*, and *thick*—is highly abstract. It is implausible, she suggests, that young children start out with a notion of [tertiary] that allows them to make sense of the use of the word *thick* in such diverse contexts as the thickness of a door, the thickness of an orange peel, and the thickness of a slice of bread. More likely, they at first understand what *thick* picks out in each of these contexts independently, and only later extract what these various uses of *thick* have in common to arrive at the feature [tertiary]. A similar analysis is applied to the word *tall* by Carey (1978) and Keil and Carroll (1980): at first children learn how to use *tall* in the context of specific referents (e.g., building: ground up; person: head to toe), and only later extract the abstract features (e.g., [spatial extent] [vertical]) that unites these uses. According to this critique, then, semantic features are the *outcome* of a lengthy developmental process—

the “lexical organizers” (Carey 1978) that children extract from words to make sense of their use across contexts—not the elements in terms of which learners analyze their experience to begin with.

Carey’s criticism of semantic primitives can be seen as related to the problem of category structure that has preoccupied us throughout this chapter. Proposed primitives are usually designated with words of a particular language, often English. Although authors may insist that they do not intend their primitives to be identical with the meanings of words in any actual language, it is not clear what they *do* in fact intend them to mean. Each language offers a different idea of what some candidate primitive is, and the child must discover this view.

Consider, for example, *support*. Does this candidate primitive include support from all directions, as in English? (cf. “The pillars support the roof,” “The drunkard supported himself by leaning against the wall,” “The actor was supported by invisible wires as he flew across the stage”). Or is it restricted to support from below, like the closest equivalent to the English word *support* in German, *stützen*? Interestingly, these two notions of support are closely aligned with the meaning of ‘on’ morphemes in the two languages: English *on* is indifferent to the orientation of the supporting surface, whereas German *auf* ‘on’ is largely restricted to support from below. Figuring out what ‘support’ is, then, is not entirely a matter of analyzing the circumstances under which objects do and do not fall—it also requires discovering how ‘support’ is conceptualized in one’s language.

Invoking semantic primitives to explain the acquisition of spatial morphemes has, in the end, a lulling effect—it makes us think we understand the acquisition process better than we do. To the extent that languages differ in what counts as ‘support’, as ‘containment’ (or ‘inclusion’), as a ‘plane’, a ‘point’ or a ‘volume’, and so on, these concepts cannot serve as the ultimate building blocks out of which children construct their meanings. Still left largely unresolved, then, is one of most recalcitrant puzzles of human development: how children go beyond their processing of particular morphemes in particular contexts—for example, “(this) cup *on* (this) table”, “(this) picture *on* (this) wall”—to a more abstract understanding of what the morphemes mean.

To conclude, I have argued that the existence of crosslinguistic variation in the semantic packaging of spatial notions creates a complex learning problem for the child. Even if learners begin by mapping spatial morphemes directly onto pre-compiled concepts of space—which is not at all obvious—they cannot get far in this way; instead, they must work out the meanings of the forms by observing how they are distributed across contexts in fluent speech. Learners’ powers of observation appear to be very acute, since their spatial semantic categories show remarkable language specificity by as early as seventeen to twenty months of age. Current

theories about the acquisition of spatial words do not yet dispel the mystery surrounding this feat. In our attempts to get a better grip on the problem, evidence from children learning different languages will continue to play an invaluable role.

Acknowledgments

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Notes

1. These examples are taken from diary records of my daughter E (cf. Bowerman 1978, 1980; Choi and Bowerman 1991).
2. Of course, the idea that human beings apprehend space with a priori categories of mind has a much older philosophical tradition.
3. David Wilkins (personal communication) suggests that Arrernte, an Arandic language of Central Australia, may instantiate the fifth logical possibility—grouping (a) and (b) together (on grounds that both the cup and the apple are easily grasped and moved independently—both covered by a general locative morpheme) and treating (c) differently (on grounds that the handle, being tightly attached, cannot be moved without moving the whole door).
4. A similar but more general point is made by Schlesinger (1977), who argues that languages depend on many categories that are not needed and will not be constructed purely in the course of nonlinguistic cognitive development. In a related point, Olson (1970, 188–189) notes that “linguistic decisions require information . . . of a kind that had not previously been selected, or attended, or perceived, because there was no occasion to look for it.”
5. Some of these crosslinguistic differences were identified in the course of typological research I conducted together with Eric Pederson on how languages express static topological spatial relations (Bowerman and Pederson 1992).
6. Some analysts have considered constructions like “the scissors have butter”, “the handle of the kitchen door”, and “the scissors are buttery” to be underlyingly spatial (see Lyons 1967 on possessive constructions and Talmy 1972 on attributive adjectives like *buttery* and *muddy*). The question remains, however, why some languages permit only these descriptions of certain relationships between entities, while others also readily describe them with overtly spatial characterizations.
7. Finnish takes the same perspective as Dutch on which is figure and which is ground, but instead of locating the hands/tree “under” the paint/ivy, Finnish locates them *in* the paint/ivy (paint/ivy-*ssa*). An English alternative that at first glance might seem comparable to the

Dutch/Finnish construction is the passive, for example, “The tree is covered by/with/in ivy.” This sentence does allow the “covered” entity to be the subject of the sentence, but the verb *cover* still assigns the role of figure to the coverer (the ivy) and the role of ground to the covered (the tree) (cf. “ivy covers the tree”), and the covered entity can be gotten into subject position only by passivization.

8. To decouple the patently important question of how speakers come to control the semantic categories of their language from the loaded Whorfian issue, Slobin (1987) has coined the expression “thinking for speaking.”

9. Here and subsequently, the reader should keep in mind that the English glosses given for the Korean verbs serve only as rough guides to their meaning. The actual meanings do not in fact correspond to the meanings of any English words, and can only be inferred on the basis of careful analysis of the situations in which the words are used.

10. The English data came from detailed diary records of my two daughters from the start of the one-word stage, supplemented by the extensive literature on the early use of English path particles reviewed in section 10.1.2. Two sets of Korean data were used: (1) from 4 children videotaped every 3–4 weeks by Choi from 14 months old to 24–28 months old; and (2) from 4 additional children taped by Choi, Pat Clancy, and Youngjoo Kim every 2 to 4 weeks from 19–20 months old to 25–34 months old. We are grateful to Clancy and Kim for generously sharing their data.

11. We adopted this procedure rather than, for example, asking children to describe actions we had already performed because several studies have shown that children first produce change-of-state predicates, including spatial morphemes, either as requests for someone to carry out an action or when they themselves are about to perform an action—the words seem to function to announce *plans* of intended action (Gopnik 1980; Gopnik and Meltzoff 1986; Huttenlocher, Smiley, and Charney 1983). If a child failed to respond after several attempts to elicit a request/command for an about-to-be-performed action, we would go ahead and perform it and then ask the child, “What did I do?” For adults, who caught on immediately to what kind of response we were looking for, we often soon abandoned the command scenario and simply displayed the actions we wanted labeled.

12. Degrees of similarity can also be computed—for example, two actions both called “take out” can be regarded as entirely similar, two called “take out” and “pull out” are partially similar, and two called “take out” and “put on” are not at all similar. For certain kinds of analyses, it is useful to organize each subject’s data as a similarity matrix showing whether, for each action paired with each other action, the subject used the same (e.g., put a 1 in the cell), similar (e.g., .5) or different (0) expressions; this allows us to disregard the fact that the expressions themselves are different across languages, as, of course, is the number of expressions used by different subjects.

13. In the quantitative analyses of the data, Choi and I have been joined in our collaboration by James Boster (see, for example, Boster 1991 for a relevant comparative analysis applied to the nonlinguistic classification of mammals by children and adults in two cultures).

14. Actions that fall outside of all the circles in a figure were responded to either very inconsistently (i.e., no “dominant response” could be identified) or (in the case of the children) received few relevant verbal responses. The use of solid versus dotted lines for the circles has no special significance—it just makes it easier to visually distinguish overlapping categories.

15. This analysis involved comparing the similarity matrices (cf. note 12) of speakers in different groups. We first constructed an aggregate matrix for the adult speakers of each language. We then correlated the similarity matrix of each child with the aggregate adult matrix for each language and with the matrices of all the other children. (The cells of the matrices, e.g., action 1 paired with action 2, action 1 paired with action 3, etc., constitute the list of variables over which the correlation is carried out.) Finally, we tested whether the children in the youngest age group for each language correlated significantly better with the adult aggregate matrix for their own language, or with same-age children speaking each of the other two languages. (We also assessed their correlation with adult speakers of each of the other two languages.)

16. The only action to which both *out* and *off* were applied (by different children) was taking a piece out of a jigsaw puzzle, and this is readily understandable: the “container” (the piece-shaped hole in the wooden base) was extremely shallow in this case, so it is probably unclear to learners whether to construe it as a “container” or a “surface” (see section 10.2.2.3 on the problem of learning the conventional conceptualization of particular objects). (For the converse action of putting the piece into the puzzle, eight children said “in” and only one said “on.”) Another action presenting a similar construal problem was “put log on train car.” The train car in question had short poles sticking up, two on a side, to keep the tiny logs from falling off. Despite the poles, 27 of the 30 adults across the three languages conceptualized this situation as one of placing a log ‘on’ a horizontal supporting surface (English *on* (*top*), Korean *nohta* ‘put on horizontal supporting surface’, Dutch (*boven*) *op* ‘on (top)’). But of the 30 children in the youngest age group across the three languages, only 5 used these words; their most typical response was *in* (English and Dutch) and *nehta* ‘put loosely in’ or *kkita* ‘fit tightly’ (Korean).

17. This pattern in Dutch also argues against a hypothesis that several people have suggested to me: that English-speaking children may learn *on* and *off* in connection with clothing as a separate, self-contained pair of meanings, so these uses should not be analyzed as part of a more general pattern of associating *on* and *off* with surface-oriented relationships. The clothing use of *uit* ‘out’ seems to interact in the course of development with other uses of *uit* in Dutch children, so this argument is incorrect for Dutch, and by extension probably also for English. (See Choi and Bowerman 1991, 110–113, for other empirical arguments against the proposal that there is extensive homonymy or polysemy in children’s early acquisition of spatial words.)

18. A similar example is provided by children learning Tzotzil Mayan (Bowerman, de León, and Choi 1995). One of the earliest spatial morphemes for “joining” actions that these children acquire is the verb *xoj*, and they seem to use it, before age 2, for a range of events that corresponds neither to the English child categories *in* or *on* nor to the Korean child category *kkita* ‘fit tightly’. In adult speech, the root *xoj* picks out a configuration of a long thing encircled by a ring-shaped thing, and can be used, for example, to describe either putting a pole through a ring or a ring over a pole. When adult Tzotzil speakers were informally tested on the same set of spatial actions Choi and I used in the elicited production described in section 10.3.2, they used *xoj* for putting tight- and loose-fitting rings on poles and occasionally for putting on clothing (the ring-and-pole configuration is instantiated by the encirclement of arms and legs by sleeves and pantlegs, feet by socks and shoes, and head by wool cap). (Adults more often described donning clothing with a verb that means “put on clothing.”) Very small Tzotzil

children also used *xoj* for putting rings on poles and (more frequently than adults) for putting on shoes, socks, and wool hat, and, beyond these manipulations with our experimental materials, they used it for other actions conforming to or approximating the ring-and-pole configuration such as threading beads, putting a coiled rope over a peg, and putting a car into a long thin box. This range overlaps the *in* and *on* categories of English-speaking children but is more restricted than either (see figure 10.3b); it also overlaps the *kkita* ‘fit tightly’ and *nehta* ‘put loosely in (or around)’ categories of the Korean children, but, again, is different from both (cf. figure 10.4b).

19. Opinions vary on whether proposed semantic primitives are irreducible units only in their role as building blocks for meaning in language, or are also perceptual or conceptual primitives on a nonlinguistic level. The remarks in this section apply either way.

20. In a different approach to whether a learner constrained by domain-specific sensitivities can acquire the meanings of spatial words across languages, Regier (1995) equipped a connectionist model with specific structural devices motivated by neurobiological and psychophysical evidence on the human visual system. Presented with frame-by-frame films instantiating the meaning of spatial words, the model was able to home in on schematized versions of several spatial categories in English, Mixtec (cf. (3) in section 10.2.1), and Russian. Whether such a model can learn to classify a more realistic set of spatial situations, including diverse objects in all their complicated functional relationships, remains to be seen.

21. A study by Imai and Gentner (1993) shows that biases in what learners think a novel word means can indeed arise through experience with the properties of a particular language. These investigators showed that English- and Japanese-speaking subjects, both child and adult, agreed in assuming that a word introduced in connection with a complex object referred to the object, and that a word introduced in the context of a gooey substance referred to the substance. But they differed in their assumptions about a word introduced in the context of a novel simple object, such as a cork pyramid. English children and adults assumed that the word referred to same-shaped objects regardless of material, whereas their Japanese counterparts assumed that it referred to entities made of the same material, regardless of shape. Imai and Gentner had predicted this outcome on the basis of Lucy’s (1992) hypotheses about differences in the meanings of nouns in languages that do and do not have numeral classifiers.

22. Also uncertain is the possible cause of these biases. For example, if children are biased against detailed shape information in learning closed-class spatial words, is this because the words are *spatial*, or because they are *closed-class*? (As Talmy 1983, 1985 has argued, closed-class morphemes have highly schematic meanings across a wide range of semantic domains.)

23. Pinker (1989, 172–176) has proposed a set of meaning components particularly relevant for learning verbs, but this set is far less constrained than the set relevant for closed-class spatial morphemes. (It includes “the main event”: a state or motion; path, direction, and location; causation; manner; properties of a theme or actor; and temporal distribution (aspect and phase); purpose, etc.) Nor are the components supposed to capture everything that can be important to the meaning of a verb, but only those aspects of meaning that can be relevant to a verb’s syntactic behavior.

References

- Antell, S. E. G., and Caron, A. J. (1985). Neonatal perception of spatial relationships. *Infant Behavior and Development*, 8, 15–23.
- Baillargeon, R. (1986). Representing the existence and the location of hidden objects: Object permanence in 6- and 8-month-old infants. *Cognition*, 23, 21–41.
- Baillargeon, R. (1987). Object permanence in 3.5- and 4.5-month-old infants. *Developmental Psychology*, 23, 655–664.
- Baillargeon, R., Graber, M., DeVos, J., and Black, J. C. (1990). Why do young infants fail to search for hidden objects? *Cognition*, 36, 255–284.
- Behl-Chadha, G., and Eimas, P. D. (1995). Infant categorization of left-right spatial relations. *British Journal of Developmental Psychology*, 13, 69–79.
- Berman, R. A., and Slobin, D. I. (1994). *Relating events in narrative: A crosslinguistic developmental study*. Hillsdale, NJ: Lawrence Erlbaum.
- Bierwisch, M. (1967). Some semantic universals of German adjectivals. *Foundations of Language*, 3, 1–36.
- Bierwisch, M. (1981). Basic issues in the development of word meaning. In W. Deutch (Ed.), *The child's construction of language*, 341–387. New York: Academic Press.
- Bloom, L. (1970). *Language development: Form and function in emerging grammars*. Cambridge, MA: MIT Press.
- Bloom, L. (1973). *One word at a time: The use of single word utterances before syntax*. The Hague: Mouton.
- Bomba, P. C. (1984). The development of orientation categories between 2 and 4 months of age. *Journal of Experimental Child Psychology*, 37, 609–636.
- Boster, J. (1991). The information economy model applied to biological similarity data. In L. Resnick, J. Levine, and S. D. Teasley (Eds.), *Socially shared cognition*, 203–225. Washington, DC: American Psychological Association.
- Bower, T. G. R. (1982). *Development in infancy*, 2d ed. San Francisco: Freeman.
- Bowerman, M. (1973). *Early syntactic development: A cross-linguistic study with special reference to Finnish*. Cambridge: Cambridge University Press.
- Bowerman, M. (1978). The acquisition of word meaning: An investigation into some current conflicts. In N. Waterson and C. Snow (Eds.), *The development of communication*, 263–287. New York: Wiley.
- Bowerman, M. (1980). The structure and origin of semantic categories in the language-learning child. In M. L. Foster and S. H. Brandes (Eds.), *Symbol as sense: New approaches to the analysis of meaning*, 277–299. New York: Academic Press.
- Bowerman, M. (1985). What shapes children's grammars? In D. I. Slobin (Ed.), *The cross-linguistic study of language acquisition*. Vol. 2, *Theoretical issues*, 1257–1319. Hillsdale, NJ: Lawrence Erlbaum.

- Bowerman, M. (1989). Learning a semantic system: What role do cognitive predispositions play? In M. L. Rice and R. L. Schiefelbusch (Eds.), *The teachability of language*, 133–169. Baltimore: Brooks.
- Bowerman, M. (1993). Typological perspectives on language acquisition: Do crosslinguistic patterns predict development? In E. V. Clark (Ed.), *The proceedings of the Twenty-fifth Annual Child Language Research Forum*, 7–15. Stanford CA: Center for the Study of Language and Information.
- Bowerman, M. (1994). From universal to language-specific in early grammatical development. *Philosophical Transactions of the Royal Society, London, B346*, 37–45.
- Bowerman, M. (1996). The origins of children's spatial semantic categories: Cognitive versus linguistic determinants In J. J. Gumperz and S. C. Levinson (Eds.), *Rethinking linguistic relativity*, 145–176. Cambridge: Cambridge University Press.
- Bowerman, M., and Choi, S. (1994). Linguistic and nonlinguistic determinants of spatial semantic development. Paper presented at the Boston University Conference on Language Development, January.
- Bowerman, M., de León, L., and Choi, S. (1995). Verbs, particles, and spatial semantics: Learning to talk about spatial actions in typologically different languages. In E. V. Clark (Ed.), *Proceedings of the Twenty-seventh Annual Child Language Research Forum*, 101–110. Stanford, CA: Center for the Study of Language and Information.
- Bowerman, M., and Pederson, E. (1992). Crosslinguistic perspectives on topological spatial relationships. Paper presented at the annual meeting of the American Anthropological Association, San Francisco, December.
- Brown, P. (1994). The INs and ONs of Tzeltal locative expressions: The semantics of static descriptions of location. *Linguistics*, 32, 743–790.
- Brown, R. W. (1958). *Words and things*. New York: Free Press.
- Brown, R. W. (1973). *A first language: The early stages*. Cambridge, MA: Harvard University Press.
- Brugman, C. (1983). *The use of body-part terms as locatives in Chalcatongo Mixtec*, 235–290. Report no. 4 of the Survey of California and Other Indian Languages. Berkeley: University of California.
- Brugman, C. (1984). Metaphor in the elaboration of grammatical categories in Mixtec. Unpublished manuscript, Linguistics Department, University of California, Berkeley.
- Carey, S. (1978). The child as word learner. In M. Halle, J. Bresnan, and G. A. Miller (Eds.), *Linguistic theory and psychological reality*, 264–293. Cambridge, MA: MIT Press.
- Carey, S. (1982). Semantic development: The state of the art. In E. Wanner and L. Gleitman (Eds.), *Language acquisition: The state of the art*, 347–389. Cambridge: Cambridge University Press.
- Caron, A. J., Caron, R. F., and Antell, S. E. (1988). Infant understanding of containment: An affordance perceived or a relationship conceived? *Developmental Psychology*, 24, 620–627.

- Choi, S., and Bowerman, M. (1991). Learning to express motion events in English and Korean: The influence of language-specific lexicalization patterns. *Cognition*, 41, 83–121.
- Cienki, A. J. (1989). *Spatial cognition and the semantics of prepositions in English, Polish, and Russian*. Munich: Sagner.
- Clark, E. V. (1973a). Nonlinguistic strategies and the acquisition of word meanings. *Cognition*, 2, 161–182.
- Clark, E. V. (1973b). What's in a word? On the child's acquisition of semantics in his first language. In T. E. Moore (Ed.), *Cognitive development and the acquisition of language*, 65–110. New York: Academic Press.
- Clark, E. V. (1983). Meanings and concepts. In J. H. Flavell and E. M. Markman (Eds.), *Mussen handbook of child psychology*. Vol. 3, *Cognitive development and the acquisition of language*, 787–840. New York: Academic Press.
- Clark, E. V. (1993). *The lexicon in acquisition*. Cambridge: Cambridge University Press.
- Clark, H. H. (1973). Space, time, semantics, and the child. In T. E. Moore (Ed.), *Cognitive development and the acquisition of language*, 27–63. New York: Academic Press.
- Colombo, J., Laurie, C., Martelli, T., and Hartig, B. (1984). Stimulus context and infant orientation discrimination. *Journal of Experimental Child Psychology*, 37, 576–586.
- DeValois, R., and DeValois, K. (1990). *Spatial vision*. Oxford: Oxford University Press.
- Freeman, N. H., Lloyd, S., and Sinha, C. G. (1980). Infant search tasks reveal early concepts of containment and canonical usage of objects. *Cognition*, 8, 243–262.
- Gentner, D. (1982). Why nouns are learned before verbs: Linguistic relativity versus natural partitioning. In S. A. Kuczaj II (Ed.), *Language development*. Vol. 2, *Language, thought, and culture*, 301–334. Hillsdale, NJ: Erlbaum.
- Gibson, E. J. (1982). The concept of affordances in development: The renaissance of functionalism. In W. A. Collins (Ed.), *The concept of development*, 55–81. Minnesota Symposia on Child Psychology, vol. 15. Hillsdale, NJ: Erlbaum.
- Gleitman, L. (1990). The structural sources of verb meanings. *Language Acquisition*, 1, 3–55.
- Goldberg, A. E. (1995). *Constructions*. Chicago: University of Chicago Press.
- Gopnik, A. (1980). The development of non-nominal expressions in 12–24-month-old children. Ph.D. diss., Oxford University.
- Gopnik, A. (1988). Conceptual and semantic development as theory change. *Mind and Language*, 3, 197–216.
- Gopnik, A., and Meltzoff, A. N. (1986). Words, plans, things, and locations: Interactions between semantic and cognitive development in the one-word stage. In S. A. Kuczaj II and M. D. Barrett (Eds.), *The development of word meaning*, 199–223. Berlin: Springer.
- Griffiths, P., and Atkinson, M. (1978). A 'door' to verbs. In N. Waterson and C. Snow (Eds.), *The development of communication*, 311–331. New York: Wiley.

- Gruendel, J. (1977). Locative production in the single-word utterance period: Study of "up-down," "on-off," and "in-out." Paper presented at the Biennial Meeting of the Society for Research in Child Development, New Orleans, March.
- Gumperz, J. J., and Levinson, S. C. (1996). *Rethinking linguistic relativity*. Cambridge: Cambridge University Press.
- Heine, B. (1989). Adpositions in African languages. *Linguistique Africaine*, 2, 77–127.
- Herskovits, A. (1986). *Language and spatial cognition: An interdisciplinary study of the prepositions in English*. Cambridge: Cambridge University Press.
- Hill, C. A. (1978). Linguistic representation of spatial and temporal orientation. *Berkeley Linguistics Society*, 4, 524–538.
- Huttenlocher, J., Smiley, P., and Charney, R. (1983). Emergence of action categories in the child: Evidence from verb meanings. *Psychological Review*, 90, 72–93.
- Imai, M., and Gentner, D. (1993). Linguistic relativity vs. universal ontology: Crosslinguistic studies of the object/substance distinction. In *Proceedings of the Chicago Linguistic Society*, 29.
- Johnston, J. R. (1984). Acquisition of locative meanings: *Behind* and *in front of*. *Journal of Child Language*, 11, 407–422.
- Johnston, J. R. (1985). Cognitive prerequisites: The evidence from children learning English. In D. I. Slobin (Ed.), *The crosslinguistic study of language acquisition*. Vol. 2, 961–1004. Hillsdale, NJ: Erlbaum.
- Johnston, J. R., and Slobin, D. I. (1979). The development of locative expressions in English, Italian, Serbo-Croatian and Turkish. *Journal of Child Language*, 6, 529–545.
- Keil, F. C. (1979). The development of the young child's ability to anticipate the outcomes of simple causal events. *Child Development*, 50, 455–462.
- Keil, F. C. (1990). Constraints on constraints: Surveying the epigenetic landscape. *Cognitive Science*, 14, 135–168.
- Keil, F. C., and Carroll, J. J. (1980). The child's acquisition of "tall": Implications for an alternative view of semantic development. *Papers and Reports on Child Language Development*, 19, 21–28.
- Lakoff, G. (1987). *Women, fire, and dangerous things: What categories reveal about the mind*. Chicago: University of Chicago Press.
- Landau, B., and Jackendoff, R. (1993). "What" and "where" in spatial language and spatial cognition. *Behavioral and Brain Sciences*, 16, 217–238.
- Landau, B., and Stecker, D. S. (1990). Objects and places: Syntactic geometric representations in early lexical learning. *Cognitive Development*, 5, 287–312.
- Langacker, R. W. (1987). *Foundations of cognitive grammar*. Vol. 1, *Theoretical prerequisites*. Stanford, CA: Stanford University Press.
- Leopold, W. (1939). *Speech development of a bilingual child*. Vol. 1. Evanston, IL: Northwestern University Press.

- Levine, S. C., and Carey, S. (1982). Up front: The acquisition of a concept and a word. *Journal of Child Language*, 9, 645–657.
- Levinson, S. C. (1994). Vision, shape, and linguistic description: Tzeltal body-part terminology and object description. *Linguistics*, 32, 791–855.
- Levinson, S. C. (in press). From outer to inner space: Linguistic categories and nonlinguistic thinking. In J. Nuyts and E. Pederson (Eds.), *Linguistic and conceptual representation*. Cambridge: Cambridge University Press.
- Levinson, S. C., and Brown, P. (1994). Immanuel Kant among the Tenejapans: Anthropology as Empirical Philosophy. *Ethos*, 22, 3–41.
- Lucy, J. A. (1992). *Language diversity and thought: A reformulation of the linguistic relativity hypothesis*. Cambridge: Cambridge University Press.
- Lyons, J. (1967). A note on possessive, existential, and locative sentences. *Foundations of Language*, 3, 390–396.
- MacLaury, R. E. (1989). Zapotec body-part locatives: Prototypes and metaphoric extensions. *International Journal of American Linguistics*, 55, 119–154.
- MacLean, D. J., and Schuler, M. (1989). Conceptual development in infancy: The understanding of containment. *Child Development*, 60, 1126–1137.
- Mandler, J. (1992). How to build a baby: II Conceptual primitives. *Psychological Review*, 99, 587–604.
- Markman, E. M. (1989). *Categorization and naming in children: Problems of induction*. Cambridge, MA: MIT Press.
- McCune-Nicholich, L. (1981). The cognitive bases of relational words in the single-word period. *Journal of Child Language*, 8, 15–34.
- Miller, G. A., and Johnson-Laird, P. N. (1976). *Language and perception*. Cambridge, MA: Harvard University Press.
- Murphy, G. L., and Medin, D. L. (1985). The role of theories in conceptual coherence. *Psychological Review*, 92, 289–316.
- Needham, A., and Baillargeon, R. (1993). Intuitions about support in 4.5-month-old infants. *Cognition*, 47, 121–148.
- Nelson, K. (1974). Concept, word, and sentence: Interrelations in acquisition and development. *Psychological Review*, 81, 267–285.
- Olson, D. R. (1970). Language and thought: Aspects of a cognitive theory of semantics. *Psychological Review*, 77, 257–273.
- Olson, D. R., and Bialystok, E. (1983). *Spatial cognition: The structure and development of the mental representation of spatial relations*. Hillsdale, NJ: Erlbaum.
- Parisi, D., and Antinucci, F. (1970). Lexical competence. In G. B. Flores D'Arcais and W. J. M. Levelt (Eds.), *Advances in psycholinguistics*, 197–210. Amsterdam: North-Holland.
- Piaget, J. (1954). *The construction of reality in the child*. New York: Basic Books.

- Piaget, J., and Inhelder, B. (1956). *The child's conception of space*. London: Routledge and Kegan Paul.
- Pieraut-Le Bonniec, G. (1987). From visual-motor anticipation to conceptualization: Reaction to solid and hollow objects and knowledge of the function of containment. *Infant Behavior and Development*, 8, 413–424.
- Pinker, S. (1989). *Learnability and cognition: The acquisition of argument structure*. Cambridge, MA: MIT Press.
- Quinn, P. C. (1994). The categorization of above and below spatial relations by young infants. *Child Development*, 65, 58–69.
- Quinn, P. C., and Bomba, P. C. (1986). Evidence for a general category of oblique orientations in four-month-old infants. *Journal of Experimental Child Psychology*, 42, 345–354.
- Quinn, P. C., and Eimas, P. D. (1986). On categorization in early infancy. *Merrill-Palmer Quarterly*, 32, 331–363.
- Regier, T. (1995). A model of the human capacity for categorizing spatial relations. *Cognitive Linguistics*, 6, 63–88.
- Richards, M. M. (1979). Sorting out what's in a word from what's not: Evaluating Clark's semantic features acquisition theory. *Journal of Experimental Child Psychology*, 27, 1–47.
- Schlesinger, I. M. (1977). The role of cognitive development and linguistic input in language development. *Journal of Child Language*, 4, 153–169.
- Sinha, C., Thorseng, L. A., Hayashi, M., and Plunkett, K. (1994). Comparative spatial semantics and language acquisition: Evidence from Danish, English, and Japanese. *Journal of Semantics*, 11, 253–287.
- Sitskoorn, M. M., and Smitsman, A. W. (1995). Infants' perception of dynamic relations between objects: Passing through or support? *Developmental Psychology*, 31, 437–447.
- Slobin, D. I. (1973). Cognitive prerequisites for the development of grammar. In C. A. Ferguson and D. I. Slobin (Eds.), *Studies of child language development*, 175–208. New York: Holt, Rinehart, and Winston.
- Slobin, D. I. (1985). Crosslinguistic evidence for the language-making capacity. In D. I. Slobin (Ed.), *The crosslinguistic study of language acquisition*. Vol. 2, *Theoretical issues*, 1157–1256. Hillsdale, NJ: Erlbaum.
- Slobin, D. I. (1987). Thinking for speaking. *Proceedings of the Thirteenth Annual Meeting of the Berkeley Linguistics Society*, 13, 435–444.
- Spelke, E. S., Breinlinger, K., Macomber, J., and Jacobson, K. (1992). Origins of knowledge. *Psychological Review*, 99, 605–632.
- Spelke, E. S., Katz, G., Purcell, S. E., Ehrlich, S. M., and Breinlinger, K. (1994). Early knowledge of object motion: Continuity and inertia. *Cognition*, 51, 107–130.
- Talmy, L. (1972). *Semantic structures in English and Atsugewi*. Ph.D. diss. University of California, Berkeley.

- Talmy, L. (1983). How language structures space. In H. Pick and L. Acredolo (Eds.), *Spatial orientation: Theory, research, and application*, 225–282. New York: Plenum.
- Talmy, L. (1985). Lexicalization patterns: Semantic structure in lexical form. In T. Shopen (Ed.), *Language typology and syntactic description*. Vol. 3, *Grammatical categories and the lexicon*, 57–149. Cambridge: Cambridge University Press.
- Talmy, L. (1991). Path to realization: A typology of event conflation. *Proceedings of the Seventeenth Annual Meeting of the Berkeley Linguistics Society*, 17, 480–519. [Supplement in the *Buffalo Papers in Linguistics*, 91-01, 182–187.]
- von der Heydt, R., Peterhans, E., and Baumgartner, G. (1984). Illusory contours and cortical neuron responses. *Science*, 224, 1260–1262.
- Whorf, B. L. (1956). *Language, thought, and reality*. Edited by J. B. Carroll. Cambridge, MA: MIT Press.
- Wierzbicka, A. (1972). *Semantic primitives*. Frankfurt: Athenäum.
- Wilkins, D., and Senft, G. (1994). A man, a tree—and forget about the pigs: Space games, spatial reference and an attempt to identify functional equivalents across languages. Paper presented at the Nineteenth International L.A.U.D. Symposium on Language and Space, Duisburg, March.